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Analyse économique des médias : aspects positifs et normatifs

HU Jun

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Avertissement

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Résumé

Les médias jouent un rôle vital dans notre vie car ils offrent aux citoyens des informations leur permettant de prendre des décisions politiques et sociales. Le marché des informations diffère des autres marchés par bien des aspects. De plus, l'essor des nouvelles technologies telles qu'Internet et les médias sociaux fait apparaître de nouveaux défis tels que les biais médiatiques, la polarisation de la société…Cette thèse explore les raisons et les conséquences des biais médiatiques d'un point de vue économique et politique.

Le premier chapitre traite de la différentiation de produits sur un marché concurrentiel de l'information. L'information rapportée par les médias est imparfaite, caractérisée par un couple espérance-variance mesurant respectivement le biais et le bruit informationnels. La qualité des produits informationnels est mesurée synthétiquement par la divergence de Kullback-Leibler. On montre qu'à l'équilibre concurrentiel le marché se segmente en deux parties. Une partie conventionnelle, commercialisant des produits d'information très biaisés et peu bruités, attire la grande majorité des consommateurs. Certains consommateurs, dont l'aversion pour les biais l'emporte sur leur aversion pour le bruit, optent, à l'autre extrême, pour des produits informationnels sans biais mais très bruités.

Le deuxième chapitre examine les effets de trois politiques réglementaires sur la réduction des biais médiatiques dans un marché duopolistique de la presse : l'introduction d'd'un média public, la réglementation par contrôle des prix et la fiscalité. Les résultats montrent que l'introduction d'un média public et d'une politique fiscale bien conçue peut être efficace pour réduire les biais médiatiques.

Le troisième chapitre étudie la relation entre l'utilisation des médias en ligne et la polarisation sociale et politique. Les résultats établissent l'existence d'une corrélation positive entre l'utilisation des médias en ligne et le niveau de polarisation (à la fois la polarisation de la société et la polarisation politique) à partir d'un panel de données V-Dem portant sur plus de 200 pays sur la période 2000-2021.

Mots-clés : Biais médiatique, divergence Kullback-Leibler, différenciation horizontale, vérification des faits, réseaux sociaux, contenu généré par les utilisateurs, fiscalité, politique réglementaire, polarisation, données de panel.

Abstract

Media play a vital role in our life as it offers information for citizens to make political and social decisions. The market for news differs from other markets in many different ways. Moreover, the development of mass technologies such as the Internet and social media fosters new challenges relative, notably, to media biases and the polarization of society. This thesis explores the reasons and consequences of media biases from economic and political perspectives.

The first chapter discusses the impacts of competition in the news market on the differentiation of its products – news. We show that most types of noise-averse consumers choose their news providers in the close vicinity of the conventional end of the market and that some "relative" bias-averse individuals choose it at the noisy end.

The second chapter examines the effects of three regulatory policies on reducing media bias in a duopolistic newspaper market: introducing a public interest firm, price-cap regulation, and taxation. The results show that introducing a public-interest firm and a well-designed tax policy can be effective in reducing media bias.

The third chapter studies the relationship between the use of online media and polarization. The results show the existence of a positive correlation between the use of online media and the level of polarization (both the polarization of society and political polarization) using panel data of 198 countries between 2000 and 2021 from the V-Dem data set.

Keywords: News media bias, Kullback-Leibler divergence, horizontal differentiation, fact-checking, social media, user-generated content, taxation, regulatory policy, polarization, panel data.

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Introduction Générale

> Falsehood flies, and truth comes limping after it, so that when men come to be undeceived, it is too late ; the jest is over, and the tale hath had its effect : like a man, who hath thought of a good repartee when the discourse is changed, or the company parted ; or like a physician, who hath found out an infallible medicine, after the patient is dead.
>
> *Jonathan Swift 1710*

0.1 Le marché de l'information.

L'industrie des médias joue un rôle essentiel dans notre vie quotidienne. Le « quatrième pouvoir », en tant que marché des idées, contribue à ce que les différents points de vue de la société soient entendus par un plus grand nombre de citoyens. De plus, en termes de société démocratique, il est souvent reconnu qu'une source d'information plus diversifiée aide les gens à prendre des décisions sociales et politiques, et fait ainsi avancer le processus démocratique (Anderson et al. 2014, Soroka et Wlezien 2022).

De la radiodiffusion aux journaux, puis à l'utilisation généralisée des téléviseurs, et maintenant à l'utilisation généralisée des plateformes de réseaux sociaux et d'internet, l'avancée des nouvelles technologies dans l'industrie des médias a facilité la manière dont nous obtenons des informations et dont nous communiquons avec les autres. Les médias en ligne, y compris les réseaux sociaux et internet, sont différents des médias traditionnels (radio, journaux, télévisions) car les utilisateurs peuvent générer du contenu en ligne et il n'y a pas de politique éditoriale (Peitz et Reisinger 2015). Ces caractéristiques des réseaux sociaux et d'internet, telles que l'accessibilité facile, les interactions directes et rapides avec les gens, et les contenus générés par les utilisateurs comme les commentaires et les recommandations, entre autres, ont fait des réseaux sociaux et d'internet le principal moyen de communication, en particulier chez les jeunes.

Le marché de l'information a des caractéristiques propres. Le produit que le marché des médias offre est l'information, qui joue un rôle très important dans la vie économique, sociale et politique des citoyens. Par conséquent, les défaillances du marché de l'information peuvent être très dommageables. Les cas extrêmes se produisent quand les entreprises de médias ont le pouvoir de manipuler ou influencer les choix des candidatures présidentielles ou d'un gouvernement lors des élections dans les sociétés démocratiques (« Media Power »), ou quand un gouvernement autocratique ou dictatorial a un pouvoir de contrôle sur l'ensemble des médias et la diffusion des informations dans un pays par la censure ou la propagande (« Media Capture ») (Besley et Prat 2006, Prat 2015, Prat 2018).

Comme le marché des autres produits, le marché des médias concerne différents agents économiques : les entreprises médiatiques qui diffusent l'information sur leurs plateformes (les radios, les journaux ou la presse, les télévisions, et les réseaux sociaux ou l'internet), les consommateurs qui recherchent des informations ou des divertissements sur les médias, les annonceurs qui utilisent les plateformes médiatiques pour faire connaître leurs produits ou services commerciaux, les utilisateurs qui donnent les avis et les commentaires sur l'internet, les politiciens qui annoncent leur programmes sur les journaux télévisées pendant les élections... Cependant, le marché des médias possède des caractéristiques propres au sens où l'information vendue sur ce marché possède des attributs distincts de ceux des autres produits ou services (Anderson et Gabszewicz 2006, Ferrando et al. 2008, Bounie et al. 2008, Gabszewicz, Resende et Sonnac 2015). Par exemple, la mesure de la qualité et de la quantité de l'information est très différente de celle des autres produits. Qui plus est, l'impact du marché des médias est susceptible d'être bien plus important que celui de la plupart des autres marchés de services, notamment lorsqu'il influe sur les décisions politiques (Neuner, Soroka et Wlezien 2019). C'est pourquoi une branche importante de l'analyse économique de ce marché relève directement de l'économie politique.

0.2 Biais médiatiques : une défaillance du marché de l'information ?

Un genre des défaillances du marché de l'information est le « biais médiatique », qui se produit lorsque les médias filtrent et biaisent l'information en décidant de la quantité et du type d'information à transmettre aux consommateurs. Un exemple est donné par les "fake news" ou "fausses nouvelles", qui semblent être devenues omniprésentes après la campagne présidentielle de 2016 aux États-Unis et le référendum de 2016 sur l'appartenance du Royaume-Uni à l'Union Européenne (Brexit). Néanmoins, ce terme assez ancien trouve son origine dans un pamphlet de John Milton en 1644 sur la liberté d'expression de la presse. Plus formellement, les "fake news" ne sont qu'une des formes de distorsion de l'information, c'est-à-dire de "biais médiatique" en termes économiques.

Quelles sont les causes du biais médiatique ?

D'une manière générale, les biais des médias proviennent des deux côtés du marché : l'offre et la demande (Sutter 2000, Duggan et Martinelli 2011, Behringer et Filistrucchi 2015, Gentzkow, Shapiro et Stone 2015, Lichter 2017).

Le premier type de biais fait référence à "spin", qui est le parti pris du côté des entreprises de médias. Par exemple, le parti pris politique ou idéologique des journalistes peut impacter le « ton » des reportages ou les parrainages lors des élections (Baron 2006, Puglisi, Snyder et al. 2008, Kaplan et Mazurek 2018) ; il est également prouvé que la propriété du capital a une influence sur le contenu « filtrant » d'un journal (Besley et Prat 2006, Prat et Strömberg 2013, Prat 2015, Prat 2018) ; d'autres agents tels que le personnel politique, les groupes de pression (Sobbrio 2011, Petrova 2012), ou les annonceurs peuvent également jouer un rôle rôle dans la sélection des informations favorisant leurs propres intérêts (Gabszewicz, Laussel et Sonnac 2002, Ellman et Germano 2009, Gabszewicz, Laussel et Sonnac 2012, Castañeda et Martinelli 2018).

Le second type de biais provient du côté de la demande du marché des médias. Les croyances et la psychologie des consommateurs, notamment, affectent leurs comportements et habitudes de consommation. Des études montrent que les gens préfèrent les informations qui confirment leurs croyances et attitudes antérieures ("confirmatory bias", voir Rabin et Schrag 1999, Mullainathan et Shleifer 2005, Xiang et Sarvary 2007, Burke 2008). En outre, les consommateurs ont tendance à rechercher des groupes de personnes qui partagent des opinions identiques ou similaires dans la vie réelle ou sur l'internet (Sunstein 2006, Gentzkow et Shapiro 2010, Gentzkow et Shapiro 2011). De plus, les effets de « bulles de filtre » ou de « chambre d'écho » (Strömberg 2004, Chan et Suen 2008, Napoli 2018) renforcent également le biais confirmatoire et favorisent ainsi in fine la formation de groupes extrêmes (Chan et Suen 2009, Luo 2017), notamment sur les réseaux sociaux. Les deux branches sont étroitement liées et peuvent se renforcer mutuellement. Le biais de confirmation des gens peut être renforcé par les histoires biaisées des médias pour répondre aux préférences de leurs consommateurs.

Preuve empirique des biais des médias : définition, catégories et mesure. Les biais médiatiques font l'objet de multiples définitions et tentatives de mesures. On en mentionne brièvement quelques-unes ci-dessous, parmi les plus influentes.

Prat et Strömberg 2013 distingue la déformation de l'information du filtrage de l'information : la première comprend le biais factuels et le biais de cadrage. Le biais factuel fait référence au choix par les médias du contenu des informations à rapporter et à la manière dont elles sont rapportées. Le biais de cadrage fait référence au biais d'opinion explicite ou implicite impliqué par les modalités de présentation de l'information par les médias.

Certains, très influencés par la théorie de l'information, désignent également le parti pris médiatique sous l'expression anglo-américaine de "slant médiatique" ou "slanting", caractérisé soit comme l'omission d'informations, soit comme la sélection d'informations, orienté par un biais d'opinion partagé par le média et son audience (Groseclose et Milyo 2005, Mullainathan et Shleifer 2005). Gentzkow, Shapiro et Sinkinson 2014, dans la même veine, classe le biais médiatique en deux catégories : i) la distorsion pure et simple, ou le biais de distorsion tel que l'omission d'informations ; ii) le filtrage des informations ou le biais de sélection (voir également Strömberg 2004, Chan et Suen 2008, Duggan et Martinelli 2011).

D'autres classifications du parti pris médiatique comprennent le parti pris structurel comme l'abandon de l'objectivité ou de la réalité (voire Lichter 2017 pour une revue de littérature), le parti pris commercial, le parti pris temporel, le parti pris visuel (pour la télévision), le parti pris des mauvaises nouvelles, le parti pris narratif, le parti pris du statu quo, le parti pris de l'équité, le parti pris de l'opportunité, le parti pris de la classe et le parti pris de la gloire (tendance à glorifier le journaliste), le parti pris de la confirmation...

Pour mesurer le pluralisme de l'information, les études empiriques utilisent les indices quantitatifs du marché de l'information, par exemple, le nombre d'articles publiés par un journal, la taille d'une entreprise médiatique (le nombre de journalistes, les revenus d'une entreprise médiatique...), l'entrée ou la sortie des entreprises médiatiques sur le marché (Berry et Waldfogel 2001, Besley et Prat 2006, Germano et Meier 2013, Cagé 2020...). En plus, pour mesurer l'exactitude de l'information, il existe des méthodes plus indirectes qui dépendent du sujet spécifique traité dans les journaux. Par exemple, la méthode de comparaison entre les bulletins d'information d'un média et les discours politiques pour mesurer le biais idéologique (Groseclose et Milyo 2005, Gentzkow et Shapiro 2010, Gans et Leigh 2012) ; la mesure de l'intensité de la couverture médiatique sur certains sujets pour identifier les positions politiques des médias (Strömberg 2004, Puglisi et Snyder Jr 2015, Galvis, Snyder Jr et Song 2016) ; la mesure du ”ton” de la couverture médiatique, c’est-à-dire favorable ou défavorable à un parti politique ou à un homme politique (Barrett et Barrington 2005, Lott Jr et Hassett 2014, Soroka et McAdams 2015) ; l’alternance des positions idéologiques avant et après le changement de propriétaire d’un média (Dunaway 2013, Wagner et Collins 2014, Archer et Clinton 2018).

La plupart des travaux empiriques se concentrent sur les préjugés idéologiques ou les préjugés partisans, y compris les préjugés de distorsion, par exemple, l’omission de faits ou le cadrage d’informations dans les reportages, et les préjugés de filtrage, par lesquels les médias accordent des poids différents aux questions politiques en fonction de la préférences idéologiques des rédacteurs ou des journalistes (Baron 2006, Prat et Strömberg 2013, Gentzkow, Shapiro et Stone 2015...). La mesure des biais dans les médias est un travail difficile pour les recherches empiriques car elle nécessite souvent une analyse quantitative ou qualitative des reportages par machine-codage ou codage humain. Pour mesurer les biais idéologiques ou partisans éditoriaux, les chercheurs utilisent souvent les propositions d’approbation ou de vote des médias (Ansolabehere, Snowberg et Snyder Jr 2006, Ho, Quinn et al. 2008, Butler et Schofield 2010, Puglisi et Snyder Jr 2015, Durante, Pinotti et Tesei 2019...), ou comparent les discours politiques avec les compte- rendus qu’en font les médias (Groseclose et Milyo 2005, Gentzkow et Shapiro 2010), ou mesurent l’intensité ou l’importance de telle ou telle question dans la couverture médiatique selon la « théorie de l’agenda-setting » (McCombs et Shaw 1972, McCombs 2002, Van Aelst et Walgrave 2016, McCombs et Shaw 2017, Vargo, Guo et Amazeen 2018). Ces résultats empiriques ont montré que les médias ont leurs préférences idéologiques et favorisent leurs candidats politiques préférés lors des élections, en particulier aux États-Unis (Puglisi, Snyder et al. 2008, Gentzkow et Shapiro 2010).

0.3 L'impact social et politique des biais médiatiques

Une littérature empirique abondante et croissante s'attache ainsi à développer l'évaluation quantitative des partis pris des médias, afin de mieux estimer leurs causes et leurs conséquences sur les comportements électoraux et les votes des citoyens. Le principal de la littérature sur les effets politiques des partis pris des médias se concentre sur les élections et les votes. Nous nous concentrons ici uniquement sur les études empiriques concernant les effets des parti pris médiatiques sur le comportement électoral (DellaVigna et Gentzkow 2010). Plusieurs études étudient les effets des journaux sur les résultats des votes et établissent leur influence significative lors des élections aux États-Unis ou au Royaume-Uni (Kahn et Kenney 2002, Ladd et Lenz 2009, Chiang et Knight 2011).

Une branche importante de cette littérature concerne la capture des médias, qui se rapporte à la capacité des médias à influencer leurs lecteurs et téléspectateurs par le biais de la définition de l'agenda, et des effets d'amorçage et de cadrage (DellaVigna et Kaplan 2007, Gentzkow, Shapiro et Stone 2015, Prat 2015, Strömberg 2015, Zhuravskaya, Petrova et Enikolopov 2020). Le personnel politique, les partis politiques et les groupes d'intérêt, y compris les propriétaires de médias, les annonceurs, les journalistes, les politiciens ou les entreprises privées, sont incités rationnellement à exercer une influence sur la couverture médiatique (Puglisi, Snyder et al. 2008, Oberholzer-Gee et Waldfogel 2009, Durante et Knight 2012, Drago, Nannicini et Sobbrio 2014). Gentzkow et Shapiro 2006 fournisse des preuves que les journaux copartisans étaient moins susceptibles de publier des articles sur les scandales politiques par analyse de contenu dans les années 1870 et 1920 aux États-Unis. Il existe également des preuves d'une couverture médiatique partisane de la corruption politique en Argentine entre 1998 et 2007 (Tella et Franceschelli 2011), au Mexique en 2001 (Stanig 2015), en Chine (King, Pan et Roberts 2013, Qin, Wu et Strömberg 2014, Qin, Strömberg et Wu 2017), en Russie (Dyck, Volchkova et Zingales 2008, Enikolopov, Petrova et Zhuravskaya 2011, Enikolopov, Petrova et Sonin 2018, Enikolopov, Makarin et Petrova 2020). D'autres études prouvent que la couverture médiatique est biaisée en faveur des annonceurs (Reuter et Zitzewitz 2006, Park et Reuter-Lorenz 2009, Alston, Libecap et Mueller 2010, Gambaro et Puglisi 2015, Shapiro 2016). Pire encore, la couverture biaisée due à la capture médiatique peut favoriser la violence, les conflits ethniques, la polarisation (Bernhardt, Krasa et Polborn 2008, DellaVigna et al. 2014, Yanagizawa-Drott 2014, Adena et al. 2015, Martin et Yurukoglu 2017).

Avec l'essor des réseaux sociaux et d'internet, un nombre croissant de chercheurs se tourn vers l'étude de l'influence des médias sociaux sur le vote, en particulier depuis les élections américaines de 2006 et le Brexit. Il va sans dire que les réseaux sociaux ont facilité les activités politiques telles que les missions en ligne ou les mouvements sociaux en ligne et hors ligne, en particulier dans la coordination des manifestations sociales et politiques dans les pays autocratiques (voir, par exemple, Diamond, Plattner et Costopoulos 2010, Jaskold Gabszewicz et Sonnac 2010, Ghonim 2012, Alaimo 2015, Sonnac 2023).

De nombreuses études établissent des preuves solides à l'appui d'une version nuancée de l'argument de la technologie de libération des réseaux sociaux et d'internet (Amorim, Costa Lima et Sampaio 2018, Larson et al. 2019). Qin, Strömberg et Wu 2017 trouve que la plateforme Sina Weibo véhicule de nombreuses informations sur les manifestations et les grèves en dépit de la censure en Chine. Acemoglu, Hassan et Tahoun 2018 montre que les messages sur Twitter étaient un bon prédicteur des manifestations sur la place Tahrir pendant le printemps arabe en Égypte. Steinert-Threlkeld et al. 2015 établit l'influence significative des tweets et de la diffusion de données sur les manifestations sur l'ampleur des manifestations dans 16 pays pendant le printemps arabe. Enikolopov, Makarin et Petrova 2020 montre qu'une augmentation de 10% de la pénétration de VK (la plate-forme de réseaux sociaux russe dominante) a augmenté la probabilité d'une manifestation de 4,6% et le nombre de manifestants de 19% en Russie en décembre 2011. Fergusson et Molina 2019 montre que Facebook a eu un impact positif, significatif et considérable sur les manifestations. Manacorda et Tesei 2020 soutient que les téléphones portables sont en effet essentiels à la mobilisation politique en période de ralentissement économique lorsque des motifs de grief émergent ou que le coût d'opportunité de la participation aux manifestations diminue.

D'autre part, les réseaux sociaux sont blâmés, dans les démocraties, pour la montée du populisme, la propagation des idées xénophobes et la prolifération des fausses nouvelles (Tufekci 2018, Mitchell et al. 2019, Lewandowsky et Pomerantsev 2022). Les fausses histoires sont plus populaires que les histoires vraies sur les réseaux sociaux, en particulier chez les partisans de droite (Vosoughi, Roy et Aral 2018, Barrera et al. 2020). Mocanu et al. 2015 documente la diffusion rapide de fausses nouvelles sur les réseaux sociaux lors des élections de 2012 en Italie. Allcott et Gentzkow 2017 signale la diffusion de fausses histoires sur Facebook lors de la campagne électorale américaine de 2016. Guess, Nagler et Tucker 2019 montre que Facebook était davantage susceptible d'être visité juste avant un site Web de fausses informations qu'avant un site Web d'informations vérifiées lors de l'élection présidentielle américaine de 2016. Bursztyn et al. 2019 démontre, en utilisant des données d'enquête nationales russes des années 2011 et 2012, qu'une plus grande pénétration est corrélée à une augmentation des crimes de haine éthnique dans les villes où le sentiment nationaliste est déjà élevé. Müller et Schwarz 2021 montre que le sentiment anti-réfugié sur Facebook un jour particulier est associé à une incidence plus élevée de crimes violents contre les réfugiés dans les endroits à forte utilisation des réseaux sociaux en Allemagne de 2015 à 2017. Müller et Schwarz 2020 montre que les tweets de Trump sur des sujets liés à l'islam étaient fortement corrélés aux crimes de haine antimusulmans après le début de sa campagne présidentielle.

On pense qu'internet et les réseaux sociaux contribuent à renforcer les biais de confirmation (Sunstein 2001, Sunstein 2018). Bakshy, Messing et Adamic 2015 montre, en utilisant les données de plus de 10 millions d'utilisateurs de Facebook, que ceux-ci rencontrent davantage de contenus politiques alignés sur leurs propres opinions que de contenus politiques opposés à ces dernières. Halberstam et Knight 2016 trouve également des preuves d'une tendance des utilisateurs de Tweeter à nouer des liens avec des personnes dont les opinions politiques sont proches des leurs lors des élections américaines de 2012. Conover et al. 2011 démontre que les retweets politiques sont fortement clivés selon des opinions partisanes, avec des connexions extrêmement faibles entre les utilisateurs de gauche et de droite. Lelkes, Sood et Iyengar 2017 montre qu'internet accroît l'hostilité partisane et la ségrégation dans la consommation des médias partisans aux États-Unis. Yanagizawa-Drott, Petrova et Enikolopov 2019 démontre que les régions des Etats-Unis dont les connexions Facebook manifestent un plus grande homophilie politique affichent également une plus grande homogénéité dans le vote.

L'effet de chambre d'écho et l'effet de bulle de filtres (ou bulle de filtrage) [1], conjugué à la prolifération des fausses nouvelles et des contenus extrêmes, sont susceptibles de contribuer à renforcer la polarisation de la vie politique. Lee, Shin et Hong 2018 a constaté que les réseaux sociaux contribuaient indirectement à la polarisation en favorisant un engagement politique accru. On a cité plus haut, dans le même sens, d'autres recherches, qui tendent à montrer que les utilisateurs de plateformes telles que Facebook et Twitter préfèrent consulter les opinions semblables aux opinions opposées aux leurs, ce qui induit des biais partisans et de ségrégation en ligne et peut conduire à un plus grand soutien aux partis extrêmes (Melki et Pickering 2014, Bakshy, Messing et Adamic 2015, Halberstam et Knight 2016, Duca et Saving 2017, Lelkes, Sood et Iyengar 2017, Sunstein 2018, Mitchell et al. 2019, Yanagizawa-Drott, Petrova et Enikolopov 2019). Barberá 2014 montre toutefois, en sens contraire, que les réseaux sociaux contribuent à exposer davantage leurs utilisateurs à leurs "liens faibles" et que cela a pour effet de diminuer la polarisation politique de masse en Allemagne, en Espagne et aux Etats-Unis. Dans le même sens, Boxell, Gentzkow et Shapiro 2017 prouve que la polarisation politique a augmenté chez les personnes âgées aux États-Unis, qui utilisent peu les médias sociaux.

Malgré les efforts accomplis sur ce terrain de l'analyse théorique et emprique, il reste de nombreuses questions de recherche à explorer : comment caractériser l'information médiatique ? Par exemple, la qualité de l'information se résume-t-elle à sa diversité ? Ou bien consiste-t-elle

1. Les deux termes sont utilisés indifféremment dans le livre de Pariser 2011. Cependant, il existe une légère différence entre eux. Une « chambre d'écho » est un phénomène où chaque consommateur n'entend que l'ensemble précis de reportages qui confirmeront ses croyances antérieures, et l'apprentissage cesse complètement (Sunstein 2006) tandis qu'une bulle de filtre est une chambre d'écho principalement produite par des algorithmes de classement engagés dans la personnalisation passive sans aucun choix actif de la part des consommateurs (Ross Arguedas et al. 2022).

plutôt en son originalité, ou encore son objectivité ? Comment mesurer la qualité de l'information ou bien les biais médiatiques ? Est-ce que la concurrence dans un marché de l'information est toujours bonne (au sens du bien-être social) ? Quels sont les facteurs qui influent sur la qualité de l'information ? Quelles sont les raisons de la propagation des "fake news" ? Les consommateurs ont-ils la capacité de distinguer les informations vraies et les informations fausses, notamment pendant les élections ? Pourquoi certains agents consomment-ils ou diffusent-ils les informations fausses, et quels sont les mécanismes (économiques, psychologiques, sociologiques…) derrière cela ? Est-ce que les caractéristiques personnelles (l'âge, la sexe, le niveau d'éducation, le métier…) ont un impact sur les habitudes de consommation des (fausses) informations ? La règlementation des réseaux sociaux est-elle compatible avec la liberté d'expression ? Comment réguler les réseaux sociaux ? … Les trois chapitres de la thèse proposent des éléments de réponse à certaines des questions ci-dessus.

0.4 Chapitre 1 : Différenciation des produits sur les marchés de l'information concurrentiels

Authors : Jean MERCIER-YTHIER(l'auteur principal), HU Jun.

Question de recherche : Les déterminants de demande de la différentiation de produits sur le marché des médias d'information : rôles respectifs de l'aversion pour les biais d'information et de l'aversion pour le bruit informationnel.

Travaux précédents sur l'analyse théorique des concurrences sur le marché des médias d'information. Les analyses microéconomiques des biais informationnels des médias (leurs "partis pris") se développent en deux courants principaux. Une première branche de la littérature s'intéresse à la "différenciation de la production" sur le marché des médias, c'est-à-dire au pluralisme ou à la diversité de l'information. Cette branche de la littérature se concentre sur la question de savoir si la concurrence entre les entreprises médiatiques augmentera ou réduira la diversité des sources d'information ou la variété de l'information. Le "pluralisme" ou la "diversité" de l'information est l'un des critères les plus importants pour mesurer la qualité des produits d'information (politique ou commerciale) sur le marché des médias. Par exemple, les médias sont les principales sources à partir desquelles le public peut obtenir des informations utiles pour ses décisions de vote dans une démocratie. Les contrôles gouvernementaux des entreprises médiatiques, à travers la propriété du capital, la censure ou la propagande, sont destructeurs de la liberté d'expression et donc nuisibles à la démocratie. Le "pluralisme" de l'information sur le marché des médias d'information correspond à une forme de différentiation de produits sur ce marché. La plupart des travaux empiriques utilisent des indicateurs tels que le nombre d'entreprises médiatiques, le nombre d'employés, la sortie ou la nouvelle entrée d'entreprises médiatiques, le contenu (par exemple, le nombre d'articles publiés par un journal) pour mesurer les facteurs qui influencent le "pluralisme" ou la qualité de l'information sur le marché des médias.

Cependant, des questions se posent, par-delà celle de la diversité apparente des médias d'information, quant à la "réalité" de cette diversité, et notamment : si, ou dans quelle mesure, la diversité observable correspond à une variété de sources d'information effectivement indépendantes ; et également sous quelles conditions ces informations diverses peuvent converger vers une information vraie, ou simplement exacte. C'est pourquoi une autre branche de la littérature apparaît, visant la "qualité des produits" sur le marché des médias, c'est-à-dire le parti pris ou la "tendance" des médias. Elle se concentre sur l'exactitude et la clarté de l'information, et notamment sur le fait de savoir si les médias rapportent le véritable état du monde et pourquoi. Plus généralement, dans un marché biface composé d'entreprises de médias et de consommateurs, comme sur les autres marchés, de nombreux facteurs peuvent déterminer l'ampleur du parti pris des médias, que ce soit du côté de l'offre ou de la demande.

Ces questions ont donné lieu à la production d'une littérature très abondante, qu'il ne saurait être question de résumer ici. Le chapitre 1 de la thèse esquisse quelques-unes de ses lignes directrices. Des revues de littérature très développées peuvent être trouvées notamment : pour les aspects empiriques, et en particulier pour la mesure de l'exactitude (« accuracy ») du compte-rendu de l'information par les médias, dans le récent ouvrage de Soroka et Wlezien 2022, *«Information and Democracy»* ; pour les aspects théoriques, dans les synthèses de Gentzkow et Shapiro 2008, Gentzkow, Shapiro et Stone 2015. On se contentera ici, à titre d'illustration, de résumer brièvement deux articles qui ont largement contribué à susciter l'intérêt pour une explication théorique de la différentiation des produits d'information s'appuyant sur des variantes du modèle de différentiation de produits de Hotelling 1929.

Gabszewicz, Laussel et Sonnac 2002 présente, à notre connaissance, l'une des toutes premières applications du modèle de Hotelling à l'analyse de la différentiation de produits sur le marché des médias. Dans ce modèle, deux chaînes de télévision, entreprises privées maximisatrices du profit, produisent chacune un programme. Leurs chiffres d'affaires correspondent à leurs recettes publicitaires, proportionnelles à leurs audiences respectives. Les programmes diffusés par les chaînes sont composés de 2 attributs (ou « caractéristiques », au sens de Lancaster) : divertissement et culture. Les auteurs montrent qu'à l'équilibre de Hotelling d'un marché libre sans intervention gouvernementale, les deux chaînes optent pour la différentiation de produit maximale : une chaîne se spécialise dans le "divertissement", l'autre dans la diffusion de programmes culturels. De plus, dans ce cas de figure, le temps de diffusion consacré à la publicité ne dépasse pas la moitié du temps de diffusion total de chaque chaîne. Les auteurs montrent également que l'introduction d'une règlementation limitant le temps de diffusion publicitaire à moins de la moitié du temps de diffusion total a pour effet de réduire la différentiation des programmes. Par exemple, dans le cas extrême où la publicité est interdite, correspondant à une situation de nationalisation de fait des médias télévisuels, la différentiation de produit disparaît tout à fait, et les deux chaînes diffusent alors un programme identique composé pour moitié d'émissions de divertissement et pour moitié d'émissions culturelles. L'analyse conduite en termes de bien-être social montre une supériorité de l'équilibre du « laisser faire » sur l'équilibre réglementé, car, dans le cas du « laisser faire », chaque téléspectateur peut satisfaire au mieux ses préférences en répartissant de façon adéquate son temps de visionnage sur les deux chaînes ; ce qui n'est plus le cas lorsque la publicité est réglementée, certaines combinaisons de divertissement et de culture cessant alors d'être accessibles, alors qu'elles seraient préférées par certains téléspectateurs.

Mullainathan et Shleifer 2002, en second lieu, propose également une application précoce du modèle de Hotelling à l'analyse de la différentiation de produits sur le marché des médias. Leur modèle se distingue du précédent par l'objet de la différentiation, en l'espèce, une différentiation en termes d'exactitude (« accuracy ») des comptes rendus factuels (« reporting ») effectués par les médias. Les auteurs supposent que les préférences politiques des consommateurs d'information les portent à choisir les comptes rendus factuels biaisés dans le sens de leurs opinions. Ils montrent que les deux entreprises de presse, maximisatrices du profit, optent à l'équilibre pour des stratégies de différentiation maximale, se traduisant par des comptes rendus factuels aussi biaisés que possible (par exemple, un compte rendu très « à gauche », l'autre très « à droite »). L'équilibre est, néanmoins, compatible avec une information sans biais des lecteurs qui la souhaitent, sous réserve que ceux-ci soient capables, comme dans le modèle précédent, de combiner de façon appropriée les deux produits (les deux sources d'information, individuellement très biaisées) disponibles à l'équilibre du marché.

Résumé du travail. Dans le premier chapitre, nous considérons la différenciation de produit sur les marchés concurrentiels de l'information, telle que déterminée par les caractéristiques de la demande confrontée à des non-convexités informationnelles fondamentales dans les activités de compte rendu factuel (« reporting ») des médias d'information. Les médias d'information, qui maximisent leurs profits, rapportent imparfaitement les informations qu'ils tirent d'un flux de données source normalement distribué.

Une mesure naturelle de la perte d'information due aux médias est la divergence de Kullback-Leibler entre les distributions normales des informations retranscrites par les médias et des données brutes. Nous montrons que les distorsions d'information s'analysent en deux composantes : (i) le biais, défini comme la différence entre les moyennes des distributions de probabilité des informations retranscrites par les médias et des données brutes ; et (ii) le bruit, défini comme la différence entre les écarts types de ces distributions. Nous montrons que les consommateurs maximisant leur utilité espérée avec des fonctions d'utilité de Bernoulli concaves ont de l'aversion pour le bruit. L'aversion pour les distorsions conjugue à la fois l'aversion pour les biais et l'aversion pour le bruit.

Nous montrons que les produits d'information fournis à l'équilibre concurrentiel sont identiques en termes d'exactitude (« accuracy »), mesurée par leur divergence de Kullback-Leibler par rapport aux données brutes. Ces produits forment une courbe dans le plan espérance-variance. Cette courbe est constituée de produits différenciés horizontalement, allant des produits d'information "conventionnels", caractérisés par des biais importants et des niveaux de bruit réduits à un minimum incompressible, aux produits d'information "bruyants", qui ramènent le biais à zéro au prix d'un niveau de bruit maximal. La frontière confronte les consommateurs qui ont de l'aversion pour les distorsions à une non-convexité fondamentale. La non-convexité entraîne une différenciation maximale des produits, les extrêmes "conventionnels" et "bruyants" étant les seuls produits d'information effectivement demandés à l'équilibre dans certaines configurations naturelles de ces derniers.

Nous montrons en outre que les consommateurs qui ont de l'aversion pour le bruit choisissent pour la plupart leurs fournisseurs de nouvelles à proximité immédiate de l'extrémité conventionnelle du marché. Le modèle fournit ainsi une justification et une explication partielle de la distinction courante entre médias d'information traditionnels et médias d'information alternatifs.

0.5 Chapitre 2 : Règlementation des médias en ligne pour lutter contre les biais médiatiques.

Author : HU Jun.

Question de recherche : Le gouvernement doit-il réglementer le contenu en ligne des médias et comment le faire ?

La désinformation, les fausses nouvelles ou la diffusion de fausses informations, qui constituent un type de biais médiatique, sont devenues une grande préoccupation dans de nombreux pays (Behringer et Filistrucchi 2015, Gentzkow, Shapiro et Stone 2015, Lichter 2017). La croissance des plateformes de réseaux sociaux a amplifié la diffusion de fausses informations (Prat et Strömberg 2013, Allcott et Gentzkow 2017, Perego et Yuksel 2018, Allcott et al. 2020). Environ 64% des Américains pensent que les réseaux sociaux sont nuisibles en raison de la désinformation, des nouvelles inventées, des discours de haine et de l'extrémisme (Auxier 2020)). Nous pouvons constater les conséquences catastrophiques de l'augmentation de la discrimination, des discours de haine et des théories du complot sur les médias en ligne.

Une brève revue de littérature sur la réglementation des médias en ligne. Les actions actuelles de régulation économique des médias en ligne se concentrent sur deux types de politiques. Le premier type de politique se rapporte au droit de la concurrence, et notamment les lois antitrust et la règlementation des fusions, telles que, par exemple, dans le droit américain, le Digital Service Act (DSA) et le Digital Market Act (DSA) (Schnitzer et al. 2021), qui visent explicitement à empêcher les abus de position dominante dans l'industrie des médias (voir, par exemple, les récentes propositions de Schnitzer et al. 2021, Crémer, Montjoye et Schweitzer 2019). Cependant, la capacité régulatrice du droit de la concurrence est limitée lorsque les biais proviennent des consommateurs (Gentzkow et Shapiro 2006, Gentzkow et Shapiro 2008, Becker et al. 2009, Germano et Meier 2013, Behringer et Filistrucchi 2015). Un deuxième type de politique porte donc sur la législation tendant à modérer le contenu en ligne, jugée nécessaire pour restreindre la diffusion de fausses informations ou de discours dangereux en ligne tels que les contenus racistes, cyberintimidateurs, obscènes ou terroristes (Lo et Wei 2002, Stutzman et Hartzog 2012, Niklewicz 2017, Wardle et Derakhshan 2017, Yablon 2020). Toutefois, certains affirment que la réglementation des contenus en ligne viole les droits fondamentaux de la liberté d'expression (Sander 2019, Svantesson 2019, Barrett 2020). En outre, la réglementation du contenu en ligne est susceptible de créer des barrières à l'entrée pour les médias et d'entraver ainsi la concurrence sur le marché des médias de manière contre-productive (Evans et Schmalensee 2017, Langvardt 2017).

La régulation d'un marché par une entreprise publique et une tarification publique est fréquemment utilisée pour corriger les défaillances du marché lorsque celui-ci se rapporte à des biens ou services mixtes au sens où ils combinent certaines caractéristiques de biens privés avec des caractéristiques (externalités) de biens publics. C'est le cas par exemple des marchés de la santé et de l'éducation (Cremer, Marchand et Thisse 1989, Cremer, Marchand et Thisse 1991, Chang, Wu et Lin 2018, Futagami, Matsumura et Takao 2019, Hehenkamp et Kaarbøe 2020...). On peut étendre aux marchés de l'information et de la communication certaines de ces politiques publiques de correction des échecs du marché pour ce type de biens, par exemple en utilisant la fiscalité et les subventions pour accroître la diversité et le pluralisme des médias. On montre toutefois que les effets des politiques de taxation et de subvention sur la consommation des médias et le bien-être social sont ambigus (Kind, Koethenbuerger et Schjelderup 2008, Kind et Møen 2015, Kind et Koethenbuerger 2018, Bourreau, Caillaud et De Nijs 2018, Bacache et al. 2015...). Peu de travaux ont, à ce jour, examiné les effets de ces réglementations sur la réduction des biais médiatiques sur le marché de l'information, en particulier dans les médias d'information en ligne. L'étude la plus pertinente à ce sujet est, à notre connaissance, le modèle de Guo et Lai 2015, qui diffère du modèle présenté en chapitre 2 de la présente thèse notamment sur les deux points suivants : les auteurs supposent que l'entreprise publique maximise son profit, et ils se concentrent exclusivement sur le marché des journaux traditionnels. Le modèle présenté en chapitre 2 considère un marché de médias d'information combinant presse traditionnelle et publication de contenus en ligne générés par le lectorat (”user generated contents”). Il étudie la régulation de ce marché à partir de deux types d’instruments : la politique de tarification d’un média public d’information maximisateur du bien-être social ; et une politique de fiscalité optimale.

Résumé du travail. La régulation des externalités générées par les médias d’information est une préoccupation partagée par de nombreux pays. Dans le chapitre, nous examinons les effets de trois politiques publiques sur la réduction des biais informationnels dans un marché de l’information duopolistique : l’introduction d’une entreprise de presse d’intérêt public, la tarification publique et la taxation. Les résultats montrent que les effets de ces trois politiques de régulation sont différents. Tout d’abord, nous examinons les effets de l’introduction, sur le marché de duopole, d’un journal d’intérêt public sans biais dont l’objectif est de maximiser le bien-être social. On montre que l’introduction de ce média public peut avoir pour effet de réduire le biais sous certaines conditions, et notamment lorsqu’il y a une diversité suffisante d’opinions parmi les lecteurs. On montre, en second lieu, qu’une politique tarifaire optimale du média public exerce deux effets en sens contraire sur les biais informationnels : elle réduit l’écart (biais de parti pris) entre les contenus de presse traditionnels des deux médias privés ; mais elle augmente l’écart (polarisation) entre les contenus générés en ligne par leurs lectorats respectifs. On montre, en troisième lieu, qu’une politique fiscale bien conçue est plus efficace que la tarification publique pour réduire les biais informationnels des médias privés. Le niveau moyen de polarisation ainsi obtenu est, notamment, plus faible que celui qu’on obtient dans le cadre de la politique tarifaire. Ces résultats contribuent à éclairer la mise en œuvre des politiques de régulation des médias numériques. Les décideurs politiques ne doivent pas se limiter à considérer les effets des politiques de régulation sur les prix et la consommation, mais doivent aussi prendre en compte leurs effets sur la qualité de l’information. Lorsque les biais informationnels proviennent à la fois du côté de l’offre et du côté de la demande, les politiques de régulation par introduction d’un média public, politique tarifaire ou politique fiscale ont des effets bien distincts, qui doivent être pris en compte.

0.6 Chapitre 3 : Les réseaux sociaux et la polarisation de la société.

Author : HU Jun.

Question de recherche : L'utilisation des réseaux sociaux rend-elle notre société plus polarisée ?

La polarisation politique est définie comme le regroupement de personnes dans deux positions extrêmes. Si les idéologies extrêmes proviennent des partis et de leurs candidats, on parle de polarisation élitaire, et si elles proviennent du public, des citoyens ou des électeurs, on parle de polarisation de masse (Fiorina, Abrams et al. 2008, Singer et al. 2019). Les chercheurs distinguent également la polarisation affective (ou idéologique) de la polarisation sociale : la première évalue dans quelle mesure l'idéologie et l'identité d'une personne sont associées à son parti politique préféré, la seconde mesure les divisions des attitudes du public à l'égard de certaines questions sociales, culturelles ou politiques importantes, telles que la protection sociale, l'avortement ou l'immigration (Iyengar et al. 2019, Boxell, Gentzkow et Shapiro 2020, Draca et Schwarz 2021). Selon le Pew Research Center, on observe une tendance croissante à la polarisation des élites dans le système de partis américain : les démocrates deviennent plus libéraux et les républicains plus conservateurs. Les idéologies au sein des partis sont de plus en plus homogènes, et les différences idéologiques entre deux partis sont de plus en plus marquées. Il y a deux conséquences possibles à la polarisation des élites ou des partis : soit les citoyens sont de plus en plus déçus par les partis politiques extrêmes, comme l'exprime le slogan du mouvement des étudiants à Paris l'année dernière : "Ni Le Pen, ni Macron"; soit le public suit les élites de son parti préféré et devient davantage partisan sur le plan idéologique, par exemple en éprouvant davantage d'aversion ou de méfiance envers les membres du parti politique adverse. C'est le cas aux États-Unis. Par exemple, Boxell, Gentzkow et Shapiro 2020 ont montré dans leur article que la polarisation idéologique et la polarisation sociale augmentent toutes deux en

Amérique. Nous pouvons également observer des cas de polarisation dans d'autres pays, comme le Royaume-Uni lors du Brexit, ou l'Italie lors des dernières élections législatives.

Quelques travaux récents analysant l'impact du développement des réseaux sociaux sur la polarisation. Les réseaux sociaux devenant une source d'information de plus en plus importante dans de nombreux pays, de nombreux chercheurs tentent d'établir un lien entre la montée de la polarisation et l'utilisation des médias sociaux. Un rapport du Pew Research Center a révélé que de nombreux citoyens de pays européens (50 % en Italie, 46 % au Danemark, 44 % en Suède...) s'informent fréquemment par le biais des réseaux sociaux et que beaucoup d'entre eux ne vérifient pas les sources de leurs informations. Dans des pays comme l'Italie, la France et l'Espagne, les personnes aux opinions populistes ont tendance à utiliser davantage les réseaux sociaux pour s'informer (Simmons et al. 2018).

Les réseaux sociaux sont-ils un moteur de la polarisation ? Les preuves empiriques existantes concernant les effets des réseaux sociaux et d'internet sur la polarisation sont mitigées. Des études ont montré qu'internet et les réseaux sociaux mettent les utilisateurs en contact avec des opinions plus diverses, et que cela tend à diminuer la polarisation. Par exemple, Barbera 2014 a montré que les réseaux sociaux contribuent à exposer davantage les utilisateurs à leurs "liens faibles", diminuant ainsi la polarisation politique de masse en Allemagne, en Espagne et aux États-Unis. En sens inverse, Boxell, Gentzkow et Shapiro 2017 montre que la polarisation politique a augmenté parmi les électeurs plus âgés aux Etats-Unis, alors que ceux-ci utilisent moins internet et les médias sociaux que les plus jeunes. D'autres recherches se concentrent sur les effets de "chambre d'écho", de "filtre à bulles" ou d'"homophilie" des réseaux sociaux et d'internet. Elles montrent que les utilisateurs de plateformes telles que Facebook et Twitter préfèrent les opinions similaires aux opinions opposées, ce qui induit un biais partisan et une ségrégation en ligne et conduit ainsi à un soutien accru aux partis extrêmes (Melki et Pickering 2014, Bakshy, Messing et Adamic 2015, Halberstam et Knight 2016, Duca et Saving 2017, Lelkes, Sood et Iyengar 2017, Sunstein 2018, Yanagizawa-Drott, Petrova et Enikolopov 2019, Mitchell et al. 2019).

Résumé du travail. Les réseaux sociaux (et internet) rendent-ils la société plus polarisée ? Cet article contribue à la littérature existante en examinant les effets des réseaux sociaux et d'internet sur la polarisation politique et la polarisation sociale à travers le monde au cours des vingt dernières années en utilisant les données de panel de plus de 200 pays de l'ensemble de données de VDem. Il examine la relation entre l'utilisation des réseaux sociaux (et d'internet) et la polarisation de la société (tant du côté des partis que des citoyens). En utilisant des données de panel provenant de 198 pays entre 2000 et 2021 pour explorer les facteurs qui rendent la société plus polarisée, cet article confirme que l'utilisation des réseaux sociaux (et d'internet) rend notre société plus polarisée. Cependant, l'impact des réseaux sociaux (et d'internet) sur la polarisation de la société (polarisation de masse) est beaucoup plus important que sur la polarisation politique (polarisation des partis).

En outre, les résultats révèlent également d'autres facteurs économiques et sociaux qui peuvent avoir une influence sur la polarisation de la société, tels que l'inégalité des revenus, les dépenses publiques, la mondialisation, la démocratie, la fragmentation ethnique... Les résultats empiriques montrent des effets asymétriques de ces facteurs, ce qui est conforme à la littérature existante. Par exemple, cet article montre que les dépenses gouvernementales ont pour effet de diminuer la polarisation de la société uniquement dans les pays démocratiques, mais pas dans les pays non démocratiques, tandis que la mondialisation augmente la polarisation de la société uniquement dans les pays à faible revenu, et que les conflits augmentent la polarisation uniquement dans les pays européens.

Chapitre 1

Informational non-convexities and demand-driven product differentiation in competitive news markets

From the personalistic point of view, statistics proper can perhaps be defined as the art of dealing with vagueness and interpersonal difference in decision situations.
Leonard Savage, *The Foundations of Statistics*, Chapter 8 (Savage 1954)

Abstract. We consider product differentiation on competitive news markets, as determined by the characteristics of demand confronting basic informational non-convexities in the activities of news reporting. Profit-maximizing news media imperfectly report the information they draw from some normally distributed flow of source data. A natural measure of information loss due to the media is the Kullback-Leibler divergence between the normal distributions of news and raw data. We show that reporting distortions depend on : (i) *bias*, defined as the difference between the means of the probability distributions of news and raw data ; and (ii) *noise*, defined as the difference between the standard deviations of these distributions. We show that expected utility maximizing consumers with concave Bernoulli utility functions are noise-averse. Distortion-averse consumers are both bias- and noise-averse. We show that the news products supplied at equilibrium are identical in terms of accuracy, as measured by their Kullback-Leibler divergence to raw data. These products make a one-dimensional locus in the mean-standard deviation space. This locus consists of horizontally differentiated products, ranging from "conventional" news products, characterized by large biases and by noise levels reduced to some incompressible minimum, to "noisy" news products, which set bias to zero at the expense of some maximum noise level. The frontier confronts distortion-averse consumers with a basic non-convexity. Non-convexity results in maximal product differentiation, the "conventional" and "noisy" extremes being the only news products actually demanded at equilibrium in some natural configurations of the latter. We moreover show that most types of noise-averse consumers choose their news providers in the close vicinity of the conventional end of the market. The model thus provides a rationale and partial explanation for the common distinction between mainstream and alternative news media.

Keywords : News media, competitive equilibrium, information accuracy, Kullback-Leibler divergence, distortion aversion, horizontal differentiation, fact reporting, fact checking

JEL Codes : C1, D4, D8, L1

1.1 Introduction

This paper considers product differentiation on competitive news markets, as determined by the characteristics of demand confronting basic informational non-convexities in the activities of news reporting.

Industrial economics traditionally considers product differentiation under two complementary aspects : its driving forces and its types (Tirole 2015, 2.1). The driving force of differentiation may be located on the supply side or on the demand side. Supply-driven differentiation follows from the incentives of profit-maximizing firms to use product differentiation as a means for alleviating the downward pressure that competition exerts on profits (Hotelling 1929, Chamberlin 1951). Demand-driven differentiation follows from the heterogeneity in product characteristics and in consumer preferences. More specifically, demand expresses consumers' individual preferences relative to the various characteristics of each commodity, such as type, quality, the time and location of delivery, and so on (Lancaster 1966). The products, or some subsets of their characteristics, are vertically differentiated if all consumers have the same preference ranking relative to these characteristics ; this happens, for instance, if, *ceteris paribus*, all prefer better quality to lesser quality. Otherwise the products are horizontally differentiated.

The vast literature relative to product differentiation in news media industries covers all the dimensions above, captured notably through the analysis of the relationship between competition and the quality of news construed as the quality, in terms of completeness and accuracy, of the information conveyed by reported situations or events (Gentzkow et Shapiro 2008, Gentzkow, Shapiro et Stone 2015 ; see also Hu 2021 for recent extensions to the social media).

The theoretical literature reviewed in Gentzkow, Shapiro et Stone 2015 typically assumes : (i) some unobserved state of the world attracting public interest ; (ii) raw data relative to this state of the world, modelled as a random variable ; and (iii) and news reports of the latter, modelled in the same way. The main concern of the theory is the explanation of media bias, concieved, using the words of Gentzkow et al., as "systematic differences in the mapping of raw facts to news reports". These systematic differences are explained by strategic manipulations of raw facts by profit-maximizing news media operating on imperfectly competitive news markets. The authors distinguish two types of biases : outright distortion, involving, using their words again, "some integral measure of the distance between news reports and raw facts" (as random variables) ; and filtering of information, where bias consists of oriented summaries or of selective accounts of source data.

The present article studies the determination of non-manipulative informational distortion at competitive equilibrium in the canonical case of normally distributed source data [1].We show that consumers' noise aversion is the main driver of product differentiation in this setup.

Accurate fact reporting is costly. We suppose that the cost-constrained reporting activities of each news provider introduce a specific ("idiosyncratic") distortion in source data, which is modelled as a random distortion term, normally distributed and statistically independent from the raw distribution. A natural measure of information loss due to the media in this setup is the Kullback-Leibler divergence between the news provided by a media firm and the statistical distribution of raw information (Kullback 1997). In the case of normal distributions, the divergence reduces to a simple function of the first and second moments of the distributions of news and raw data. This function introduces in turn a natural synthetic description of reporting distortion as a two-dimensional object consisting of (i) *bias*, construed as the difference between the means of the distributions of, respectively, news and raw data [2] and (ii) *noise*, construed as the difference

1. The case of manipulative outright distortion of normally distributed raw data is studied notably by Mullainathan et Shleifer 2005.

2. This notion of bias fits the notion that is commonly used in descriptive statistics. It sharply differs from the notion of media bias of Gentzkow, Shapiro et Stone 2015. The latter notably refers to Blackwell's criterion for the comparison of information structures (Blackwell 1951 ; see also Laffont 1991, chap. 4). According to this criterion, an information structure (i.e. a mapping from the space of "signals" to the space of probability measures over signals) is better, or more informative, than another structure, if all Bayesian expected utility maximizers make better decisions (i.e. increase their expected utility) when they substitute the former for the latter in their Bayesian revision of probabilities conditional on observed signals. This criterion of first-order stochastic dominance yields a partial ranking of information structures, which provides a natural candidate for a notion of information accuracy, alternative to the Kullback-Leibler criterion mobilized in the present paper, and well suited to Gentzkow and Shapiro's basic object, namely, their discussion of the ability of media markets to "make *beliefs* converge toward the truth" (Gentzkow et Shapiro 2008 ; my emphasis). We do not introduce any notion of Bayesian behavior

between the standard deviations (or variances) of these distributions [3]. We show that expected utility maximizing consumers with concave Bernoulli utility functions are noise-averse. They may or may not be bias-averse. A distortion-averse consumer, who, by definition, is both bias- and noise-averse, typically confronts, at equilibrium, a trade-off between the various combinations of bias and noise supplied by the market (in many respects analogous to the mean-variance arbitrage in portfolio choices, in the capital asset pricing model).

Each news product is synthetically described as a mean-standard deviation pair. We show that, at competitive equilibrium, media firms provide news products that are identical in terms of accuracy, that is, in terms of their Kullback-Leibler divergence to raw data. These products make a one-dimensional locus in the mean-standard deviation space, hereafter called the frontier of equilibrium supply. This frontier provides an array of horizontally differentiated products, ranging from, at one end of the spectrum, "conventional" news products characterized by large biases and by noise levels reduced to some incompressible minimum, to, at the other end of the spectrum, "noisy" news products, setting bias to zero at the expense of some maximum noise level. The frontier confronts distortion-averse consumers with a basic non-convexity in their choice of a news product. Non-convexity results in maximal product differentiation, the "conventional" and "noisy" extremes being the only news products actually demanded at equilibrium, at least in some natural configurations of the latter.

The type of horizontal differentiation implied by the model evokes some aspects of the distinction commonly made between (i) "mainstream" news media, on the one hand, such as, for example, in the USA, *ABC News, Fox News*, the *New York Times* or the *Wall Street Journal*, or, in

or beliefs on behalf of consumers or media firms in the present paper. Our basic concern is, paraphrasing Gentzkow and Shapiro, the ability of media markets to make *fact reporting* converge toward accurate reporting. Finally, note that the Kullback-Leibler divergence fits the notion of outright distortion as "some integral measure of the distance between news reports and raw facts" of Gentzkow et al. (2015), with a minor qualification that follows from the fact that it is not a distance in the strict, mathematical sense of the word (it does not verify the triangular inequality)

3. These notions of bias and noise match those used by Kahneman, Sibony and Sunstein in Noise (2021), their comprehensive study of the informational basis of judgment. The book reviews a considerable number of empirical studies relative to the cases of professional judgment involved in such diverse fields as crime punishment, medical diagnosis and the management of human resources (among others). The authors convincingly argue that bias and noise, as we define them in the present paper, should be treated on the same footing, as being, the both of them, major sources of flaw in human judgment.

France, *TF1, Le Figaro, Le Monde* or *Les Echos*, and (ii), on the other hand, "alternative" news media such as, for example again, *Vox* or the *HuffPost* in the USA, and *Mediapart* or *Atlantico* in France (e.g., for the French press, see Lyubareva, Rochelandet, Haralambous et al. 2020). In one possible reading of the model, the conventional news products would be mainly issued by mainstream outlets, and the noisy ones would be notably produced by alternative outlets. We show that most types of noise-averse consumers choose their news providers in the close vicinity of the conventional end of the market. Noise aversion thus provides a rationale and partial explanation of why conventional outlets are mainstream, in our setup at least.

The paper is organized as follows. Section 3.2 details the information setup. Section 3.3 describes supply and characterizes competitive supply equilibrium. Section 3.4 describes demand and introduces distortion aversion. Section 2.5 characterizes the frontier of equilibrium supply, and describes the associate bias-noise arbitrage. Section 1.6 characterizes market equilibrium. Section 1.7 interprets product differentiation in terms of journalistic practice. Section 1.8 concludes.

1.2 Information setup

Information is construed as a flow of signals emitted from some underlying phenomenon of potential public interest, such as, for example, clusters of emerging viral epidemics, or rumors of inappropriate personal behavior of political leaders in conducting public or private affairs. The signals convey imperfect, incomplete[4] elements of description of the underlying "true" phenomenon (e.g. the true state of viral infection of the population, or the true personal behavior

4. Information is necessarily incomplete if the purpose of description is defined comprehensively, as aiming to provide an exhaustive account of a state of the world (e.g. the circulation of a virus in a population ; or the personal behavior of a political leader). It can be complete if the purpose of description is defined in a selective, tractable way, such as, for example, in terms of confirming or rejecting the hypothesis of the presence of antibodies of a definite type in a patient's blood. Incompleteness is a fundamental form of information imperfection. Information can be imperfect also in a second sense, even when it is complete in the sense above. Namely, when it provides an erroneous (albeit complete) description of certain facts. For example, a "false negative" test rejecting the presence of antibodies of the relevant type in the blood of an infected patient.

of political leaders). They are modelled below as a random variable d (the "raw data" source), normally distributed, with mean μ and variance σ^2. [5]

There are J types of for-profit media firms, denoted by index *j = 1,..., J*. Each firm collects imperfect, possibly incomplete pieces of the raw data flow, and converts them into a news flow, sold on the media market. The news produced by a media firm of type *j* is a random variable n^j, normally distributed, with mean μ_j and variance σ_j^2. We moreover assume that the "noise" $\varepsilon^j = n^j - d$, also called "informational distortion" below, is uncorrelated to the data source (i.e. its variance is equal to $\sigma_j^2 - \sigma^2$; and of course ε^j is normally distributed and its mean is $\mu_j - \mu$). In other words, we suppose that the process of data collection and/or conversion into news is perturbed by phenomena that are not fully controlled by the firm and that are statistically unrelated to the data source. Media firms are not fully transparent in this respect. They are independent sources of imperfection or incompleteness of the information conveyed to consumers through the media market.

A natural measure of the mean loss of information incurred by substituting the news n^j for the raw data flow d is the Kullback-Leibler divergence between the associate densities, that is, $\int_{-\infty}^{+\infty} f_0(s) \log \frac{f_0(s)}{f_j(s)} ds$, where : s denotes an observation (a "signal" or "information", which may consist of a raw data d_e or a news $n_e xpj$ observed in a state of nature e) ; f_j denotes the probability density of n^j (i.e. $f_j : s \to \frac{1}{\sigma_j \sqrt{2\pi}} exp \frac{-(s-\mu_j)^2}{2\sigma_j^2}$) ; and $n^0 = d$. Following Kullback (1959), we denote the divergence of f_j relative to f_0 by $I(0 : j)$. We refer to it as the K-L divergence below.

$I(0 : j)$ can also be interpreted as a measure of the data-processing activity of a firm of type j, due to the natural connection between the K-L divergence and the maximum likelihood criterion (see Appendix A.1). We interpret $I(0 : j)$ below as the outcome of some implicit process of constrained minimization of the K-L divergence, reflecting the practical characteristics of, and practical limitations on, type j's operations of collection and processing of the data.

5. Normally distributed raw data are assumed, notably, by Gentzkow et al. (2015) in their account of filtering bias, and also in the case of outright distortion studied by Mullainathan and Shleifer (2005).

The constraints on K-L divergence minimization notably include the (monetary) cost of these operations, which is modelled explicitly in section 3 below.

This may be illustrated through the following simple facts of theoretical statistics. Suppose that a media of type j collects, from the flow of raw data d, a sample of N pairwise distinct, independently identically distributed observations $S = \{d_1, ..., d_N\}$. The empirical law of d built from sample S is $\hat{p}(s) = \frac{1}{N}\sum_{i=1}^{N}\delta(s - d_i)$, where $\delta : \mathbb{R} \to \mathbb{R}$ denotes the Dirac measure (i.e. $\delta(s - d_i)$ is equal to 0 everywhere except at 0 where it is equal to 1). The firm believes that the true distribution is parametric, with unknown parameters θ. Let p_θ denote the corresponding distribution. The K-L divergence of p_θ relative to $\hat{p}$ reads : $D(\hat{p} \mid\mid p_\theta) = \sum_{s\in S}\hat{p}(s)\log\frac{\hat{p}(s)}{p_\theta(s)}$. A simple calculation yields : $D(\hat{p} \mid\mid p_\theta) = \sum_{s\in S}\hat{p}(s)\log\hat{p}(s) - \frac{1}{N}\sum_{s\in S}\log p_\theta(s)$. Let $H(\hat{p}) = -\sum_{s\in S}\hat{p}(s)\log\hat{p}(s)$ denote the Shannon entropy of the empirical distribution. The first term in the difference above is equal to $-H(\hat{p})$. The second term in the difference, $\frac{1}{N}\sum_{s\in S}\log p_\theta(s)$, is the log-likelihood of the parametric distribution (divided by the number of observations). For a firm of type j that wants to estimate the parameters θ from sample S, it is equivalent, in particular, to derive θ from the maximization of the likelihood of p_θ or to compute it from the minimization of $D(\hat{p} \mid\mid p_\theta)$. Accordingly, we will interpret $I(0 : j)$ below as the outcome of some implicit process of constrained minimization of the K-L divergence, reflecting the practical characteristics of, and practical limitations on, type j's operations of collection and processing (including interpretation) of the data.

As a standard fact of information theory, we obtain $I(0 : j) = \log(\frac{\sigma_j}{\sigma}) + \frac{1}{2}(\frac{\sigma^2}{\sigma_j^2} + \frac{(\mu_j - \mu)^2}{\sigma_j^2} - 1)$.[6] The divergence is null if and only if $j = 0$. It is positive, and increasing in $|\mu_j - \mu|$ if $j \neq 0$. As measured by divergence $I(0 : j)$, the distortion introduced by a media firm of type j in reporting the raw data thus involves two dimensions, which are respectively associated with the first and second moments of the statistical distribution of ε^j : distance $|\mu_j - \mu|$, hereafter called type ***j's systematic bias***, which corresponds to the absolute value of the mean discrepancy between type j's news and the data ; and distance $|\sigma_j^2 - \sigma^2| = \sigma_j^2 - \sigma^2$, hereafter called type ***j's idiosyncratic***

6. E.g. https://fr.wikipedia.org/wiki/Loi_normale, 5.5.3.

noise, which corresponds to the variance that the news of type j adds to the variance of raw data. [7]

Figure 1.1 maps the graph (Fig. 1a) and a set of contour lines (Fig. 1b) of $I(0:j)$ as a function of (σ_j, μ_j) when f_0 is the centered reduced law (i.e. when $(\sigma, \mu) = (1, 0)$). [8]

Propositions 1 and 2 below collect a number of basic properties of $I(0:j)$ and of function $\varphi : \mathbb{R}_{++}\mathbb{R} \to \mathbb{R}$ defined by $\varphi(x, y) = \log(\frac{x}{\sigma}) + \frac{1}{2}(\frac{\sigma^2}{x^2} + \frac{(y-\mu)^2}{x^2} - 1)$. [9]

Proposition 1 : For all $j = 0, ..., J$, $I(0:j) \geq 0$, with equality if and only if j =0.

Proposition 2 : Function φ is : (i) C^∞ ; (ii) strictly increasing in its second argument ; (iii) strictly increasing in its first argument over $\left\{(x, y) \in \mathbb{R}_{++}\mathbb{R} : x^2 - \sigma^2 > (y-\mu)^2\right\}$; (iv) strictly decreasing in its first argument over $\left\{(x, y) \in \mathbb{R}_{++}\mathbb{R} : x^2 - \sigma^2 < (y-\mu)^2\right\}$; (v) Partial functions $y \to \varphi(x, y)$ are strictly concave for all $x \in \mathbb{R}_{++}$.

All proofs are collected in the appendix (Appendix A.3).

1.3 Supply setup

In order to spell out as neatly as possible the independent role of consumers' noise aversion in the determination of product differentiation on the market for news, we assume away any motive of product differentiation that may stem, on the supply side of the market, from situations of imperfect competition *à la* Hotelling or otherwise. [10] Accordingly, we suppose that the market

7. Interestingly, the K-L divergence is increasing (resp. decreasing) in the idiosyncratic noise $\sigma_j^2 - \sigma^2$ if and only if the latter is larger (resp. smaller) than the square of the systematic bias $|\mu_j - \mu|$ (see Proposition 2 below).

8. We follow the standard practice established by the capital asset pricing model in finance, which consists of treating the variance (or standard deviation) as an abscissa and the expectation as an ordinate.

9. The non-negativity and other properties below rely to a large extent on the convexity of function $t \to t\log t$. Non-negativity, in particular, is closely related to Jensen's inequality. These properties should be viewed, therefore, in the special case of normal distributions we considered here, as the expression of basic axiomatic properties of information measures.

10. This makes another sharp difference between the model examined in this paper and the literature reviewed in Gentzkow et al. (2015). The latter considers a mix of demand and supply determinants of product differentiation,

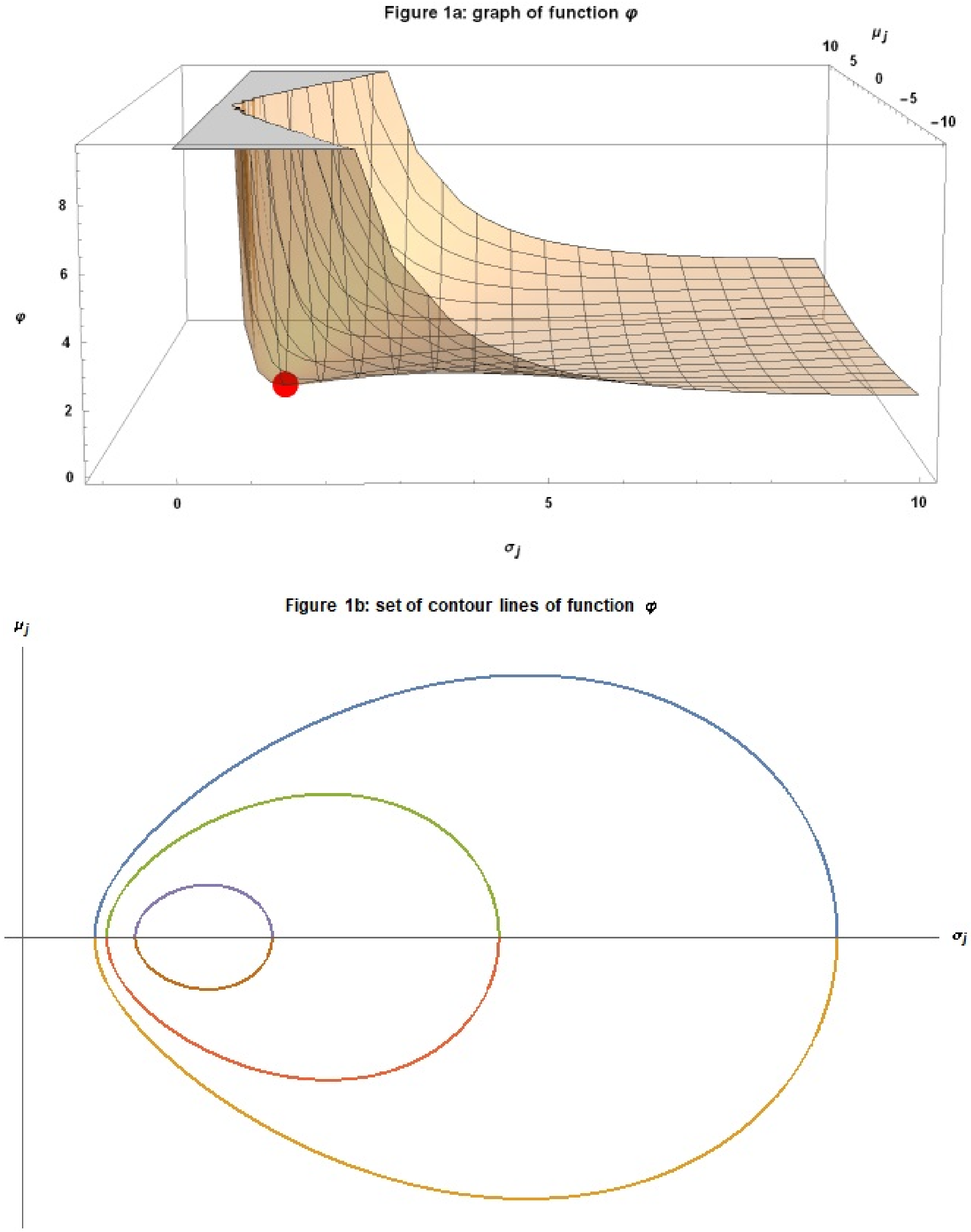

Figure 1.1 – *Function* φ.

for news is perfectly competitive, and we moreover assume, for simplicity, that firms' data-processing technologies are identical. We show below that, unsurprisingly, this implies that all firms provide the same quality of information at equilibrium. In particular, our setup leaves no room for vertical differentiation on news markets.

We argued above that divergence $I(0:j)$ could be interpreted as a measure of the quality, in the sense of the informational accuracy, of type j's information services : the smaller $I(0:j)$ is, the more accurately, on average, the news provided by a firm of type j matches raw data, with full accuracy (i.e. exact match) obtained if and only if the divergence is null. In the sequel we let $q_j = \dfrac{1}{I(0:j)}$ measure the quality of the information services provided by the firms of type j to their consumers. The quality index q_j is monotonically decreasing in divergence $I(0:j)$. It runs over $]0,+\infty[$ as divergence $I(0:j)$ runs over $[0,+\infty]$. Full accuracy is obtained if and only if $q_j = +\infty$.

The representation of media behavior developed here combines two types of activities.

First, data collection and data processing activities aim at information accuracy. They are captured through the quality index q_j of the news provided by the media. The product of these activities can be viewed as information sheets, collecting facts appropriately arranged and interpreted. Their average informational content is measured, in units of information accuracy, by index q_j.

Second, broadcasting activities convey information sheets to news consumers. We let z_j denote the number of information sheets so dispatched by a firm of type j. Note that the "sheet" should not be interpreted literally, as a piece of paper. The informational content q_j can be conveyed in both verbal and written form, and via any technical support such as electronic or herzian channels, or traditional newspapers. The quantity z_j will be treated as a continuous variable below. It captures the mass dimension of the activities of the news industry.

which notably involves firms' strategic manipulation of both prices and information. The model considered here presents a pure case of demand-driven differentiation à la Lancaster, where differentiation is solely determined by consumers' preferences relative to bias and noise as joint characteristics of news products.

Summing up, the product of a firm of type j consists of information sheets of average informational content q_j replicated z_j times. It is measured therefore by quantity $q_j \cdot z_j$ corresponding to a number of units of (average) information accuracy broadcast to its customers. The media charges a price p for each replica. Here again, we need not be too specific about the financing details of these expenses. They are typically covered, in practice, by advertisement budgets and customer fees, in various proportions according to the media, but always narrowly related (by and large proportional) to its audience. We will suppose here, for simplicity, and without substantial loss of generality, that the price is paid by the customer. The firm's sales revenue is equal to $p \cdot q_j \cdot z_j$.

For the reasons developed in the introductory section, we make the following simple, conservative assumptions concerning the technology of the information industry, compatible in particular with a competitive partial equilibrium of the information market. All firms are endowed with the same decreasing (marginal) returns technology, described by cost function $(q_j, z_j) \rightarrow c(q_j, z_j)$, defined over $[0, +\infty][0, +\infty]$, strictly increasing, strictly convex, C^2 in $\mathbb{R}_{++}$, and such that $c(0, 0) = 0$ and $c(+\infty, z_j) = c(q_j, +\infty) = +\infty$ for all (q_j, z_j).

The specific structure of media products and activities, which combine, in a multiplicative way, a qualitative dimension (data-processing, captured through q_j) and a scale dimension (mass broadcasting, captured through z_j), may potentially be a source of production non-convexities, such as scale economies and a non-concave profit function $(q_j, z_j) \rightarrow p \cdot q_j \cdot z_j - c(q_j, z_j)$.[11] This might occur even if the cost function is convex, as clearly shown by the following simple example :

Example 1 - Scale economies related to quality investments : We suppose technically

11. See Strömberg 2004 for a closely related representation of the cost function of media firms, and for an extensive discussion of the consequences of the particular type of scale economies involved. Reformulated in non-technical terms, a basic specificity of information industries, relative to other activities of mass-manufacturing, seems to lie in the larger importance, in relative terms, of the qualitative, immaterial features of its products. These characteristics are not embodied in physical objects as in most large-scale activities of the primary and secondary sectors. They are not even embodied in types of standardized services as in most large-scale tertiary activities of the financial or commercial branches. They "are" or "make" the product, so to speak.

separable data-processing and broadcasting activities, and constant unit-costs equal to 1 for each, that is, $c(q_j, z_j) = q_j + z_j$. The average cost per dispatched unit $\frac{c(q_j, z_j)}{z_j} = \frac{q_j}{z_j} + 1$ is then decreasing in the scale factor z_j. That is, information quality plays the role of a fixed cost, generating scale economies. The corresponding profit function $(q_j, z_j) \to p \cdot q_j \cdot z_j - q_j - z_j$ is clearly not concave (it is even strictly convex for any fixed ratio $\frac{z_j}{q_j} = k$, that is, along any "ray" $\left\{(q_j, z_j) \in \mathbb{R}^2_+ : z_j = k \cdot q_j ; k > 0\right\}$, if $p > 0$).

The profit of a firm of type j reads $p \cdot q_j \cdot z_j - c(q_j, z_j)$. Competitive profit maximization consists of solving program $\max\{p \cdot q_j \cdot z_j - c(q_j, z_j) : (q_j, z_j) \in [0, +\infty[[0, +\infty[\}$ for all given price p.[12] Proposition 3 below illustrates, in the context of this model, the general issue of the compatibility of competitive pricing with profit-maximization in the presence of scale economies. Loosely speaking, the curvature of the cost function, as measured by $\partial^2_{qz} c(q_j, z_j) + \sqrt{\partial^2_{qq}(q_j, z_j) \cdot \partial^2_{zz}(q_j, z_j)}$, puts an upper bound on the range of compatible competitive equilibrium prices. If, in particular, this curvature is null, as in Example 1 above, then there exists no competitive equilibrium. In other words, the cost function must be "convex enough" for a competitive equilibrium to exist. The examples 2 and 3 of the appendix (Appendix A.2) provide simple computable instances of such cost functions and of the corresponding equilibria.

Proposition 3 : Suppose that $p > 0$, and let $(q_j^*, z_j^*) \in \mathbb{R}^2_{++}$ solve $\max\left\{p \cdot q_j \cdot z_j - c(q_j, z_j) : (q_j, z_j) \in [0, +\infty[[0, +\infty[\right\}$. Then : (i) $p = \frac{\partial^2_q c(q_j^*, z_j^*)}{z_j^*} = \frac{\partial^2_z c(q_j^*, z_j^*)}{q_j^*}$; and (ii) $\mid p - \partial^2_{qz} c(q_j^*, z_j^*) \mid \leq \sqrt{\partial^2_{qq} c(q_j^*, z_j^*) \cdot \partial^2_{zz} c(q_j^*, z_j^*)}$. If, moreover, $\mid p - \partial^2_{qz} c(q_j^*, z_j^*) \mid < \sqrt{\partial^2_{qq} c(q_j^*, z_j^*) \cdot \partial^2_{zz} c(q_j^*, z_j^*)}$, then (q_j^*, z_j^*) is the unique solution to $\max\left\{p \cdot q_j \cdot z_j - c(q_j, z_j) : (q_j, z_j) \in [0, +\infty[[0, +\infty[\right\}$.

In the remainder of this paper, we assume that a supply equilibrium (q^*, z^*) exists and is unique.

12. Note that we implicitly assume here that full accuracy (i.e. $q_j = +\infty$) is never achieved, due to prohibitive costs. This follows from the first-order conditions of Proposition 2-(i), for example, if marginal cost $\partial_q c(q_j, z_j)$ grows to infinity as $q_j \to +\infty$.

1.4 Demand setup

There are N types of individual consumers of information, denoted by index $i = 1, ..., N$. Each of them chooses a single news provider in the set $\{n^1, ..., n^J\}$ supplied by the market, and purchases the corresponding news at price p. Our basic behavioral assumption, in terms of consumption, is expected utility maximization. We also make a quasi-linearity assumption, well suited to this study's spirit of partial equilibrium analysis. That is, a consumer of type i selects the editorial product n^j that maximizes his quasi-linear expected utility $\int_{-\infty}^{+\infty} f_j(n_e^j)u_i(n_e^j)dn_e^j - p$ in the set of news products $\{n^1, ..., n^J\}$ accessible on the market. Given our assumptions on probability densities, the expected utility derived by a consumer of type i from editorial product n^j is a function of the sole first and second moments of normal distribution f_j, of the type $U_i(\sigma_j, \mu_j, p) = V_i(\sigma_j, \mu_j) - p$.

The Bernoulli utility functions u_i are standardly assumed to be strictly increasing, twice continuously differentiable, and strictly concave. We retain the last two assumptions (twice continuous differentiability and strict concavity) but depart from the first one for the following reasons.

Recall that we assumed $n^j = d + \varepsilon^j$, where the term ε^j corresponds to the distortion that type j's editorial operations impose on raw data. It seems reasonable to assume that consumers are averse to distortion, at least under some circumstances. A strictly increasing Bernoulli utility function is clearly not compatible with distortion aversion, as it implies that the consumer's utility $u_i(n_e^j) = u_i(d_e + \varepsilon_e^j)$ is, *ceteris paribus*, always strictly increasing in the distortion term ε_e^j. Thus we complement the standard apparatus of expected utility maximization with the following specific assumption of distortion aversion.

Distorsion aversion : U_i exhibits *bias aversion* over some subset S of its domain if it is decreasing in $\mid \mu_j - \mu \mid$ over S, that is, if $\mid \mu_j - \mu \mid > \mid \mu'_j - \mu \mid$ implies $U_i(\sigma_j, \mu_j, p) < U_i(\sigma_j, \mu'_j, p)$ for all pairs $\big((\sigma_j, \mu_j, p), (\sigma_j, \mu'_j, p)\big)$ of elements of S. It exhibits *noise aversion* over some subset

S of its domain if it is decreasing in σ_j over S. It exhibits *distortion aversion* over some subset S of its domain if it exhibits both bias and noise aversion over S. [13]

As a simple consequence of a standard fact of expected utility theory [14], replicated in Proposition 4 below, the normal probability distribution, combined with the strict concavity of the Bernoulli utility function, together imply noise aversion.

Proposition 4 : Suppose that u_i is C^2 and strictly concave. Then U_i exhibits noise aversion over its whole domain.

Note that a bias-averse expected utility can be decreasing in μ_j (see the proof of Proposition 4). We retain bias-aversion as one of our main behavioral assumptions below. In other words, we assume that news consumers agree with statisticians that "systematic" (i.e. average) misreporting should be reduced, *ceteris paribus*, whenever possible. Note, nevertheless, that expected utility maximization does *not* imply bias-aversion. Alternative behaviors, involving "prone-to-bias" preferences, are compatible with this framework. They might follow, for example, in relevant contexts, from the cases of slanting commonly discussed in the literature (e.g. Mullainathan et Shleifer 2005), that is, biases expressing consumers' political preferences.

1.5 The frontier of equilibrium supply and the bias-noise arbitrage

In this section and the next one, we let p^* denote a given, fixed (competitive) equilibrium price of the media market, and we assume that the sufficient condition of Proposition 3 for a unique equilibrium supply holds true. We let (q^*, z^*) denote the corresponding equilibrium

13. Note that, as a consequence of Proposition 2, the inverse (or the opposite) of the K-L divergence $I(0:j) = \log(\frac{\sigma_j}{\sigma}) + \frac{1}{2}(\frac{\sigma^2}{\sigma_j^2} + \frac{(\mu_j-\mu)^2}{\sigma_j^2} - 1)$, viewed as a function of (σ_j, μ_j), displays bias aversion in the sense above everywhere over $[\sigma, +\infty[\mathbb{R}$, but displays noise aversion only over $\left\{(\sigma_j, \mu_j) \in [\sigma, +\infty[\mathbb{R} : \sigma_j^2 - \sigma^2 > (\mu_j - \mu)^2\right\}$.

14. See, for example, Laffont 1991, p.229.

quality-scale mix. We assume that there exists a level of incompressible noise added by media firms to raw data, measured by $\overline{\sigma} - \sigma > 0$, that is, we suppose that $\sigma_j \geq \overline{\sigma} > \sigma$ for all j and all feasible n^j. And we define the *frontier of equilibrium supply* associated with p^* as $F(p^*) = \left\{(\sigma_j, \mu_j) \in [\overline{\sigma}, +\infty[\mathbb{R} : \varphi(\sigma_j, \mu_j) = \frac{1}{q^*}\right\}$.[15]

We show below that the equilibrium condition embodied in the definition of the frontier maintains possibilities of product differentiation on the news market, on the basis of a trade-off between bias aversion and noise aversion.

Let $h : \mathbb{R}_{++} \to \mathbb{R}$ be defined by $h(x) = \left(1 + \frac{2}{q^*} - 2log(\frac{x}{\sigma})\right) x^2 - \sigma^2$.The frontier above may be conveniently characterized as $F(p^*) = \left\{(\sigma_j, \mu_j) \in [\overline{\sigma}, +\infty[\mathbb{R} : \mu_j = \mu \pm \sqrt{h(\sigma_j)}\right\}$. Its main characteristics are detailed in Proposition 5 below and illustrated in Figure 1.2.

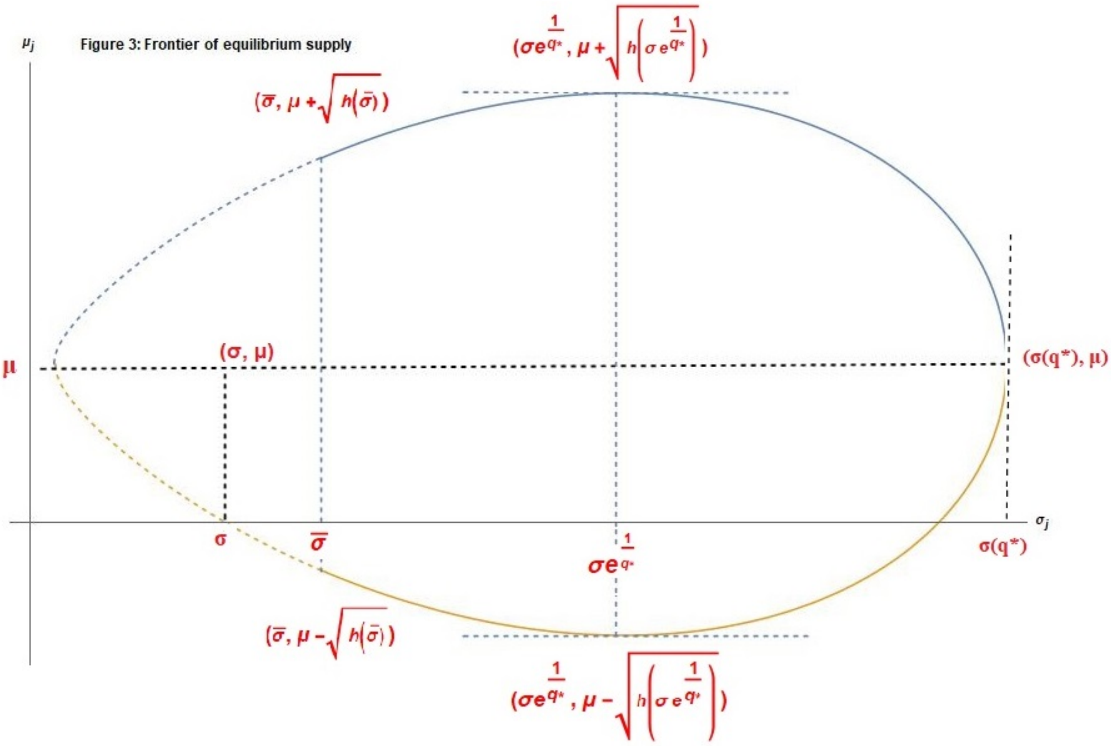

Figure 1.2 – *Frontier of equilibrium supply*

Proposition 5 : Suppose that $\overline{\sigma} < \sigma \cdot exp(\frac{1}{q^*})$.

15. The frontier plays, within the present setup, a role analogous to the role of Minkowski's efficiency frontier in the capital asset pricing model, that is, it characterizes a locus in the mean-standard deviation plane where market equilibrium must lie.

(i) There exists a unique $\sigma(q^*) > \sigma \cdot exp(\frac{1}{q^*})$ such that $h(\sigma(q^*)) = 0$.

(ii) Function $\sqrt{h}$ is :

(a) C^∞, positive and increasing over $[\overline{\sigma}, \sigma \cdot exp(\frac{1}{q^*})[$;

(b) C^∞, positive and decreasing over $]\sigma \cdot exp(\frac{1}{q^*}), \sigma(q^*)[$.

(iii) There exists $\varepsilon \in \mathbb{R}_{++}$ such that $\sqrt{h}$ is differentiably strictly concave over $] - \varepsilon + \sigma \cdot exp(\frac{1}{q^*}), \sigma(q^*)[$.

(iv)

$$\lim_{x \to \sigma(q^*)^-} \partial\sqrt{h(x)} = -\infty$$

(v) There exists $\varepsilon \in \mathbb{R}_{++}$ and a function $g :]\mu - \varepsilon, \mu + \varepsilon[\to \mathbb{R}$ that is C^∞, differentiably strictly concave, and such that $g(\mu) = \sigma(q^*))$ and $(g(y), y) \in F(p^*)$ for all $y \in]\mu - \varepsilon, \mu + \varepsilon[$

As a consequence of Proposition 5, $F(p^*)$ is a smooth (C^∞) one-dimensional manifold with boundary, compact, and symmetrical with respect to horizontal line $L = \Big\{(\sigma_j, \mu_j) \in \mathbb{R}\mathbb{R} : \mu_j = \mu\Big\}$. In the half-plane above L, it coincides with the graph of the restriction of $\sigma_j \to \mu + \sqrt{h(\sigma_j)}$ to $[\overline{\sigma}, (\sigma(q^*)]$. In the half-plane below L, it coincides with the graph of the restriction of $\sigma_j \to \mu - \sqrt{h(\sigma_j)}$ to $[\overline{\sigma}, \sigma(q^*)]$. It has three non-degenerate critical points, namely, $\Big(\sigma \cdot exp(\frac{1}{q^*}), \mu \pm \sqrt{h(\sigma \cdot exp(\frac{1}{q^*}))}\Big)$, and $(\sigma(q^*), \mu)$, the first two associated with a horizontal tangent and the third one with a vertical tangent to $F(p^*)$.

These properties hold true if the minimum level of idiosyncratic noise stemming from the media is small enough, that is, if $\overline{\sigma} < \sigma \cdot exp(\frac{1}{q^*})$.

In terms of interpretation, the (potential) supply described by the frontier confronts the consumer with an arbitrage between noisy and biased information which may be described as follows. Starting from minimal noise $\overline{\sigma} - \sigma$ and moving to the right along the upper or lower branches of the frontier, bias, as measured by $\mid \mu_j - \mu \mid$, and idiosyncratic noise, as measured by $\mid \sigma_j - \sigma \mid$, together increase up to maximum bias level $\sqrt{h(\sigma \cdot exp(\frac{1}{q^*}))}$, reached at noise level $\sigma(exp(\frac{1}{q^*}) - 1)$. Still moving to the right along the frontier, from critical points $\left(\sigma \cdot exp(\frac{1}{q^*}), \mu \pm \sqrt{h(\sigma \cdot exp(\frac{1}{q^*}))}\right)$, bias decreases as noise increases, down to a minimum, null bias level, reached at maximum noise level $\sigma(q^*)$.

Clearly, a distortion-averse consumer will purchase his news either at boundary points $\left(\overline{\sigma}, \mu \pm \sqrt{h(\overline{\sigma})}\right)$ or to the right of the vertical axis through critical points $\left(\sigma \cdot exp(\frac{1}{q^*}), \mu \pm \sqrt{h(\sigma \cdot exp(\frac{1}{q^*}))}\right)$. The first type of choice means that the consumer's aversion to informational noise outweighs his aversion to informational bias. The second type of choice means, symmetrically, that his noise-aversion is outweighed by his bias-aversion.

1.6 Informational non-convexities and demand-driven product differentiation

In this section, we provide a formal definition of this notion of relative bias or noise aversion outlined in the former paragraph. We show that the non-convex structure of the set of alternatives implied by the convexity properties of the K-L divergence [16], combined with consistent relative aversion either to bias or to noise, induces the concentration of demand distortion-averse consumers on the left and right ends of the frontier. We moreover establish that "prone-to-bias", noise-averse consumers choose their news outlets in the neighborhood of the left end of the frontier. Among the types of noise-averse consumers reviewed below, only one, namely, the relative

16. More precisely, quasi-concave programming supposes the maximization of quasi-concave objective functions subject to quasi-concave constraint functions. We show in the proofs of Theorems 1 and 2 that a maximum of a quasi-concave U_i in $F(p^*)$ must be either a local maximum of U_i subject to $\varphi(\sigma_j, \mu_j) \geq \dfrac{1}{q^*}$, or a local maximum of U_i subject to $-\varphi(\sigma_j, \mu_j) \geq -\dfrac{1}{q^*}$. The non-linear functions φ and $-\varphi$ cannot be simultaneously quasi-concave. Moreover, function φ is clearly *not* quasi-concave. And it is not clear whether $-\varphi$ is quasi-concave or not in general. Hence the non-convexity referred to in main text above. Note nevertheless that, according to this criterion, prone-to-bias consumers may confront a convex optimization problem if $-\varphi$ is quasi-concave (their maximum turns out to be a local maximum of U_i subject to $\varphi(\sigma_j, \mu_j) \leq \dfrac{1}{q^*}$). Note also that relative bias-averse consumers clearly confront a non-convex problem, their maximum being a local maximum of U_i subject to $\varphi(\sigma_j, \mu_j) \geq \dfrac{1}{q^*}$.

bias-averse type, may choose its news provider at the "noisy" (i.e. right) end. All others choose it in the vicinity of the "conventional" (i.e. left) end.

Let $\psi_1 = \mu + \sqrt{h}$ and $\psi_2 = \mu - \sqrt{h}$. The two functions $[\overline{\sigma}, \sigma(q^*)] \to \mathbb{R}$ defined by $\sigma_j \to U_i(\sigma_j, \psi_1(\sigma_j), p^*)$ and $\sigma_j \to U_i(\sigma_j, \psi_2(\sigma_j), p^*)$ describe consumer i's utility along the upper and lower branches of frontier $F(p^*)$ respectively. Subject to the assumptions of Propositions 4 and 5, they are twice continuously differentiable over $]\overline{\sigma}, \sigma(q^*)[$, and their first derivatives read $\sigma_j \to \partial_\sigma U_i(\sigma_j, \psi_k(\sigma_j), p^*) + \partial_\mu U_i(\sigma_j, \psi_k(\sigma_j), p^*) \cdot \partial\psi_k(\sigma_j), k \in \{1, 2\}$.

We know from the implicit function theorem that $\partial\psi_k(\sigma_j) = -\frac{\partial_x\varphi(\sigma_j,\psi_k(\sigma_j))}{\partial_y\varphi(\sigma_j,\psi_k(\sigma_j))}$. Supposing $\partial_\mu U_i(\sigma_j, \psi_k(\sigma_j), p^*) \neq 0$, we see therefore that the sign of $\partial_\sigma U_i(\sigma_j, \psi_k(\sigma_j), p^*) + \partial_\mu U_i(\sigma_j, \psi_k(\sigma_j), p^*) \cdot \partial\psi_k(\sigma_j)$ is equal to the sign of difference $-\frac{\partial_x\varphi(\sigma_j,\psi_k(\sigma_j))}{\partial_y\varphi(\sigma_j,\psi_k(\sigma_j))} - \left(-\frac{\partial_\sigma U_i(\sigma_j,\psi_k(\sigma_j),p^*)}{\partial_\mu U_i(\sigma_j,\psi_k(\sigma_j),p^*)}\right)$ if $\partial_\mu U_i(\sigma_j, \psi_k(\sigma_j), p^*) > 0$, and to the sign of difference $-\frac{\partial_\sigma U_i(\sigma_j,\psi_k(\sigma_j)),p^*}{\partial_\mu U_i(\sigma_j,\psi_k(\sigma_j),p^*)} - \left(-\frac{\partial_x\varphi(\sigma_j,\psi_k(\sigma_j))}{\partial_y\varphi(\sigma_j,\psi_k(\sigma_j))}\right)$ if $\partial_\mu U_i(\sigma_j, \psi_k(\sigma_j), p^*) < 0$.

The ratio $-\frac{\partial_\sigma U_i(\sigma_j,\psi_k(\sigma_j),p^*)}{\partial_\mu U_i(\sigma_j,\psi_k(\sigma_j),p^*)}$ is the marginal rate of substitution of noise for bias at point $(\sigma_j, \psi_k(\sigma_j))$ of the frontier. The ratio $-\frac{\partial_x\varphi(\sigma_j,\psi_k(\sigma_j))}{\partial_y\varphi(\sigma_j,\psi_k(\sigma_j))}$ may be viewed, accordingly, with some terminological leeway, as the marginal rate of transformation of noise for bias at $(\sigma_j, \psi_k(\sigma_j))$. Thus the sense of variation of the utility of distortion-averse consumers at any point of the frontier of equilibrium supply depends, essentially, on two determinants : the sign of $\psi_k(\sigma_j) - \mu$, that is, whether the news sold by firm j overestimate or underestimate, on average, raw expectation μ ; and the sign of $-\frac{\partial_\sigma U_i(\sigma_j,\psi_k(\sigma_j),p^*)}{\partial_\mu U_i(\sigma_j,\psi_k(\sigma_j),p^*)} - \left(-\frac{\partial_x\varphi(\sigma_j,\psi_k(\sigma_j))}{\partial_y\varphi(\sigma_j,\psi_k(\sigma_j))}\right)$, that is, whether the consumer's marginal rate of substitution of noise for bias is larger or smaller than the corresponding marginal rate of transformation.

Clearly, the utility of a distortion-averse consumer is decreasing along the part of the upper and lower branches of the frontier corresponding to low "noise levels", ranging in $]\overline{\sigma} - \sigma, \sigma(exp(\frac{1}{q^*}) - 1))]$. This is a simple consequence of distortion aversion, combined with the fact that noise and bias both increase to the right along this part of the frontier.

There is no such simple consequence of distortion aversion when noise reaches the higher levels ranging in $]\sigma(exp(\frac{1}{q^*})-1)), \sigma(q^*)-\sigma[$, because noise and bias move in opposite directions along this part of the frontier (i.e. bias decreases as noise increases). This source of complexity in individual decisions motivates the following (rough) distinction between two types of distortion-averse consumers, namely, consumers whose noise aversion outweighs their bias aversion, and consumers who have the symmetrical, opposite characteristic when they confront a bias-noise arbitrage on the frontier of equilibrium supply. From here on, we distinguish between bias and noise aversion in an *absolute* sense, as defined in section 3.4, and in a *relative* sense, as defined below.

Relative noise (resp. bias) aversion : Let U_i be distortion-averse over $F(p^*)$. We say that U_i exhibits *relative noise* (resp. *relative bias*) *aversion* if $\left|-\frac{\partial_\sigma U_i(\sigma_j,\psi_k(\sigma_j),p^*)}{\partial_\mu U_i(\sigma_j,\psi_k(\sigma_j),p^*)}\right| > \left|-\frac{\partial_x \varphi(\sigma_j,\psi_k(\sigma_j))}{\partial_y \varphi(\sigma_j,\psi_k(\sigma_j))}\right|$ (resp. $\left|-\frac{\partial_\sigma U_i(\sigma_j,\psi_k(\sigma_j),p^*)}{\partial_\mu U_i(\sigma_j,\psi_k(\sigma_j),p^*)}\right| < \left|-\frac{\partial_x \varphi(\sigma_j,\psi_k(\sigma_j))}{\partial_y \varphi(\sigma_j,\psi_k(\sigma_j))}\right|$) for all $\sigma_j \in]\sigma \cdot exp(\frac{1}{q^*}), \sigma(q^*)[$ and all $k \in \{1, 2\}$.

Unsurprisingly, consumers whose preferences exhibit noise aversion in both the absolute and the relative sense choose their news providers on the boundary of the frontier, that is, inside $\{(\overline{\sigma}, \psi_1(\overline{\sigma})), (\overline{\sigma}, \psi_2(\overline{\sigma}))\}$, corresponding to the set of news products that establish the level of informational noise to the accessible minimum. Consumers whose preferences exhibit relative bias aversion make their choice inside $\left\{ (\overline{\sigma}, \psi_1(\overline{\sigma})), (\overline{\sigma}, \psi_2(\overline{\sigma})), (\sigma(q^*), \mu) \right\}$, which notably contains the news product that is without informational bias (and maximizes informational noise). These facts are summarized in Theorem 1 below and illustrated in Figure 1.3. The detailed proof is developed in the appendix.

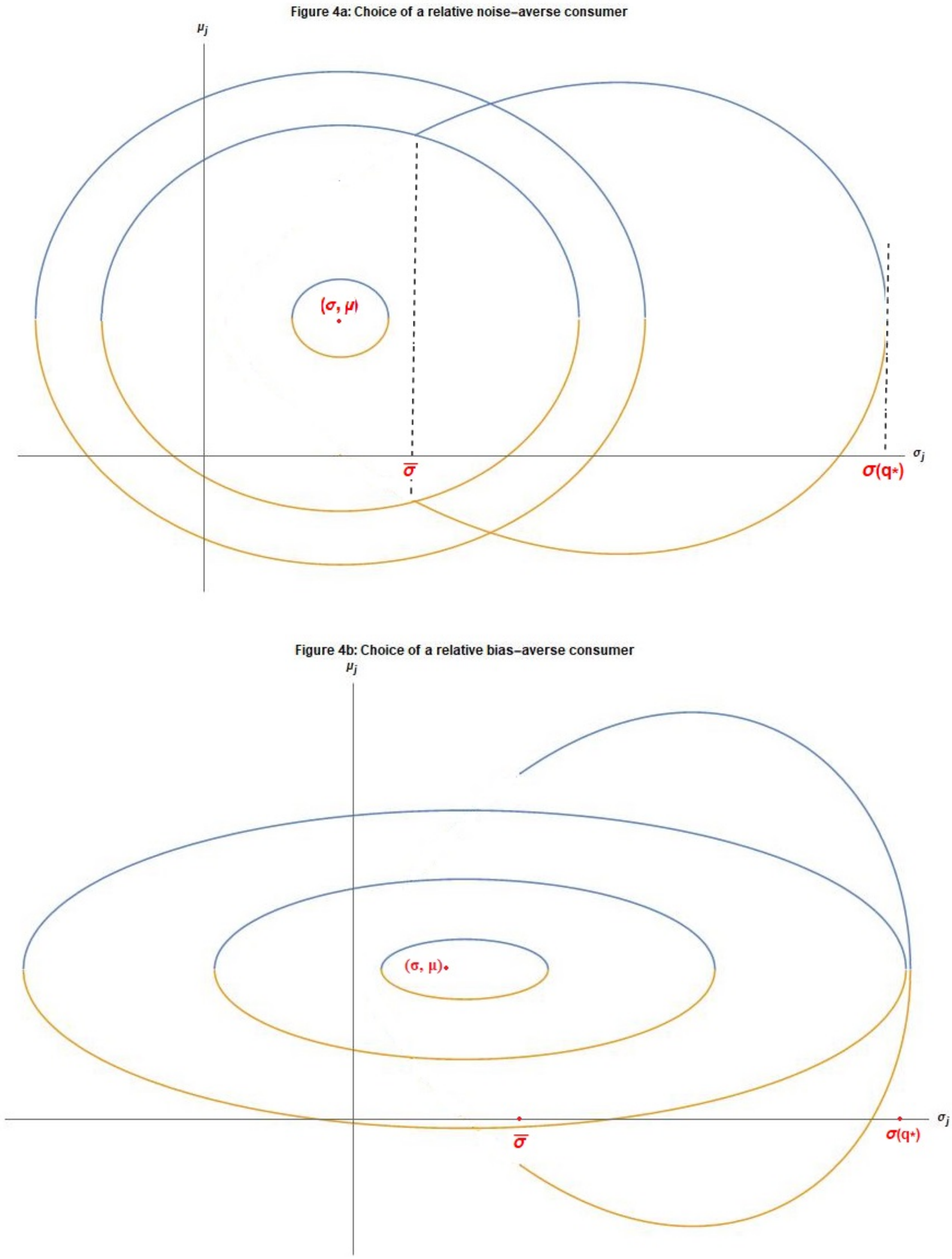

Figure 1.3 – *Choice of a consumer*

Theorem 1 : Suppose that : $p^* > 0$ is a competitive equilibrium price of the media market ;

the associate equilibrium quality-scale mix (q^*, z^*) is unique ; $\overline{\sigma} < \sigma \cdot exp(\frac{1}{q^*})$; and for all i, u_i is C^2 and strictly concave and U_i exhibits absolute bias aversion over $F(p^*)$. Then for all i, (i) U_i has at least one maximum in $F(p^*)$; and (ii) the set of maxima of U_i in $F(p^*)$ is contained in $\Big\{(\overline{\sigma}, \psi_1(\overline{\sigma})), (\overline{\sigma}, \psi_2(\overline{\sigma}))\Big\}$ $\bigcup \Big\{(\sigma_j, \mu_j) \in F(p^*) : \sigma_j > \sigma \cdot exp(\frac{1}{q^*})\Big\}$. Moreover, (iii) If U_i is quasi-concave and displays relative noise aversion, then the set of maxima of U_i in $F(p^*)$ is contained in $\Big\{(\overline{\sigma}, \psi_1(\overline{\sigma})), (\overline{\sigma}, \psi_2(\overline{\sigma}))\Big\}$, and (iv) if U_i displays relative bias aversion, then the set of maxima of U_i in $F(p^*)$ is contained in $\Big\{(\overline{\sigma}, \psi_1(\overline{\sigma})), (\overline{\sigma}, \psi_2(\overline{\sigma})), (\sigma(q^*), \mu)\Big\}$.

"Prone-to-bias" preferences, finally, are easily accommodated in this setup. Theorem 2 below shows that prone-to-bias, noise-averse consumers choose their news providers at the upward sloping part of the upper half of the frontier (i.e., the half-part located above the symmetry axis L) when they favor overestimating biases, that is, if their utility is increasing in μ_j whenever $\mu_j > \mu$. Likewise, prone-to-bias, noise-averse consumers who favor underestimating biases (i.e. whose utility is decreasing in μ_j whenever $\mu_j \leq \mu$) choose their news providers at the downward sloping part of the lower half of the frontier. These behaviors mitigate the property of maximal horizontal differentiation implied by Theorem 1 without altering its main structural features, namely, the propensity of noise-averse consumers to choose their news providers in the "conventional" part of the frontier, that is, inside $\Big\{(\sigma_j, \mu_j) \in F(p^*) : \overline{\sigma} \leq \sigma_j < \sigma \cdot exp(\frac{1}{q^*})\Big\}$.

Theorem 2 : Suppose that : $p^* > 0$ is a competitive equilibrium price of the media market ; the associate equilibrium quality-scale mix (q^*, z^*) is unique ; $\overline{\sigma} < \sigma \cdot exp(\frac{1}{q^*})$; and u_i is C^2 and strictly concave. Suppose moreover that U_i is quasi-concave and is prone-to-bias in one of the following two senses : it is strictly increasing in its second argument over $\Big\{(\sigma_j, \mu_j) \in F(p^*) : \mu_j \geq \mu\Big\}$; or it is strictly decreasing in its second argument over $\Big\{(\sigma_j, \mu_j) \in F(p^*) : \mu_j \leq \mu\Big\}$. Then : (i) U_i has at least one maximum in $F(p^*)$; and (ii) the set of maxima of U_i in $F(p^*)$ is contained in $\Big\{(\sigma_j, \mu_j) \in F(p^*) : \overline{\sigma} \leq \sigma_j < \sigma \cdot exp(\frac{1}{q^*})\Big\}$.

1.7 An interpretation in terms of journalistic practice

Central to the model is the description of journalism as accurate fact reporting. Accordingly, its properties may be interpreted as a (stylized) description of the good practices of this profession's elite. Journalism itself is construed here as a risky activity striking some balance between two conflicting aims : on the one hand, drawing attention to *novel* facts of supposedly general interest, preferably "breaking news" and ideally "scoops" (i.e., exclusive breaking news), and, on the other hand, guaranteeing the *accuracy* of the novel facts conveyed to public attention by spending sufficient time and other scarce resources checking and assessing them. Thus horizontal differentiation opposes two complementary styles of good journalistic practice. One style of journalism prioritizes novelty by privileging scoops, thereby increasing the chances of revealing "truth", that is, of performing accurate reporting in a *timely* manner, at the expense of severely deviating from the truth on specific occasions. The other style of journalism shies away from novelty, thereby reducing the risk of missing the point by too large a margin on any specific occasion, at the expense of systematically "lagging behind" accurate reporting on average in the long run.

The model thus interpreted provides a rationale and partial explanation for the distinction, briefly referred to in our introduction, between "mainstream" and "alternative" news media. The type of product differentiation implied by this distinction is well established in political science. [17] Lyubareva, Rochelandet, Haralambous et al. 2020 provide an empirical account of this fact for French news media, which appears to be very close to the interpretation above. They evaluate the "originality" of news products by computing an index of linguistic distance between the news published by a media and the formulation of the same facts in the dispatches of the *Agence France Presse* (the basic common information source of the French press). The similarity graph they draw from these statistics (their Figure 1, p. 153) exhibits two characteristic

17. See for example the recent survey by the *Pew Research Center. Broad agreement in U.S. – even among partisans – on which news outlets are part of the 'mainstream media'* 2021 relative to the news media of the USA : `https://www.pewresearch.org/fact-tank/2021/05/07/broad-agreement-in-u-s\-even-among-partisans-on-which-news-outlets-are-part-of-the-mainstream-media/`

features. First, the overall (linguistic) distance between the news published by the medias of the studied sample appears small. And second, the graph concentrates a large fraction of the sample into two groups, one of them, by far the largest, concentrated in close proximity to the *Agence France Presse*, and the second, much smaller in size, in close proximity to *Mediapart*, at some distance from the *Agence France Presse*.The first group includes all the main titles of the French "mainstream" news media, while the second group is rich in innovative pure players.

Lyubareva, Rochelandet, Haralambous et al. 2020 interpret originality in terms of information quality, and view it as a dimension of vertical differentiation of media outlets (they assume that all consumers prefer, *ceteris paribus*, more originality). Our own interpretation emphasizes novelty and identifies the quality of information with its accuracy, construed as a bi-dimensional object involving an evaluation of both bias and noise. Thus, the type of differentiation at stake is viewed as horizontal. Note that the linguistic distance between the factual accounts published by the various news media is commonly found to be small in the literature of political science (as this is actually the case in the study of Lyubareva, Rochelandet, Haralambous et al. 2020). This latter type of facts leans toward an interpretation of the distinction between mainstream and alternative (news) medias as a form of horizontal, rather than vertical, differentiation. That is, such facts support the view that the news provided by mainstream and alternative medias, considered from the standpoint of the journalistic skills they implement, are actually very close in quality.

1.8 Conclusion

We studied the fact reporting activity of non-manipulative news providers operating on competitive markets for news. In this setup, consumers' noise aversion results in the horizontal differentiation of news products. The general view sketched in the theorems suggests that most noise-averse consumers will actually choose their news provider in the vicinity of the "conventional" end of the market, and also that some, among the consistently "relative" bias-averse individuals, will choose it at the opposite, noisy end.

We noticed in the introduction that the notions of bias and noise mobilized in this paper match those of Kahneman, Sibony et Sunstein 2021. The latter, unfortunately, does not include news media in their wide-ranging review of empirical findings relative to noise and human judgment. We concur with these authors in emphasizing the general relevance and importance of noise, both factually and normatively, as a basic determinant of the quality of information, and we claim that this general statement applies to the sub-field of news media as well.

The role that bias and noise play in the model, as determinants of the quality of information, and as characteristics (in Lancaster's sense) of news products, owes much to the assumption that raw facts make a univariate normal distribution. We conclude below with a brief outlook over possible extensions to more general constructs for future research.

A first, and actually straightforward extension to the case of multivariate normal distributions would presumably preserve the main properties of the univariate case, with some additional complexities due to the fact that the covariance matrix then substitutes for the standard deviation in the calculation of the KL-divergence. Other extensions of the same type can be considered, to cases of statistical distributions yielding tractable formulas for the calculation of the KL-divergence. Kullback 1997 provides a comprehensive list, which notably includes Poisson and multinomial distributions.

A second extension would substitute Blackwell's dominance criterion for KL-divergence, in the characterization of accurate fact reporting. We mentioned in the introduction that this was the main option retained by Gentzkow, Shapiro et Stone 2015 in their review of media bias theory. We moreover emphasized, in section 3.4, the narrow connection between noise aversion and the concavity of Bernoulli utility function. A setup which would characterize, jointly, *accuracy* through Blackwell's criterion, and *noise aversion* through the concavity of Bernoulli utility functions, would have the great advantage of freeing the analysis, essentially, from the specific characteristics of the statistical distributions describing raw data. A criterion of second-order stochastic dominance could be introduced, notably, in order to complement Blackwell's first-order dominance criterion in a way that would consistently integrate noise aversion in the evaluation of the quality of information. We suggest this type of approach as the most promising one, although presumably also the most demanding one, for future theoretical research on this topic.

Chapitre 2

The public firm as an instrument for regulating a duopolistic newspaper market

Abstract. This paper examines the effects of introducing a public-interest firm on reducing media bias in a duopolistic newspaper market. Two newspaper firms have both print and online versions, and users can interact with each other online. Introducing a public-interest firm will decrease the media bias and the subscription fees when the data source of the newspaper is accurate. Besides, subsidy for truthful reports (or taxation for slanting) can be also effective in reducing media bias. However, price-cap regulation is not effective as online newspapers get more polarized. These findings shed light on the current policy debate about fact-checking, fact-reporting and digital taxation.

Keywords : Online Newspaper, Media Bias, User-Generated Content, Taxation, Regulatory Policy.

JEL Codes : C54, D04, O14, O38, L38.

2.1 Introduction

The media industry, reckoned as the "fourth estate," acts as a marketplace for the exchange of different points of view. In a democratic society, a greater diversity of sources of information can push the democratic process forward. The rise of social media has facilitated the gate-keeping role of media outlets, especially in our political life. However, more dissemination of fake information, made-up news, hate speeches, and extremism on social media is also assumed to be harmful. [1]

Many countries deal with media bias and push different corrective actions to fight fake news and misinformation by making relevant laws, especially regarding online content, the "EU Digital Services Act" for instance. How should the government regulate the (online) news media bias ? Current regulatory actions of online media outlets focus either on competition law such as antitrust law and merger law, or on online content moderation. However, The former is proven to be not effective when bias comes also from the demand side, while the latter is argued to violate the fundamental right of freedom of speech. This paper aims to examine the effect of using a public firm as an instrument for regulating a duopolistic newspaper market.

This paper constructs a location-price game to examine the effects of introducing a third public-interest newspaper firm to regulate a newspaper market. We apply the concept of introducing a public-interest media firm to regulate a market (Cremer, Marchand et Thisse 1989) to the framework of Yildirim, Gal-Or et Geylani 2013 where two newspapers have offline and online markets.

We construct a location-price game to examine the effects of introducing a third public-interest newspaper firm without slant. In a duopolistic newspaper market, two newspaper firms sell both print newspapers and online newspapers to their readers. The online version is different from the print version due to the user-generated content ("UGC") online. Media bias comes from

1. See Pew Research Center's investigation report by Brooke Auxier in 2020 : https://pewrsr.ch/3dsV7uR.

both the supply side and the demand side. The socially optimal reporting position of the duopoly is the mean value of the opinions of their readers. When the third public-interest firm is introduced, the prices of the duopolistic newspapers drop and so does the level of slanting due to the competition pressure. If the data source is accurate, the reporting position of the two private newspapers are less biased than the duopoly case in the model of Yildirim, Gal-Or et Geylani 2013, and also less biased than the monopoly case in the model of Mullainathan et Shleifer 2005. However, the effectiveness of introducing a public-interest newspaper on reducing slanting requires that the data source be accurate. This finding emphasizes the importance of fact-checking, which is at the centre of the public debate. Then we examine two other policies : price-cap and taxation (or subsidy) in the extension part. We find that the print newspapers get less biased but the online newspapers become more biased under price-cap regulation. This result is intuitive as the online newspaper is less costly, hence, the online newspapers bear less competition pressure. In terms of taxation or subsidy, the level of slanting decreases with the taxation, put it the other way, the reports for truth increase with the subsidy. These findings shed light on some policy implementations such as the competition law and the digital tax in the current policy debate.

Our paper is related to the literature on competition in the news market and media bias.

More competition in the media market will foster the diversity of information, thus generating more independence of media firms, less suppression of information or censorship from the government, and will ensure a higher likeliness of having better-informed citizens (Gentzkow et Shapiro 2008). Therefore, to stimulate competition in the media market, a government often adopts antitrust policies or merger policies to prevent the abuses of a monopoly's dominant position in the media industry. However, when the demand-side bias is taken into consideration, competition in the media market may lead to more biased news as the media firms are prone to cater to their consumers' biased opinions (Gentzkow et Shapiro 2006, Xiang et Sarvary 2007). In a Hotelling model of Mullainathan et Shleifer 2005, they show that print newspapers in duopoly can be more biased than monopoly newspapers as they cater to the confirmatory preferences of their readers. Yildirim, Gal-Or et Geylani 2013 demonstrate that newspapers will get less polarized for their print versions but their online versions will get more biased if they have both print and online versions. This paper complements this branch of literature by adding a third public no-slanting newspaper. The results show that the competition between public and private newspapers will alleviate media bias when the data source is accurate, which highlights the important role of fact-checking and fact-reporting in decreasing media bias.

This paper contributes also to the literature on regulatory instruments in the media market.

Current regulatory actions of online media outlets concentrate on two branches. The first regulatory policy is competition law, such as antitrust law and merger law, e.g. the Digital Markets Act (DMA), aiming at preventing the abuses of a monopoly's dominant position in the media industry. However, competition law is argued to be ineffective when bias comes also from the demand side. The second regulatory policy is online content moderation legislation, which is deemed necessary to restrict the dissemination of false information or dangerous speech online such as racist, cyber-bullying, obscene, or terrorist content (the Digital Service Act for instance). Nevertheless, some argue that online content regulation will increase the barriers to entry for media outlets and thus impede the competition in the media market in a counterproductive way. As far as we are concerned, little literature has examined the effects of economic regulations such as price caps and taxation on online media bias. This paper tries to fill this gap.

Regulating a market by a public firm and price-cap regulation is often used to correct the market failure in a mixed market such as the healthcare and education markets (Chang, Wu et Lin 2018, Hehenkamp et Kaarbøe 2020). Tax reductions and subsidies are used to increase media diversity and media pluralism. [2] Nevertheless, the effects of taxation and subsidy policies on media consumption and social welfare are not clear (Kotsogiannis et Serfes 2010, Foros, Kind et Wyndham 2019, Bourreau, Caillaud et De Nijs 2018). Little literature has examined the effects of these regulations on taking media bias into consideration. The most relevant paper is the model of Guo et Lai 2015, which differs from our model notably in the following two

2. For example, see the European Council's discussions of digital taxation : https://www.consilium.europa.eu/en/policies/digital-taxation/.

respects : 1) they suppose that the public firm maximizes the profits, and 2) they only focus on the print newspaper market.

The rest of this paper is structured as follows : section 3.2 presents the basic set-up of the game ; section 3.3 analyzes the effects of introducing a public-interest media outlet ; section 3.4 extends the policies to price-cap regulation and taxation ; section 2.5 concludes.

2.2 Model

2.2.1 The newspaper firms

Consider a market with two private newspaper firms, and each firm has a print version and an online version. The newspaper firms are profit-maximizing and their only revenue comes from their readers' subscription fees. In terms of costs, generally, we consider the returns to scale in the traditional print newspaper industry to be increasing. As the production costs of collecting data and writing the news reporting are fixed, the variable cost equals the reprinting and delivering an additional copy (Reddaway 1963, Rosse 1967). Suppose that a print version's total cost ***c*** is higher than that of an online one ($c\delta$). The subscription fee for a print newspaper (P_i) is also higher than its online version (K_i).

The online newspaper is also different from the print newspaper in that the consumers can interact with each other on the web or through the applications by making comments or discussing with other readers, i.e., producing user-generated content ("UGC"). Therefore, online users' opinions are influenced by the newspapers' news reporting and other users' comments online. We assume that online readers' opinions are thus more extreme than the subscribers to the print ones because of the user-generated content.

A private newspaper firm's role is to collect data (d) about the state of the world (t) and then report a piece of news (*n*) based on the data that it collects. The variable *t* is assumed to be normally distributed with mean as 0 and variance as v_t, i.e., $t \sim N(0, v_t)$, where $1/v_t$ is the precision. The data received by a newspaper firm *i* is then $d_i = t + \varepsilon_i$, where ε_i is a random variable of a noise term, with $\varepsilon_i \sim N(0, v_\varepsilon^i))$, $i = \{1, 2\}$. Therefore, the data d_i also follows a normal distribution, i.e., $d_i \sim N(0, v_d)$, with $v_d = v_t + v_\varepsilon$. Define $\frac{1}{v_d}$ as the precision or accuracy of the data source. Newspaper *i* reports news *n* $n_i = d_i + s_i$, where s_i is a slant of the news reports of the newspaper *i*. Analogously, we have $n_i^o = d_i + s_i^o$, with n_i^o online news report and s_i^o the slant of an online newspaper.

2.2.2 The third public-interest newspaper

Introducing a public firm as an instrument for government regulation is not new. [3] This idea has recently been applied to many mixed markets, such as the healthcare, education, and cultural markets, where public and private services exist. In this kind of mixed market, the government often subsidizes public firms to guarantee high-quality products. We assume here that the media market is also mixed as the ownership of the news media firms can be either public or private. Public media outlets can provide more socially valuable news ("hard news") than private news media, for example, public British television news such as *BBC news* is proven to have higher quality than private American news (Zaller 1999). Moreover, information can also be considered to be a public good such as education or healthcare for its essential role in informing people for making their political decisions.

Hence, we assume first that there exists a public-interest media outlet that does not slant, i.e., it accurately reports the data *d*. Secondly, this third public-interest media outlet has no digital version. The intuition behind the second assumption is simple : user-generated content, as the mean opinions of online subscribers, can make the online newspaper's position more extreme. Thirdly, suppose that a public-interest media outlet with no-slanting news reports aims at maxi-

3. see for example Cremer, Marchand et Thisse 1989, Futagami, Matsumura et Takao 2019

mizing social welfare. The expected utility of a reader of belief b from reading a public-interest newspaper is :

$$E[U_3] = \overline{u} - E[\varphi(d-b)^2] - (1-\tau)P_3 = \overline{u} - \varphi(v_d + b^2) - (1-\tau)P_3, \quad (2.1)$$

where the price of the public-interest newspaper P_3 comprises two parts : the copayment of readers $(1-\tau)P_3$ and the subsidy from the government τP_3, with a subsidy rate of $\tau \in [0, 1]$.

Proof. See online appendices B.1. □

2.2.3 Readers

A mass of readers can subscribe to either the print version or the online version of a newspaper. [4] Readers of the newspapers are uniformly distributed between $[-b_o, b_o]$. The total number of readers is normalized to unity. A reader of type b has prior beliefs about the state of the world and these beliefs follow normal distribution $N(b, v_t)$. Readers may have biased beliefs about the expected value of *t*. The belief b can be interpreted as the political opinions of a reader : for instance, $b \in [-bo, 0)$ corresponds to the belief of a left-wing party supporter, and $b \in (0, bo]$ represents the opinions of a right-wing party supporter.

The net utility function of a biased reader of belief b from reading a private newspaper *i*, $i = \{1, 2\}$, is :

$$U_i^b = \begin{cases} U_i^p = \overline{u} - \chi(s_i)^2 - \varphi({n_i}^p - b)^2 - P_i & \text{for reading a print newspaper;} \\ U_i^o = \overline{u} - \chi({s_i}^o)^2 - \varphi({n_i}^o - b)^2 - K_i & \text{for reading an online one,} \end{cases}$$

where $\overline{u}$ is the reservation price, χ the dislike parameter for slanting, φ calibrates readers' preference for hearing confirming news, $s_i(s_i^o)$ is the slanting of a print and online newspaper's news

4. Suppose that the reader is single-homing.

report, $n_i(n_i^o)$ is the print(online) newspapers' news report, b is the belief of reader, and $P_i(K_i)$ is the price of a print(online) newspaper. We follow the assumptions of Bernoulli's utility for the utility function in the model of Mullainathan et Shleifer 2002 and Yildirim, Gal-Or et Geylani 2013.

For the slanting strategy, we follow the assumptions in the model of Mullainathan et Shleifer 2002 and Yildirim, Gal-Or et Geylani 2013 : $s_i(d_i) = \frac{\varphi}{(\chi+\varphi)}(B_i - d_i)$ and $s_i^o(d_i) = \frac{\varphi}{(\chi+\varphi)}(B_i^o - d_i)$, with $s_i(d_i)$ the slanting strategy of a print newspaper and $s_i^o(d_i)$ of an online one. B_i is denoted as the reporting location of a newspaper *i*'s print version, and B_i^o is the reporting location of its online version, which can be interpreted as the political stance of a newspaper during the elections. We also assume that newspaper 1 is located at the left of newspaper 2, i.e. $B_1 < B_2$. The position of the digital version of a private newspaper *i* takes the form $B_i^o = B_i + U[b_i^o]$, where $U[b_i^o]$ is the "user-generated content", i.e., the weighted mean opinions of online subscribers. More precisely, we assume that :

$$B_1^o = B_1 + \frac{\alpha(-b_o + \hat{b}_1)}{2} \quad \text{and} \quad B_2^o = B_2 + \frac{\alpha(b_o + \hat{b}_2)}{2}, \tag{2.2}$$

where $\hat{b}_i$ is the opinion of marginal readers who are indifferent between the print version and the online version of a newspaper, and b_0 is the extremest opinions of readers.

The online position of a newspaper, e.g., the political opinions of an online newspaper, is a by-product of the position of its print version and user-generated content (e.g., the weighted average opinions of its online subscribers). Therefore, online readers' opinions are more extreme than the subscribers to the print ones because of the user-generated content.

The expected prior utility of a reader of type b reading a newspaper *i*, *i*={1, 2} [5], is then :

$$E[U_i] = \begin{cases} E[U_i^p] = \overline{u} - \frac{\varphi^2}{(\chi+\varphi)}(B_i - b)^2 - \frac{\chi\varphi}{(\chi+\varphi)}(b^2 + v_d) - P_i \\ E[U_i^o] = \overline{u} - \frac{\varphi^2}{(\chi+\varphi)}(B_i^o - b)^2 - \frac{\chi\varphi}{(\chi+\varphi)}(b^2 + v_d) - K_i, \end{cases} \tag{2.3}$$

where $E[U_i^p]$ stands for the expected utility of a reader *b* reading the print version of newspaper *i*, and $E[U_i^o]$ the utility for reading an online newspaper respectively.

The game unfolds in the following three stages :

— Stage 1 : The two private newspapers announce their positions on the print version and then their slanting strategy. The third public-interest newspaper without slant is introduced.

— Stage 2 : The prices of the print and digital versions of the two private newspapers, and the price of the third public-interest newspaper are then decided.

— Stage 3 : The consumers make their subscription decisions, the newspapers publish their news, and online readers can interact online with other readers via user-generated content (if they choose the digital version).

This location-price game will be solved by backward induction : firstly, we determine the marginal readers who delimit the five market shares of the news outlets provided in stage 3 (see figure 2.2) ; then we analyze the newspapers' price strategies in stage 2 ; and last, we examine the newspapers' slanting strategies and reporting location choices (see figure 2.1).

5. This expected utility function comes from the model of Mullainathan et Shleifer 2005, LEMMA A1 in Appendix, P1043-1044. The market for news. *American Economic Review*, 2005, vol. 95, no 4, p. 1031-1053.

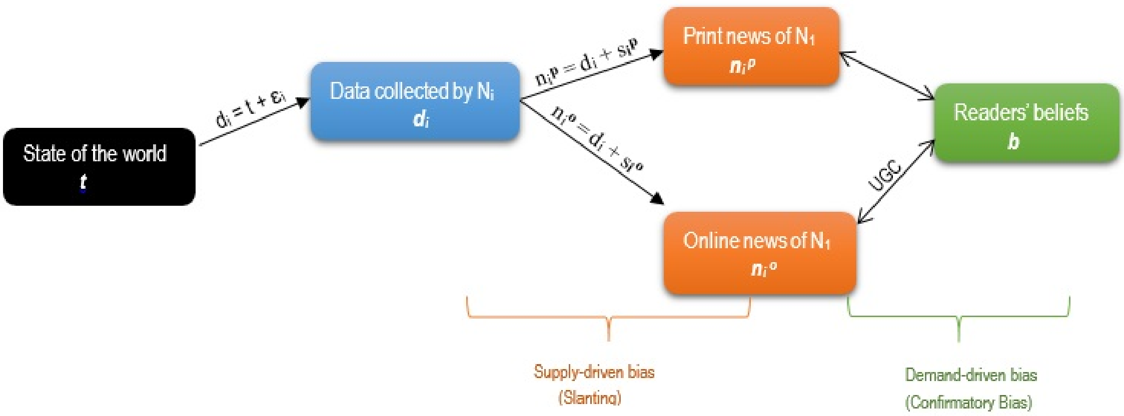

Figure 2.1 – *Timing of the game in a duopolistic market for news.*

2.3 Equilibrium analysis

2.3.1 Market shares

Denote market shares as $(MS)_1^o, (MS)_1^p, (MS)_3, (MS)_2^p, (MS)_2^o$ respectively, as shown in Figure 2.2 :

— $(MS)_1^o = [-b_0, \hat{b}_1]$ is the market share for the online version of newspaper 1.

— $(MS)_1^p = [\hat{b}_1, \hat{b}_{ind}^1]$ is the market share for the print version of newspaper 1.

— $(MS)_3 = [\hat{b}_{ind}^1, \hat{b}_{ind}^2]$ is the market share for the (print) newspaper 3 (the third public-interest newspaper).

— $(MS)_2^p = [\hat{b}_{ind}^2, \hat{b}_2]$ is the market share for the print version of newspaper 2 ;

— $(MS)_2^o = [\hat{b}_2, b_0]$ is the market share for the online version of newspaper 2.

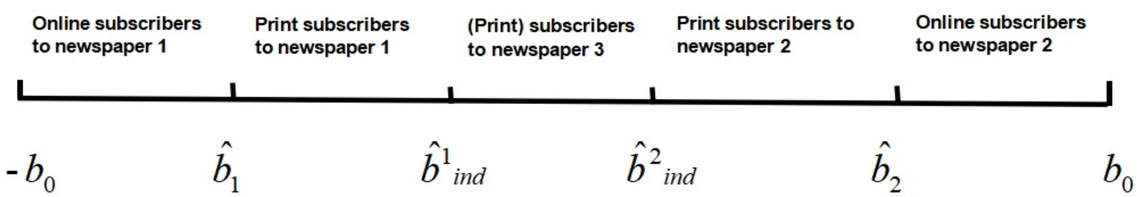

Figure 2.2 – *Segmentation of the market when a third public-interest newspaper is introduced into a duopolistic newspaper market.*

Using $E[U_i^o] = E[U_i^p]$ and equation (2.2), we get the beliefs of readers who are indifferent between the digital and print versions of a newspaper $i, i = \{1, 2\}$:

$$\begin{cases} \hat{b}_1^* = \frac{2B_1^*+(2-\alpha)b_0-2\sqrt{\Delta_1}}{4-\alpha}, \Delta_1 = (b_0 - B_1^*)^2 - \frac{(4-\alpha)(P_1^*-K_1^*)(\varphi+\chi)}{\alpha\varphi^2}; \\ \hat{b}_2^* = \frac{2B_2^*-(2-\alpha)b_0+2\sqrt{\Delta_2}}{4-\alpha}, \Delta_2 = (b_0 + B_2^*)^2 - \frac{(4-\alpha)(P_2^*-K_2^*)(\varphi+\chi)}{\alpha\varphi^2}. \end{cases} \tag{2.4}$$

The public firm is posited, by construction, on an interval of the market line that contains the "unbiased," "neutral," or "central" belief $b = 0$ in its interior. The boundaries of its market share are computed as follows. Let us denote by b_{ind}^i the belief of a reader who is indifferent between the public newspaper and the print version of the newspaper $i, i = \{1, 2\}$.

Using $E[U_3] = E[U_i^p]$, we have the readers who are indifferent between the public newspaper 3 and the print version of the newspaper $i, i = \{1, 2\}$:

$$\begin{cases} (\hat{b}_{ind}^1)^* = \frac{((B_1^*)^2-v_d)}{2B_1^*} + \frac{(P_1^*-(1-\tau)P_3^*)}{2B_1^*}\frac{(\varphi+\chi)}{\varphi^2}; \\ (\hat{b}_{ind}^2)^* = \frac{((B_2^*)^2-v_d)}{2B_2^*} + \frac{(P_2^*-(1-\tau)P_3^*)}{2B_2^*}\frac{(\varphi+\chi)}{\varphi^2}. \end{cases} \tag{2.5}$$

Proof. See online appendices B.2. □

2.3.2 Price choices

The profit functions Π_i of newspaper $i, i = \{1, 2\}$, as derived from their market shares, read :

$$\begin{cases} \Pi_1 = \frac{(\hat{b}_1+b_0)}{2b_0}(K_1 - c\delta) + \frac{(\hat{b}_{ind}^1-\hat{b}_1)}{2b_0}(P_1 - c); \\ \Pi_2 = \frac{(b_0-\hat{b}_2)}{2b_0}(K_2 - c\delta) + \frac{(\hat{b}_2-\hat{b}_{ind}^2)}{2b_0}(P_2 - c), \end{cases} \tag{2.6}$$

where P_i (K_i) is price for the print (online) newspaper, c ($c\delta$) is the cost of the print (online) newspaper, with $\delta \in (0, 1)$ a discount parameter as we suppose that the online version has a lower cost.

Given the locations of the marginal readers computed in (2.4) and (2.5), the two private newspapers make their price choices P_i and K_i in order to maximize their profits.

The public-interest newspaper maximizes social welfare :

$$\begin{aligned}\overbrace{SW}^{\text{public newspaper's objective}} &= \overbrace{U}^{\text{consumers' utilities}} + \overbrace{\sum_{i=1}^{3}\Pi_i}^{\text{newspapers' profits}} \overbrace{-\tau P_3 \frac{(\hat{b}^2_{ind} - \hat{b}^1_{ind})}{2b_0}}^{\text{subsidy}} \\ &= U + \Pi_1 + \Pi_2 + \frac{(\hat{b}^2_{ind} - \hat{b}^1_{ind})}{2b_0}((1-\tau)P_3 - c).\end{aligned} \tag{2.7}$$

The maximization of objective functions (2.6) and (2.7) with respect to P_i yields the following equilibrium relationships between the prices and the reporting positions of print newspapers :

$$\begin{cases} P_1^* = c - \frac{\varphi^2}{2(\chi+\varphi)}\left((B_1^*)^2 + 2b_0 B_1^* - 2v_d + \frac{4b_0}{(\frac{1}{B_1^*}-\frac{1}{B_2^*})} - B_1^* B_2^*\right) \\ P_2^* = c - \frac{\varphi^2}{2(\chi+\varphi)}\left((B_2^*)^2 - 2b_0 B_2^* - 2v_d + \frac{4b_0}{(\frac{1}{B_1^*}-\frac{1}{B_2^*})} - B_1^* B_2^*\right) \\ P_3^* = \frac{1}{(1-\tau)}\left(c - \frac{\varphi^2}{(\chi+\varphi)}\left(\frac{4b_0}{(\frac{1}{B_1^*}-\frac{1}{B_2^*})} - v_d - B_1^* B_2^*\right)\right) \end{cases} \tag{2.8}$$

Likewise, the following equilibrium relationships between print and online prices are derived from the maximization of profit functions (2.6) with respect to K_i :

$$\begin{cases} K_1^* = P_1^* + c(\delta - 1) - \frac{\alpha\varphi^2}{2(\chi+\varphi)}(b_0 + \hat{b}_1^*)\Big((2-\alpha)b_0 - (4-\alpha)\hat{b}_1 + 2B_1^*\Big) \\ K_2^* = P_2^* + c(\delta - 1) - \frac{\alpha\varphi^2}{2(\chi+\varphi)}(b_0 - \hat{b}_2^*)\Big((2-\alpha)b_0 + (4-\alpha)\hat{b}_2 - 2B_2^*\Big) \end{cases} \tag{2.9}$$

Proof. See online appendices B.3. □

2.3.3 Efficiency benchmark

We turn to the base model of Yildirim, Gal-Or et Geylani 2013 where there are only two private newspapers (duopoly) in the following analyses (see Figure 2.3) [6].

6. To simplify, we assume that production costs for (print and online) newspapers are zero.

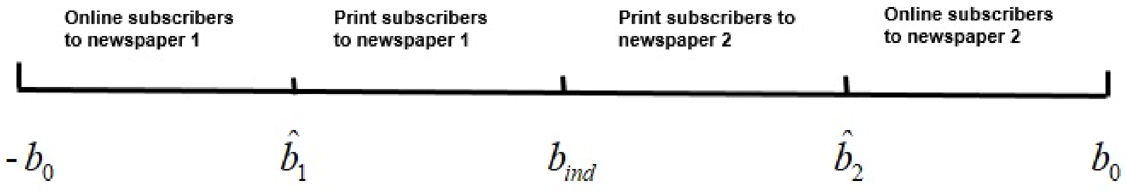

Figure 2.3 – *Segmentation of the newspaper market in the model of* Yildirim, Gal-Or *et* Geylani *2013*.

Define the social welfare of the duopolistic market as the total surplus of the newspaper firms and their readers :

$$W = \int_{-b_0}^{\hat{b}_1} \frac{U_1^0}{2b_0} db + \int_{\hat{b}_1}^{b_{ind}} \frac{U_1^p}{2b_0} db + \int_{b_{ind}}^{\hat{b}_2} \frac{U_2^p}{2b_0} db + \int_{\hat{b}_2}^{b_0} \frac{U_2^0}{2b_0} db + \Pi_1 + \Pi_2 \tag{2.10}$$

Optimizing the above social welfare equation with respect to the (print and digital) reporting locations of the newspaper separately, we get :

i) The socially optimal slanting levels when $0 \leq \alpha \leq 1$:

$$\begin{cases} B_1^0 = \frac{(\hat{b}_1 - b_0)}{2}; B_1 = \frac{(b_{ind} + \hat{b}_1)}{2}; \\ B_2 = \frac{(b_{ind} + \hat{b}_2)}{2}; B_2^0 = \frac{(b_0 + \hat{b}_2)}{2}. \end{cases} \tag{2.11}$$

Thus, the symmetric solutions for optimal (first-best) reporting locations are :

$$(B_1^0, B_1, B_2, B_2^0)^{SO} = \left(\frac{(-\hat{b} - b_0)}{2}, \frac{-\hat{b}}{2}, \frac{\hat{b}}{2}, \frac{(\hat{b} + b_0)}{2} \right)$$

where the subscript *SO* stands for ”Socially Optimal”, and $-\hat{b}_1 = \hat{b}_2 = \hat{b}, b_{ind} = 0$.

ii) The optimal levels of slants are :

$$(s_1^0(d_1), s_1(d_1), s_2(d_2), s_2^0(d_2))^{SO} =$$
$$\left(\frac{-\varphi}{(\varphi + \chi)}(\hat{b} + b_0 + d_1), \frac{-\varphi}{(\varphi + \chi)}(\frac{\hat{b}}{2} + d_1), \frac{\varphi}{(\varphi + \chi)}(\frac{\hat{b}}{2} - d_2), \frac{\varphi}{(\varphi + \chi)}(\frac{(\hat{b} + b_0)}{2} - d_2) \right).$$

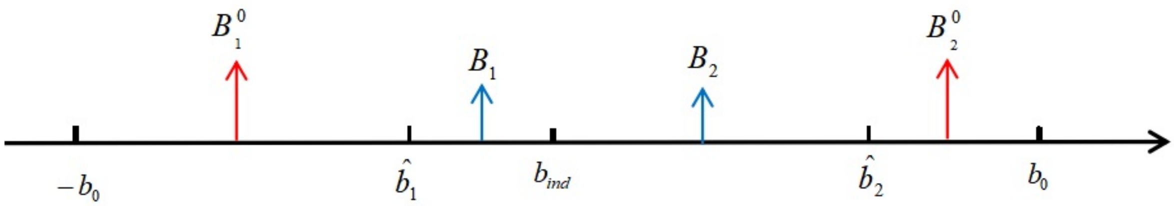

Figure 2.4 – *The optimal (first-best) reporting location choices* ($0 < \alpha < 1$).

Recall that when there are only two private newspapers in the market in the model of Yildirim, Gal-Or et Geylani 2013 are [7] :

$$\begin{cases} B_0^D > \frac{3b_0}{2} > B^D > \frac{15b_0}{16}; \\ P_i^D = c + \frac{4\varphi^2}{(\varphi+\chi)} b_0 B^D; \\ K_i^D = P_i^D + c(\delta - 1) + \frac{\varphi^2}{2(\varphi+\chi)}(b_0 - \hat{b}^D)(b_0 + 3\hat{b}^D - 2B^D), i = 1, 2. \end{cases} \tag{2.12}$$

Proposition

Proposition 1 (The socially optimal slanting levels)**.** *We have :*

i) The socially optimal slanting level is the mean value of the opinions of readers in the print or digital market.

ii) When $\alpha < \frac{1}{4}$, the print and online newspapers' reporting opinions are more extreme than when there are only print newspapers in the news market, i.e. $B^{(sw)} > \frac{3}{2}b_0$;

iii) $B_i^o > B_i$. Socially optimal, the digital version of a newspaper is more biased than its print version ;

iv) Under the symmetric case, the duopoly newspapers are more biased compared to the socially optimal level of slanting.

Proof. See online appendices B.4. □

7. see equations (11), (12), (14), and proposition 1, with the symmetric case and $\alpha = 1$, where the subscript D stands for "Duopoly".

Social welfare is maximized when newspapers express more diverse but less extreme opinions. When the media outlets' reports are "neutral" and "objective", social welfare is maximized. Namely, the media market functions as "a marketplace of ideas" where different points of view can be exchanged in the market and diverse opinions can be reported in the news reports (Milton 2006). Moreover, the optimal slanting level for a traditional print newspaper increases with the difference between the average opinions of readers and the data source and decreases with the weight of readers' preferences for confirming news and slanting news ($\frac{\chi}{\varphi}$). The optimal slanting level for an online newspaper depends not only on its data source (d_i), on its readers' preference for "confirmatory news" (φ) and dislike for slanting news (χ), but also on the extremist readers' opinions (b_0). The more extreme readers' opinions are, the higher the level of socially optimal slanting.

2.3.4 Reporting positions and slanting strategies

By plugging the equilibrium prices P^* and K^* into the profit functions Π_i and then by optimizing the new profit functions to the locations B_i, we get the following relationships between the reporting positions and the prices at equilibrium :

$$\begin{cases} \frac{\partial \Pi_1}{B_1^*} = \frac{1}{2b_0}\left(((K_1^* - c\delta) - (P_1^* - c))\frac{\partial \hat{b}_1}{\partial B_1^*} + (P_1^* - c)(\frac{\partial \hat{b}_{ind}^1}{\partial B_1^*} + \frac{\partial \hat{b}_{ind}^1}{\partial P_3^*}\frac{\partial P_3^*}{\partial B_1^*})\right); \\ \frac{\partial \Pi_2}{B_2^*} = \frac{1}{2b_0}\left((-(K_2^* - c\delta) + (P_2^* - c))\frac{\partial \hat{b}_2}{\partial B_2^*} + (P_2^* - c)(\frac{\partial \hat{b}_{ind}^2}{\partial B_2^*} + \frac{\partial \hat{b}_{ind}^2}{\partial P_3^*}\frac{\partial P_3^*}{\partial B_2^*})\right). \end{cases} \tag{2.13}$$

Taking the reporting position of the print version of newspaper 2 (B_2) for example, we get the reporting position that maximize the profit of the newspaper 2 as follows :

$$2\alpha\left((\hat{b}_2^*)^2 - (b_0)^2\right) = \left(\frac{1}{2} + \frac{v_d}{2(B_2^*)^2} - \frac{(B_1^* + B_2^*)(2b_0 + B_1^* - B_2^*)}{4B_2^*(B_2^* - B_1^*)} - \frac{1}{2B_2^*}(B_1^* + \frac{4b_0(B_1^*)^2}{(B_2^* - B_1^*)^2})\right)$$
$$\left(B_1^*B_2^* - (B_2^*)^2 + 2b_0B_1^* - \frac{4b_0B_1^*B_2^*}{B_2^* - B_1^*} + 2v_d\right)$$

To simplify the mathematical analyses, we only consider the symmetric solutions when $\alpha = 1$ hereinafter.[8] Suppose that $-B_1^* = B_2^* = B^*, (-B_1^o)^* = (B_2^o)^* = (B^o)^*, (-\hat{b}_1)^* = (\hat{b}_2)^* = \hat{b}^*, \left(-\hat{b}_{ind}^1\right)^* = \left(\hat{b}_{ind}^2\right)^* = \hat{b}_{ind}^*$, suppose also that UGC has an important role in deciding the online position of the newspaper, i.e. $\alpha = 1$.

The indifferent readers' positions and prices in equations (2.4), (2.5), (2.8) and (2.9) can be rewritten as :

$$\begin{cases} -(\hat{b}_{ind}^1)^* = (\hat{b}_{ind}^2)^* = \hat{b}_{ind}^* = \dfrac{B^* - v_d}{2B^*}; \\ -\hat{b}_1^* = \hat{b}_2^* = \hat{b}^* = \dfrac{4B^* + 5b_0}{7}; \\ P_i^* = (1-\tau)P_3^* = c - \frac{\varphi^2}{(\varphi+\chi)}\left((B^*)^2 - 2b_0B^* + v_d\right); \\ K_i^* = P_i^* - c(1-\delta) + \frac{\varphi^2}{2(\chi+\varphi)}(b_0 - \hat{b}^*)\Big(b_0 + 3\hat{b}^* - 2B^*\Big), i = 1, 2. \end{cases} \tag{2.14}$$

The symmetric equilibrium results for reporting positions then read :

$$\frac{65}{49}(B^*)^4 + \frac{5b_0}{2}(B^*)^3 + \left(\frac{25(b_0)^2}{49} - \frac{v_d}{2}\right)(B^*)^2 - \frac{b_0 v_d}{2}B^* - \frac{v_d}{2} = 0$$
$$(B^o)^* = B^* + \frac{(b_o + \hat{b})}{2} \tag{2.15}$$

Lemma 1 (Conditions for market segmentation). To support the market segmentation in figure 2.2 at the symmetric equilibrium, the following conditions need to be satisfied :

$$\frac{(-10b_0B - 8B^2 + 7B)}{7} \leq v_d \leq B \leq \frac{b_0}{2}. \tag{Lemma 1}$$

The market segmentation needs $0 \leq \hat{b}_{ind}^* \leq \hat{b} \leq b_0$, i.e. $\frac{B^* - v_d}{2B^*} \leq \frac{(4B^* + 5b_0)}{7} \leq b_0$, which implies that both the reporting position of a print newspaper and the variance of the data source should not be bigger than $\frac{b_0}{2}$. Combine the results in equation B.2 and in Lemma 1, we find that the reporting position of a print newspaper at equilibrium depends both on v_d and bo, i.e. the variance of the data source and the opinions of the extremist readers.

8. The asymmetric solutions are either too complicated or may not exist at all.

Recall that when there are only two private newspapers in the market in the model of Yildirim, Gal-Or et Geylani 2013, the symmetric equilibrium prices when $\alpha = 1$ are :[9]

$$\begin{cases} B_0^E > \frac{3b_0}{2} > B^E > \frac{15b_0}{16}; \\ P_i^E = c + \frac{4\varphi^2}{(\varphi+\chi)} b_0 B^E; \\ K_i^E = P_i^E + c(\delta - 1) + \frac{\varphi^2}{2(\varphi+\chi)}(b_0 - \hat{b}^E)(b_0 + 3\hat{b}^E - 2B^E), i = 1, 2. \end{cases} \tag{2.16}$$

Comparing equation (symmetric results) with (2.16), we deduce the following results :

Proposition

Proposition 2 (Changes in reporting positions and prices)**.** *When conditions in equation* (B.2) *and the conditions in Lemma 1 are satisfied, we have :*

i) There exists at least one solution for the reporting position of the print private newspapers at the symmetric equilibrium, denoted as $B^*(= -B_1^* = B_2^*)$, and $B^* < B^E$ and $(B^o)^* < B_0^E$. The print and online private newspapers get less extreme after introducing a third public-interest newspaper if the data source is accurate.

ii) $\frac{\partial B^*}{\partial b_0} \geq 0$. The reporting position at the equilibrium B^* increases with the opinions of the extremest readers (b_0).

iii) $P_i^E \geq P_i^*$ and $K_i^E \geq K_i^*$. When we introduce a third public-interest newspaper firm without slant, the prices of both print and online versions of the two private newspapers will drop.

Proof. See online appendices B.5. □

Competition between public and private firms will lower prices and increase the quality of news reports. The reporting position at equilibrium is lower than $\dfrac{b_0}{2}$ when the variance of the data source is low enough, i.e. $v_d \leq 0.6037(b_0)^2$. Note that the precision or accuracy of the data source is defined as $\dfrac{1}{v_d}$, which means when the data source is less precise or accurate, the print newspaper will get more biased. In fact, when the variance of the data source is lower than

9. Derived from equations (11), (12), (14) and proposition 1 in the model of Yildirim, Gal-Or et Geylani 2013.

$0.6037(b_0)^2$, there are three solutions for the reporting position at equilibrium, two of which are located between 0 and $\frac{b_0}{2}$, and one between $0.77b_0$ and $0.895b_0$. As long as the variance of the data source is higher than $0.6037(b_0)^2$, the position of a print newspaper becomes bigger than $0.895b_0$ and increases with both the variance of the data source (v_d) and the extremist opinions of its readers (b_0). Therefore, the reporting position at equilibrium after introducing a third public-interest newspaper can be less extreme than the reporting position when there is only a print newspaper, i.e. $\frac{3}{2}b_0$ in the model of Mullainathan et Shleifer 2005, or when there is no third public-interest newspaper (B^E and B_0^E in the model of Yildirim, Gal-Or et Geylani 2013).

The intuition behind this result is simple. The introduction of a third public-interest newspaper will only be effective when it can capture a share of the market. The market share of the public-interest newspaper increases with a decreasing v_d, i.e. a higher precision of data. A lower value of v_d means a higher share of the market which is occupied by the public-interest newspaper, thus there will be more unbiased news reports in the market. What's more, the price functions of two private newspapers increase with the value of reporting positions. The private newspapers will drop their prices to attract more readers, which implies a lower value of reporting position.

This result corresponds to the existing findings about the effects of the Internet and demand-side bias on the quality of news reports. More competition is argued to help improve the quality of news reports, i.e. to reduce the media bias from the supply side, especially when there is the manipulation of information by the government or media owners (Gentzkow et Shapiro 2006, Chan et Suen 2008, Anderson et McLaren 2012, Blasco et Sobbrio 2012, Gentzkow, Shapiro et Sinkinson 2014, Foros, Kind et Sørgard 2015). However, when the demand-side bias (Rabin et Schrag 1999, Mullainathan et Shleifer 2005, Xiang et Sarvary 2007, Burke 2008, Garz et al. 2018) is taken into consideration, competition in the media market may lead to more biased news as media outlets are prone to cater to their consumers' biased opinions (Gentzkow et Shapiro 2006, Gentzkow et Shapiro 2008, Becker et al. 2009, Germano et Meier 2013, Behringer et Filistrucchi 2015). The cognitive bias from the readers incites them to search for a group of people who share similar opinions with them, which enforces their prior beliefs, fosters the polarization of ideas, and makes extremists' voices louder (Sunstein 2006, Chan et Suen 2009, Gentzkow et Shapiro 2010, Gentzkow et Shapiro 2011,Flaxman, Goel et Rao 2016, Napoli 2018, Luo 2017). The "filter bubble" or "echo chamber" effects of social media and the Internet have enhanced the dissemination of false information online are also proved by empirical studies (Mocanu et al. 2015, Allcott et Gentzkow 2017, Guess, Nyhan et Reifler 2018, Vosoughi, Roy et Aral 2018, Grinberg et al. 2019, Henry, Zhuravskaya et Guriev 2022).

The policy of introducing a third public-interest newspaper can be effective in decreasing news bias if the data source is accurate, which emphasizes the important role of fact-checking (imposed or voluntary, as shown in Henry, Zhuravskaya et Guriev 2022) or cross-checking in deterring fake news, especially for online news. There is a rising work of using AI and big data by content analysis to detect misinformation or disinformation (Rashkin et al. 2017, Krause et al. 2020, Walter et al. 2020...). Many newspapers in Europe have already installed fact-checking sites to verify the public published figures or information online : for example, the "Desintox" section of *Liberation*, and "True or Fake" of *France Info* in France ; the Reality Check blog of the *Guardian* and the Full Fact site in the UK ; the Münchhausen-Check of *Der Spiegel*, the Faktomat of *Die Zeit*, and the ZDFcheck of ZDF television in Germany ...(Graves et Cherubini 2016).

2.4 Extensions

We have shown that the government regulation of a duopolistic newspaper market by introducing a third public newspaper without slant can be effective if the data source of the newspaper is accurate ($v_d \leq 0.6{b_0}^2$). Now we turn to examine the effects of two other regulatory policies : price-cap regulation and taxation.

2.4.1 Price-cap regulation

We now turn to another regulatory policy, price-cap regulation, to see its effects on deterring slanting in the newspaper market.

Price cap regulation has a long history in the telecommunication industry, especially in the postal sector (Littlechild 1983, Crew et Kleindorfer 1996, Villemeur et al. 2003). Suppose that the government sets price caps $\overline{P}$ for the print newspapers and $\overline{K}$ for the digital versions. The payoff functions for the two private newspapers under price regulation are then :

$$\begin{cases} \overline{\Pi}_1 = \frac{(\hat{b}_1+b_0)}{2b_0}(\overline{K} - c\delta) + \frac{(b_{ind}-\hat{b}_1)}{2b_0}(\overline{P} - c) \\ \overline{\Pi}_2 = \frac{(b_0-\hat{b}_2)}{2b_0}(\overline{K} - c\delta) + \frac{(\hat{b}_2-b_{ind})}{2b_0}(\overline{P} - c) \end{cases} \tag{2.17}$$

Since $\frac{\partial\overline{\Pi}_1}{B_1^*} \geq 0$, $\frac{\partial\overline{\Pi}_2}{B_2^*} \leq 0$, $\frac{\partial\overline{\Pi}_1}{(B_1^o)^*} \leq 0$, and $\frac{\partial\overline{\Pi}_2}{(B_2^0)^*} \geq 0$, print newspapers tend to locate at the center with $\overline{B}_1 = 0, \overline{B}_2 = 0$, and online versions locate at the end with $\overline{B}_1^o = -b_0, \overline{B}_2^o = b_0$. [10]

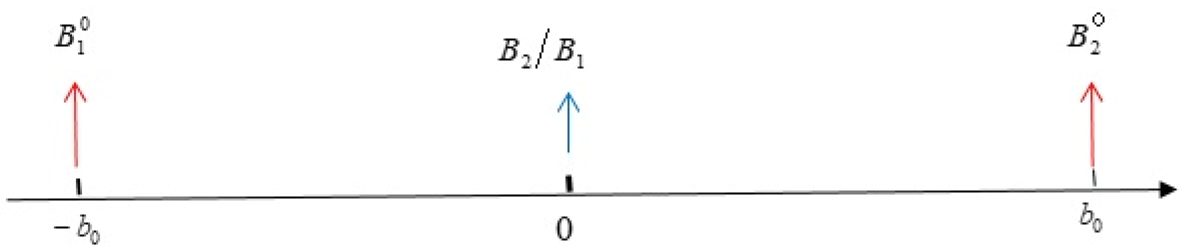

Figure 2.5 – *The reporting positions under price regulation.*

Therefore, we can obtain the following observations (see Fig. 2.5) :

Proposition 3 (Effects of price-cap regulation)**.** *Under price-cap regulation, the equilibrium reporting positions of newspapers are* $(\overline{B}_1^o, \overline{B}_1, \overline{B}_2, \overline{B}_2^o) = (-b_0, 0, 0, b_0)$ *; and the slanting strategies are* $(\overline{s}_1^o(d_1), \overline{s}_1(d_1), \overline{s}_2(d_2), \overline{s}_2^0(d_2))$

$$= \left(\frac{-\varphi}{(\varphi+\chi)}(b_0 + d_1), \frac{-\varphi d_1}{(\varphi+\chi)}, \frac{-\varphi d_2}{(\varphi+\chi)}, \frac{\varphi}{(\varphi+\chi)}(b_0 - d_2)\right).$$

10. We suppose $\overline{P} - c \geq \overline{K} - c\delta$, although the results still stand if we relax this assumption, see online appendices for more discussions.

Proof. See online appendices B.6. □

Price-cap regulation has effectively decreased the bias from print newspapers but not the online ones. When there are price-caps for the print and online newspapers, both versions will set the prices at the maximal level, i.e. $\overline{P_i}$ and $\overline{K}_i$. The profit of the print newspaper i decreases with the reporting position, while the online version's payoff increases with the reporting position. Hence, both print newspapers tend to move toward the median readers to maximize their profits ($B_1 = B_2 = 0$) as in Guo et Lai 2015, while the online newspapers, on the contrary, move away from the center by offering different products, i.e. $-B_1^o = B_2^o = b_0$. When there are price caps, newspapers face less price competition stress and will compete on the quality of the news reports. Print newspapers cater to the "median" readers with neutral and objective news reports and will occupy more readers, while online versions search for product differences and thus cater to the extreme readers.

Moreover, price-cap regulation will not produce a lower quality as shown in Crew et Kleindorfer 2002, Armstrong et Sappington 2007, Armstrong et Porter 2007, Sappington et Weisman 2010, and that is the same case with the market for news. If the government sets price caps for print and online newspapers, print newspapers will report zero expected slants, while online newspapers will report socially undesirable extreme news. However, print newspapers get more consumers. As the price of a print newspaper is higher than that of an online one, the newspaper firm will try to get more market share for the print version. The print version of the newspaper captures a higher share of the news market than its online one as α increases and will totally crowd out the extreme online version when user-generated content plays an important role in deciding the online news' position (i.e. $\alpha = 1$).

2.4.2 Subsidy for truthful reporting (or tax on media bias)

We propose a "slanting-based tax" or a "tax on misinformation" **T** on the slanting level from the media outlets. In the same vein, if the media outlets have a high reputation for reporting truth and verity, they can receive a subsidy (**T** < 0).

The payoffs of the two private newspapers in (2.6) then become :

$$\begin{cases} \Pi_1^T = \dfrac{(\hat{b}_1 + b_0)K_1}{2b_0} + \dfrac{(b_{ind} - \hat{b}_1)P_1}{2b_0} - T\left(E_d(s_1(d_1)^2) + E_d({s_1}^0(d_1)^2)\right) \\ \Pi_2^T = \dfrac{(b_0 - \hat{b}_2)K_2}{2b_0} + \dfrac{(\hat{b}_2 - b_{ind})P_2}{2b_0} - T\left(E_d(s_2(d_2)^2) + E_d({s_2}^0(d_2)^2)\right). \end{cases} \tag{2.18}$$

Optimizing the news payoff functions with respect to p_i, $i = 1, 2$ yields the same results for prices at the last stage, as did in Yildirim, Gal-Or et Geylani 2013 :

$$\begin{cases} P_1^T = c + \frac{\varphi^2}{(\varphi+\chi)}(B_2 - B_1)(\frac{(B_2+B_1)}{3} + 2b_0); \\ P_2^T = c + \frac{\varphi^2}{(\varphi+\chi)}(B_2 - B_1)(-\frac{(B_2+B_1)}{3} + 2b_0); \\ K_1^T - P_1^T = -c(1-\delta) + \frac{\varphi^2}{(\varphi+\chi)}\frac{(b_0+\hat{b}_1)(b_0-3\hat{b}_1+2B_1)}{2}; \\ K_2^T - P_2^T = -c(1-\delta) + \frac{\varphi^2}{(\varphi+\chi)}\frac{(b_0-\hat{b}_2)(b_0+3\hat{b}_2-2B_2)}{2} \end{cases}$$

We only consider the symmetric equilibrium results ($-B_1 = B_2 = B, -\hat{b}_1 = \hat{b}_2 = \hat{b}, b_{ind} = 0.$). Then we get $P_1^T - c = P_2^T = -c = P^T - c = \frac{\varphi^2}{(\varphi+\chi)^2}4b_0B$, $K_1^T - c\delta = K_2^T - c\delta = K^T - c\delta = \frac{\varphi^2}{(\varphi+\chi)^2}4b_0B + \frac{\varphi^2}{(\varphi+\chi)^2}\frac{(b_0-\hat{b})(b_0+3\hat{b}-2B_2)}{2}$. Substitute the P^T and K^T into the payoff functions under tax in equation (2.18) and maximize the new payoff functions regarding B_i and B_i^0, we can then get the reporting positions at the first stage, taking B_2 for example :

$$\frac{\partial \Pi_2^T}{\partial B_2} = \frac{\partial \Pi_2}{\partial \hat{b}_2}\frac{\partial \hat{b}_2}{\partial B_2} + \frac{\partial \Pi_2}{\partial b_{ind}}\frac{\partial b_{ind}}{\partial B_2} + \frac{\partial \Pi_2}{\partial b_{ind}}\frac{\partial b_{ind}}{\partial P_1}\frac{\partial P_1}{\partial B_2} - 2B_2T\frac{\varphi^2}{(\varphi+\chi)^2} = 0$$

$$[(-B_1 = B_2 = B, \alpha = 1, c = 0)](\text{Symmetric Solutions})B^T = \frac{\left((\hat{b}_2)^2 + (b_0)^2\right)}{4b_0(\frac{T}{(\varphi+\chi)} + \frac{1}{3})}$$

We can then draw the following conclusions :

Proposition 4 (Effects of subsidy/taxation policy)**.** *Under tax regulation, the symmetric reporting positions at equilibrium are :*

$$-(B_1^T)^* = (B_2^T)^* = (B^T)^* = \frac{\left((\hat{b})^2 + (b_0)^2\right)}{4b_0(\frac{T}{(\varphi+\chi)} + \frac{1}{3})}$$

$$-((B_1^0)^T)^* = ((B_2^0)^T)^* = ((B^0)^T)^* = \frac{\left((\hat{b})^2 + (b_0)^2\right)}{4b_0(\frac{T}{(\varphi+\chi)} + \frac{1}{3})} + \frac{(b_0 + \hat{b})}{2}$$

The reporting positions of the (print and online) newspapers at equilibrium decrease with the tax level T, but increase with the vectors of readers' sensibility to media bias $\varphi + \chi$.

Proof. See online appendices B.7. □

When government imposes a tax on media slanting, the reporting positions of the (print and online) newspapers at equilibrium decreases with the tax level T, increases with the vectors of readers' sensibility to media bias $\varphi+\chi$ and the position of marginal readers ($\hat{b}$) and the extremest readers' position (b_0). The higher the tax is, the fewer readers are sensitive to media bias, and the more extreme the readers are (e.g. when $\hat{b}$ approaches 0 or b_0), the more biased the newspapers will become. Equilibrium prices increase with the slanting level (B) and decrease with the tax level (T). When the other conditions remain unchanged, taxation can decrease the slanting level of print and online newspapers.

2.4.3 The average bias level

Define the average bias level (**ARB**) for the heterogeneous readers as : [11]

$$ARB = \int_b E_d[(n_i - d_i)^2] = \frac{\varphi^2}{2b_0(\varphi+\chi)^2}\Big((\hat{b}_1 + b_0)(B_1^0)^2 + (b_{ind} - \hat{b}_1)(B_1)^2 + (\hat{b}_2 - b_{ind})(B_2)^2 + (b_0 - \hat{b}_2)(B_2^0)^2\Big)$$

We can compare the average bias level under the above three different regulation policies : [12]

1) Socially optimal, $(-B_1^0, B_1, B_2, B_2^0) = (-\frac{b_0}{2}, 0, 0, \frac{b_0}{2})$, so :

$$(ARB)^{(SW)} = \frac{\varphi^2}{(\varphi+\chi)^2}\frac{b_0(b_0 - \hat{b})}{4}$$

2) Under price-cap regulation, $(-B_1^0, B_1, B_2, B_2^0) = (-b_0, 0, 0, b_0)$, so :

$$(ARB)^{(PR)} = \frac{\varphi^2}{(\varphi+\chi)^2} b_0(b_0 - \hat{b})$$

3) Under tax regulation :

$$(ARB)^T = \frac{\varphi^2}{(\varphi+\chi)^2}\left((B^T)^2 + \frac{((b_0)^2 - (\hat{b})^2)}{b_0}B^T + \frac{(b_0 - \hat{b})(b_0 + \hat{b})^2}{4b_0}\right),$$

$$(B^T)^* = \frac{\Big((\hat{b})^2 + (b_0)^2\Big)}{4b_0(\frac{T}{(\varphi+\chi)} + \frac{1}{3})}$$

For $(ARB)^T \leq (ARB)^{(PR)}$, we need $(B^T)^2 + \frac{((b_0)^2-(\hat{b})^2)}{b_0}B^T + \frac{(b_0-\hat{b})(b_0+\hat{b})^2}{4b_0} \leq b_0(b_0 - \hat{b})$, i.e. $(B^T)^2 + \frac{((b_0)^2-(\hat{b})^2)}{b_0}B^T - \frac{(b_0-\hat{b})^2(3b_0+\hat{b})}{4b_0} \leq 0$, which always holds true.

Proposition 5 (The average bias level). $(ARB)^{PR} > (ARB)^T > (ARB)^{SW}$.*The average bias level under taxation is lower than that under price-cap regulation.*

11. As in MS 2015, the average bias is defined as "the average amount by which the news read deviates from the data for the average reader".
12. Again, we only see the symmetric solutions for analytic and mathematical reasons.

Proof. See online appendices B.8. □

The average bias is measured by the average value of the media slanting, i.e. the difference between the news reports and the data collected. The average bias level increases with the position of the extremest readers (b_0) and the reporting position of the newspapers (B^T) at equilibrium. It also decreases with the proportion of the two bias-dislike vectors (the slanting-dislike vector to the preference for confirmatory bias, i.e. $\frac{\chi}{\varphi}$). Tax policy can then effectively decrease the average bias level compared to price-cap regulation.

Due to the knowledge externalities of newspapers and the importance of keeping citizens informed, it is necessary to support the circulation of different newspapers and halt the morality of print newspapers. Tax policy such as a reduced value-added tax (VAT) or subsidy (a negative tax value) is often used to improve pluralism in the media market. Opponents often reckon that a ”tax on knowledge” will reduce newspaper circulation (Nielsen et Linnebank 2011).

Nevertheless, these arguments do not take the quality of the news and the two sides of the media market into consideration. Misinformation in the media markets should be considered as a ”public bad” and thus the ”tax on misinformation” is more like a sin tax. What’s more, some studies show that a higher tax will decrease the prices and increase the consumption in the two-sided markets such as media markets (Kind, Koethenbuerger et Schjelderup 2008, Kind, Schjelderup et Stähler 2013, Kind et Koethenbuerger 2018, Foros, Kind et Wyndham 2019). Due to the special characteristics of two-sided markets, news proposals such as a user-based revenue tax in the digital market. The EU digital service taxation (DST), and the UK Diverted Profits tax for instance, are discussed by many researchers (Cui et Hashimzade 2019, Cui 2019, Köthenbürger 2020).

2.5 Conclusion

The market for news is different from the traditional product market due to the special characteristics of their market and their product. Therefore, the regulatory policies targeting the media market, especially the digital market should be re-examined. Current regulatory policies in the digital media market concentrate on either competition law or online content moderation legislation. This paper examines the effects of three different regulatory policies on reducing media bias in a duopolistic newspaper market where print newspapers and digital newspapers coexist : introducing a public-interest firm without slant, price-cap regulation, and taxation.

The effects of the three regulatory policies are different. Firstly, introducing a third public-interest newspaper firm without slanting can reduce media bias if the data source is accurate. Secondly, under price regulation, print newspapers are less biased but online news reports get more extreme. Thirdly, a well-designed tax policy is more effective than price-cap regulation in reducing media bias. The average bias level under tax policy is also lower than that under the price-cap regulation policy. These findings shed light on policy implementations for media outlet regulation when offline media outlets and online platforms coexist. Policymakers should not only consider the effects of regulatory policies on prices and consumption but also their effects on the quality of news, especially in the digital market. The results in this model emphasize the importance of fact-checking and the role of extreme readers' opinions in the newspaper market, which are consistent with some new regulatory policies such as the EU digital service tax (DSA). Future research can extend this paper by considering : i) the multi-homing of consumers in a digital market; and ii) a two-sided market for taxation or price-cap regulation.

Chapitre 3

Does the use of online media make society more polarized ? Theory and evidence.

Abstract. Does the use of online media make our society more polarized ? This paper studies the impact of the use of online media on social polarization and political polarization. In a simple political voting game, we estimate that a higher level of use of social media will increase the polarization of media reports and also the partisan voters in society. Using panel data of 198 countries between 2000 and 2021 from the V-Dem data-set, we find that a higher level of use of online media in a country does increase the level of polarization in society (both social polarization and political polarization). The results are robust to a number of specifications, including an instrumental variable approach that addresses the endogeneity of internet penetration. What's more, the relationship between the use of online media and social polarization or political polarization differs from the countries according to their income level. The results also show different relationships between other economic and social explanatory factors and polarization, such as income inequality, government expenditures, and globalization.

Online media, political polarization, social polarization, panel data.

JEL Codes : C23, O11, O33.

3.1 Introduction

As social media becomes a more and more important source of information for people in many countries, many researchers relate the rising polarization to the use of online media. For example, many citizens in European countries get their news frequently from social media, and many of them do not verify the sources of their news according to a report by the Pew Research Center. In European countries such as France and Italy, people with extreme opinions often get their news through social media [1].

Is the use of online media a driver of polarization in our society ? Existing literature on the effects of social media on polarization shows different results. Most of the work focuses on the use of social media platforms within one country, such as the effects of using Facebook and Twitter during the 2012 election in the US or during Brexit. Few literature looks at the cross-country effects of the use of social media on polarization. This paper sheds light on this question at a cross-country level.

This paper examines the effects of social media on both political polarization and social polarization using panel data from over 200 countries from 2000 to 2021 from the V-Dem data set. We find that a higher level of online media use in a country does increase the level of social and political polarization. The results are robust to an instrumental variable approach that addresses the endogeneity of the use of online media. The results also show that the effects of the driven factors of polarization differ across countries according to their income level and the level of democracy.

Our paper is related to the literature on measuring the determinants of polarization. Political polarization is defined as the grouping of people into two extreme positions, such as elite polarization or mass polarization (Fiorina, Abrams et al. 2008, Singer et al. 2019). Researchers also distinguish “affective polarization” (or “ideological polarization”) from “social polarization” :

1. https://www.pewresearch.org/journalism/2018/05/14/in-western-europe-public-attitudes-toward-new

the former measures the extent to which a person's ideology and identity are associated with their preferred political party, and the latter measures the divisions of the public's attitudes towards some important social, cultural, or political issues, such as social welfare, abortion, immigration (Iyengar et al. 2019, Boxell, Gentzkow et Shapiro 2020, Draca et Schwarz 2021)… This paper involves the measurement of both political and social polarization.

Many economic and social factors have been proven to be important in determining polarization in the existing literature. One of the most mentioned is income inequality (Londregan et Poole 1996, Pontusson et Rueda 2008). Grechyna 2016 shows that income inequality and social networks (measured by distrust) are the main drivers of mass attitude polarisation using the World Value Survey data. Winkler 2019 proves evidence that increasing inequality has led to more support for far-right political parties in 25 European countries in recent years. More government expenditures are also proven to reduce polarization (Jha et Gozgor 2019). For example, the shrinking spending for welfare and social protection after 2011 is proven to be a strong driving factor behind Brexit (Fetzer 2019, Becker, Fetzer et Novy 2017). However, some argue that higher government spending decreases political polarisation in democratic countries, but not in non-democratic countries (Lindqvist et Östling 2010). Thirdly, globalization is also mentioned as an important determinant of polarization (Pleninger et Sturm 2020). On the one hand, globalization can increase income inequality, thus will increase polarization (Sturm et De Haan 2015). For instance, the "Leave" votes in the Brexit referendum are higher in regions that are hit harder by economic globalization (Colantone et Stanig 2018a). Globalization may also lead to different ethical, ideological, and religious polarization. The switching votes for Trump in the 2016 presidential election in the US are shown to be highly correlated to globalization-related attitudes (Berggren et Nilsson 2015, Dorn, Hanson, Majlesi et al. 2020, Rodrik 2021). On the other hand, globalization is argued to alleviate polarization by increasing public spending (Adam et Ftergioti 2019, Heimberger 2021).

Our results complement the empirical literature of examining the relationship between online media and polarization at a cross-country level. Existing empirical evidence about the effects of social media on polarization is mixed. Studies have shown that the use of social media helps users get more diverse opinions and thus can decrease polarization. For example, Barberá 2014 shows that social media helps users to get more exposure to their "weak ties" and it then decreases mass political polarization in Germany, Spain, and the U.S. Boxell, Gentzkow et Shapiro 2017 also proves that political polarization has increased among older voters in the US, who do not often use social media. More research focuses on the "echo chamber", "bubble filter", or "homophily" effects of social media. They prove that users on platforms such as Facebook and Twitter prefer like-minded opinions instead of opposing opinions, which induces partisan bias and segregation online and thus leads to more support for extreme parties (Melki et Pickering 2014, Bakshy, Messing et Adamic 2015, Halberstam et Knight 2016, Duca et Saving 2017, Lelkes, Sood et Iyengar 2017, Sunstein 2018, Yanagizawa-Drott, Petrova et Enikolopov 2019, Mitchell et al. 2019). Our results confirm the effects of the use of online media on increasing polarization in our society.

The rest of the paper is structured as follows : Section 3.2 presents the theoretical model, Section 3.3 describes empirical results ; and Section 3.4 concludes.

3.2 Theoretical framework

3.2.1 Set-up

There are three types of players : 2 political parties, 2 media outlets, and voters. Two office-motivated political candidates $i = \{L, R\}$ announce their policies on media outlets. We suppose that politician L is a left-wing candidate and R is a right-wing candidate.

Media outlets $j \in \{A, B\}$ report positive news n_i^j about their preferred candidate i. Media outlets have their ideological stances. Media outlet A is left-wing and reports positive news about candidate L and negative news about candidate R, and media outlet B is right-wing and reports positive news about candidate R and negative news about candidate L. Therefore, a left-wing partisan voter l gets informed from media A, and r gets informed from media B. A fixed proportion of these partisan voters, denoted by β, shares the content on social media. A centrist c is randomly informed by media outlets and/or social media. Media outlet j's objective is to maximize the total viewing time $T_j = \sum_{\theta\in\Theta} \mu_\theta t^*_\theta$ by choosing the reporting ratio n^j_i about candidate i, where μ_θ is the audience of type θ and t^*_θ is their reading time [2].

Citizens are distinguished by their political preferences with the type of $\theta \in \Theta = \{l, c, r\}$, where l is a left-wing partisan citizen, r is a right-wing partisan citizen, and c is a centrist. Suppose that the fraction of partisan citizens (l and r) is w, and the proportion of left-wing partisan citizen is $w\eta$, with $0 < w < 1$ and $0 < \eta < 1$. The utility of a citizen from getting information from a media outlet is $u^A = (\gamma + n^A_L - n^A_R)t - \frac{t^2}{2}$ from A, and $u^B = (\gamma + n^B_R - n^B_L)t - \frac{t^2}{2}$ from B, with $\gamma > 0$ the entertainment utility from viewing a media. The probabilities that a centrist is swung by the partisans on social media are P_L (to the left wing) and P_R (to the right wing).

The timing of the game is as follows :

Stage 1. Two media outlets $j \in \{A, B\}$ simultaneously choose their reporting ratios for each candidate $n^j_i \in \{0, 1\}^2$.

Stage 2. Partisan citizens share their political opinions on social media. Centrists get informed on social media, then a fraction of P_L of them are swung to left-wing voters, and P_R of them become right-wing.

Stage 3. Citizens (partisan and swung centrists) choose their likely-minded medium and decide their viewing time t^*_θ.

Stage 4. Citizens vote for their preferred political candidate.

2. The viewing time function and the utility function of viewers are based on the definitions in Bernhardt, Krasa et Polborn 2008.

3.2.2 Equilibrium analysis

The game is solved by backward induction.

Recall that the factions of left-wing citizens, right-wing citizens, and centrists are $w\eta, w(1-\eta), (1-w)$. Partisans l and r get informed from media outlets A and B, and they share their political opinions on social media. The proportion of centrists who are swung to the left wing is then $(1-w)P_L$, and $(1-w)P_L$ of them become right-wing, with $P_L = \frac{n_L^A - n_L^B + \beta w\eta}{2+w}$, $P_R = \frac{n_R^B - n_R^A + \beta w(1-\eta)}{2+w}$, where β stand for the fixed proportion of partisan readers who share biased "news" on social networks. Politician L wins the election if the majority votes for him, i.e. if $\mu_l = w\eta + (1-w)P_L > \frac{1}{2}$. Politician R wins otherwise.

By maximizing readers' utility with respect to their viewing time, we get the viewing time at equilibrium for left-wing and right-wing citizens. They are $t_l^* = \gamma + n_L^A - n_R^A$ and $t_r^* = \gamma + n_R^B - n_L^B$ respectively. The total viewing times are then $T^A = (1-\mu_r)t_l^* = (1-w(1-\eta)-(1-w)P_R)(n_L^A - n_R^A)$ for media outlet A, and $T^B = (1-\mu_l)t_r^* = (1-w\eta-(1-w)P_L)(n_R^B - n_L^B)$ for media outlet B. Media outlets choose their reporting ratios to maximize each total viewing time.

Define the reporting strategy (1,1) as full reporting, (1,0) as left-biased reporting, (0,1) as right-biased reporting, and (0,0) as no reporting. We have the following results at equilibrium :

Proposition 6 (Social media and polarization)**.** *i) The reporting strategies of both newspapers A and B are (1,1) at equilibrium if* $\eta \leq \min\{\frac{(1-\beta)w^2+(\beta+1)w+\gamma(1-w)-2}{(1-\beta)w^2+(\beta+2)w}, \frac{2+w-\gamma(1-w))}{(1-\beta)w^2+(\beta+2)w}\}$.

ii) When $\eta \in [\max\{\frac{(1-\beta)w^2+(\beta-1)w+\gamma(1-w)}{(1-\beta)w^2+(\beta+2)w}, \frac{3w-\gamma(1-w)}{(1-\beta)w^2+(\beta+2)w}\}, \frac{2+w}{(1-\beta)w^2+(\beta+2)w}]$*, newspaper A is left-biased and newspaper B is right-biased at equilibrium, that is, their strategies are (1,0) and (0,1) respectively.*

Proof. See appendix C.1. □

The full reporting situation happens when the proportion of the left partisans is less than a certain level. The higher the level of the utilization of social media (β), the stricter this condition becomes, and the less likely full reporting of political news from the media outlets will be. On the contrary, the condition for the biased reporting for two newspapers will become less strict as the level of utilization of social media increases.

The influence of social media in our model is direct. Non-partisans can not only be informed by ideological newspapers but also by the partisans online. Left partisans and right partisans share their political opinions on social media, and non-partisans get informed directly and quickly on the Internet. The swinging effect of newspapers and social media thus depends on the proportions of partisans. The use of social media forms a vicious circle. More partisans will lead to more biased and polarized newspapers that aim to cater to the ideological opinions of their partisan readers, thus more ideological content will be published on social media. As a consequence, more and more partisans will be influenced by biased newspapers and social media and society become more polarized around partisans and their sharply opposing political stances.

3.3 Empirics

3.3.1 Data and methods

We use the New Varieties of Democracy (V-Dem) database which includes up to 202 countries from 2000 to 2021(Mechkova et al. 2019) [3] to test the relationship between the use of social media and polarization.

3. We exclude the data before 2000 as the internet has not existed until around 2000, and three countries have been excluded due to lack of data.

3.3.1.1 Preliminary data analysis

Figure 3.1 and figure 3.2 show the trends of political polarization and social polarization after 2000. We can see an obvious increasing tendency of polarization in the world.

Figure 3.3 to 3.11 presents the bi-variate plots that show relationships between the variables of interest using averages of the variables for the years 2000–2021. Figure 3.3 and 3.4 show that there is a positive bi-variate relationship between social polarization and online media use, and a (slight) negative relationship between political polarization and online media use in all countries. If we look at the relationships separately in democratic regimes with polity scores of 8 or higher (Fig. 3.5 and Fig. 3.6) and in autocratic regimes with polity scores of 2 or lower (Fig. 3.7 and Fig. 3.8), the relationship is more significant in autocratic countries, especially for social polarization. There exists also slight differences between countries according to their levels of income (Fig. 3.9 to Fig. 3.11). From these figures, we can have the following predictions :

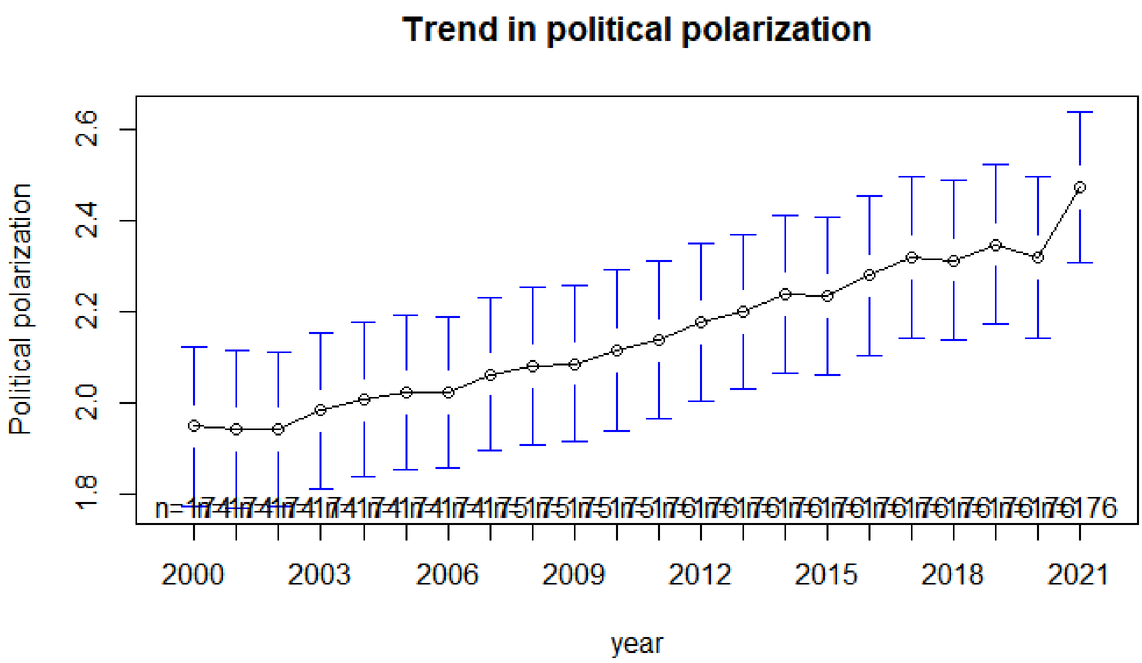

Figure 3.1 – Trend in political polarization from 2000 to 2021 (0 means no political polarization and 4 means a high level of political polarization).

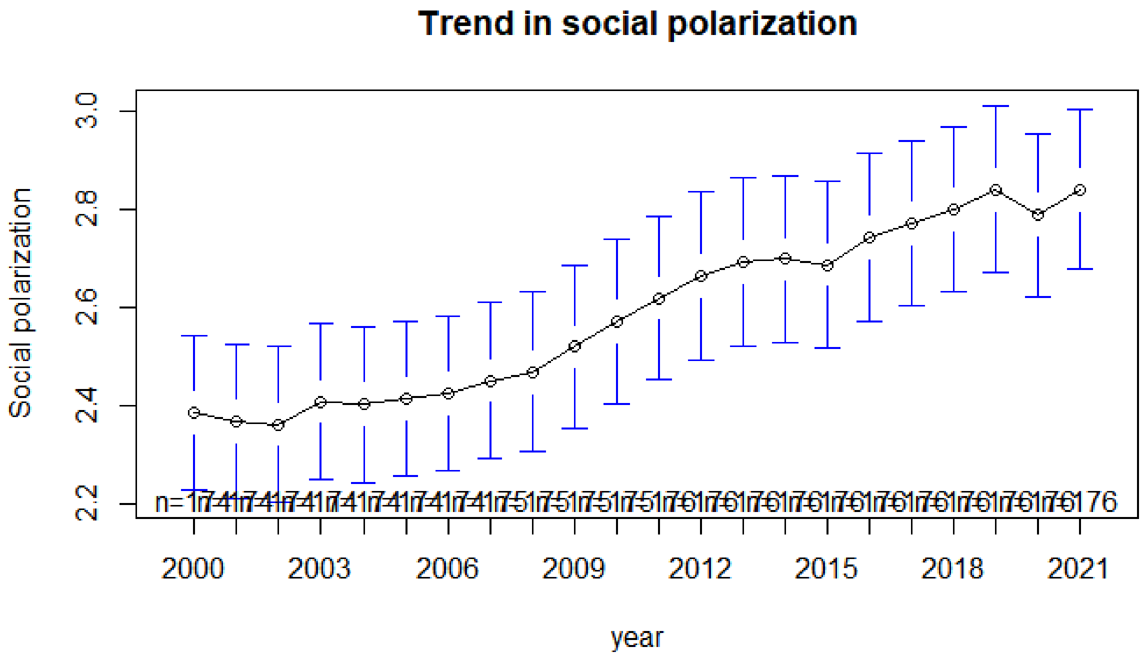

Figure 3.2 – Trend in social polarization from 2000 to 2021 (0 means no political polarization and 4 means a high level of political polarization).

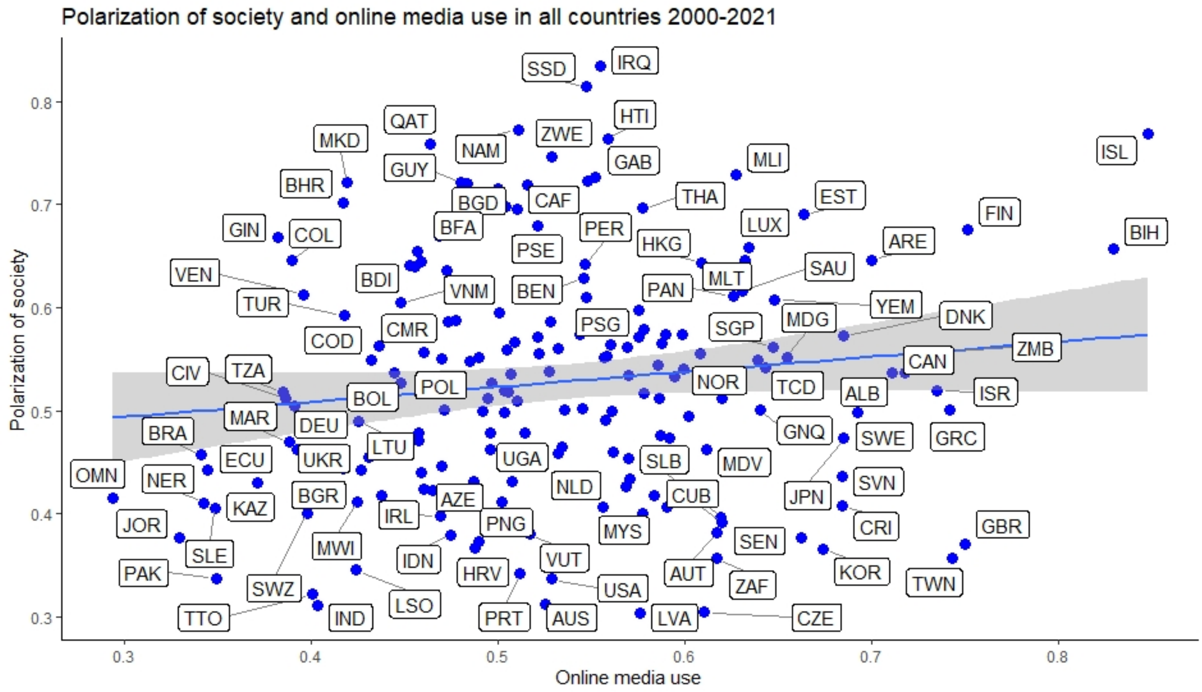

Figure 3.3 – *Social polarization and online media use in all countries 2000-2021.*

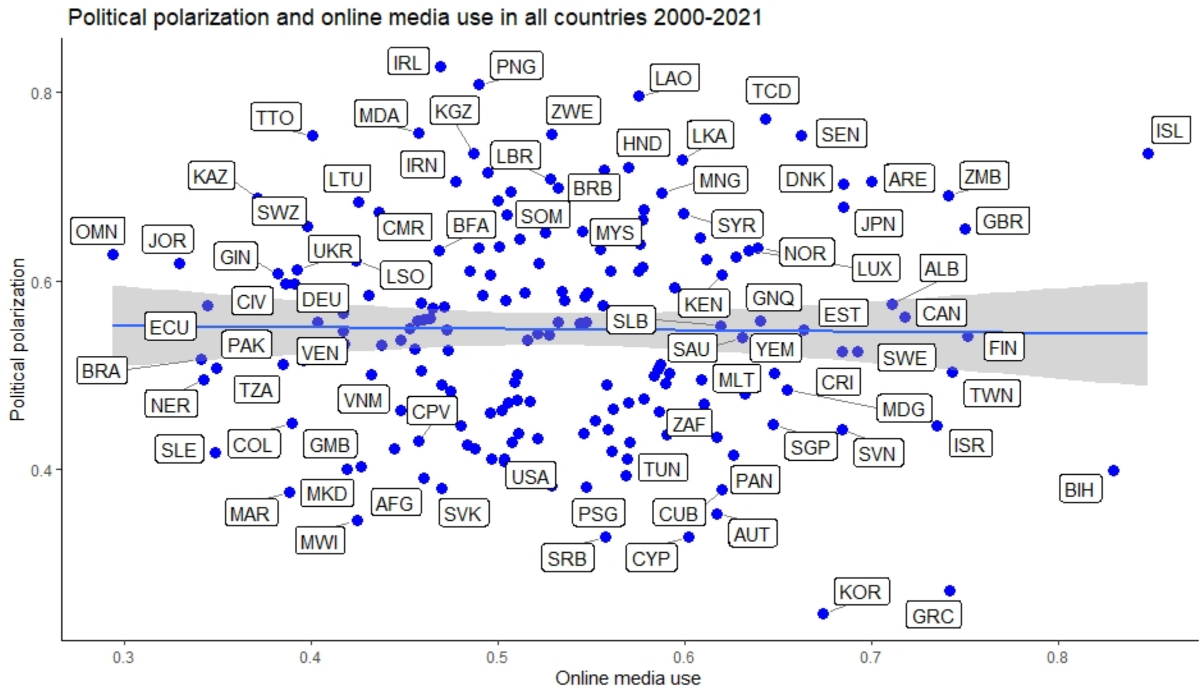

Figure 3.4 – *Political polarization and online media use in all countries 2000-2021.*

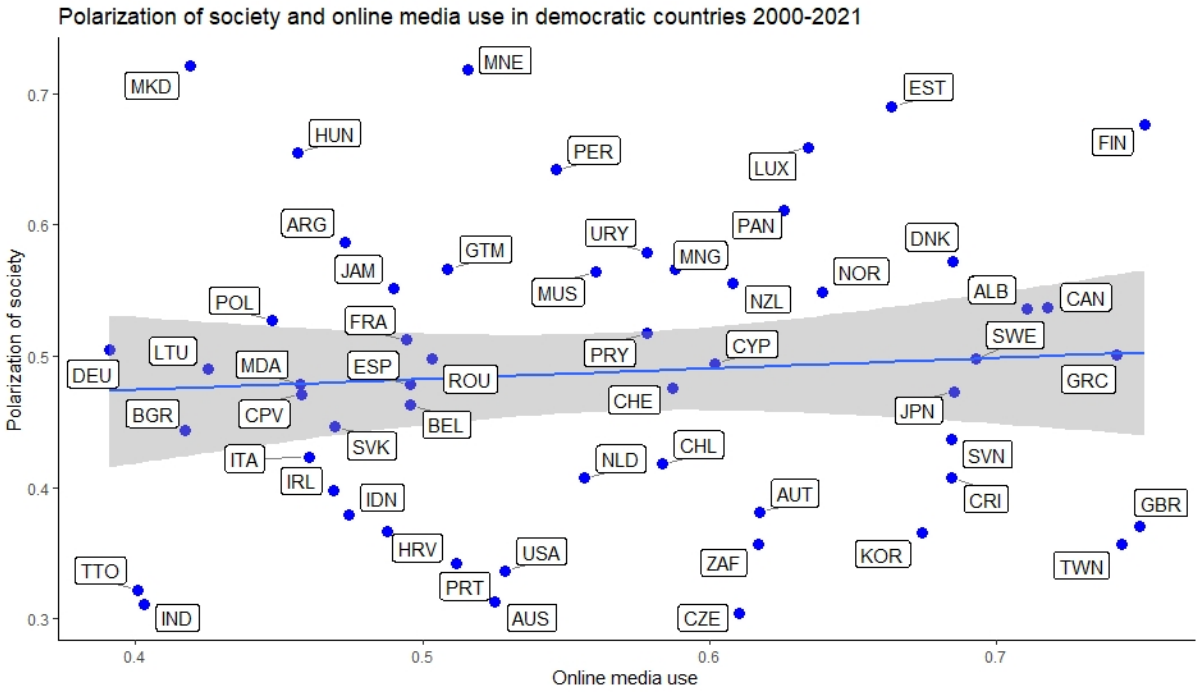

Figure 3.5 – *Social polarization and online media use in democratic countries (polity score ≥ 8) 2000-2021.*

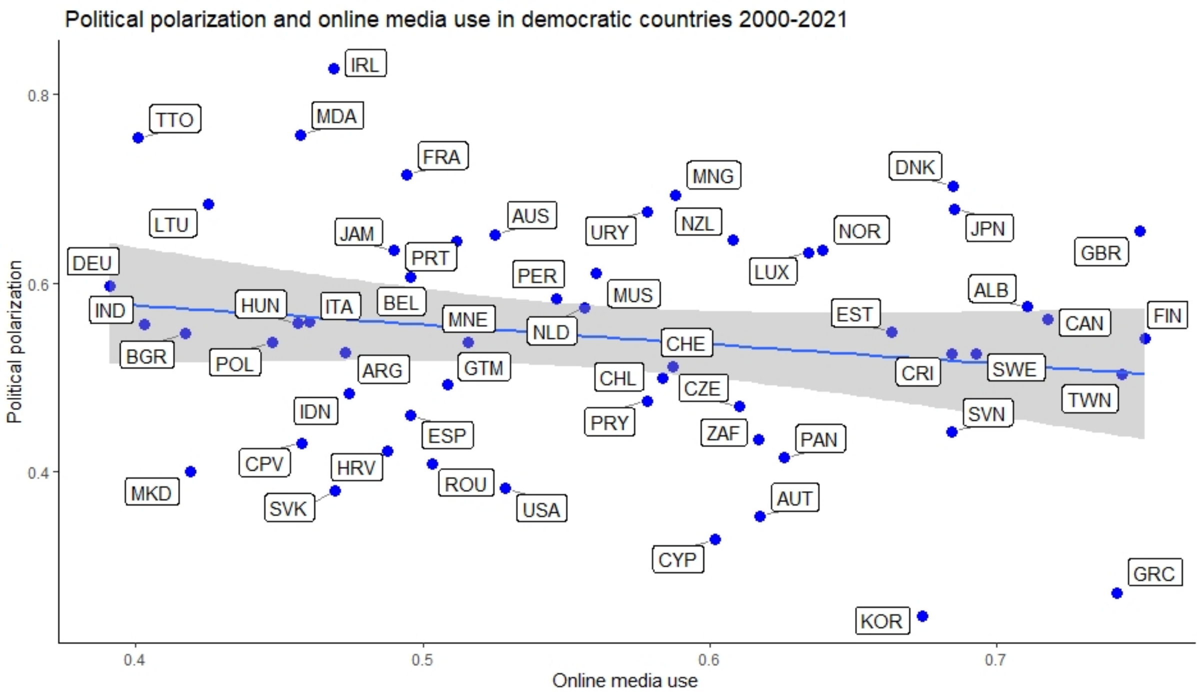

Figure 3.6 – *Political polarization and online media use in democratic countries (polity score ≥ 8) 2000-2021.*

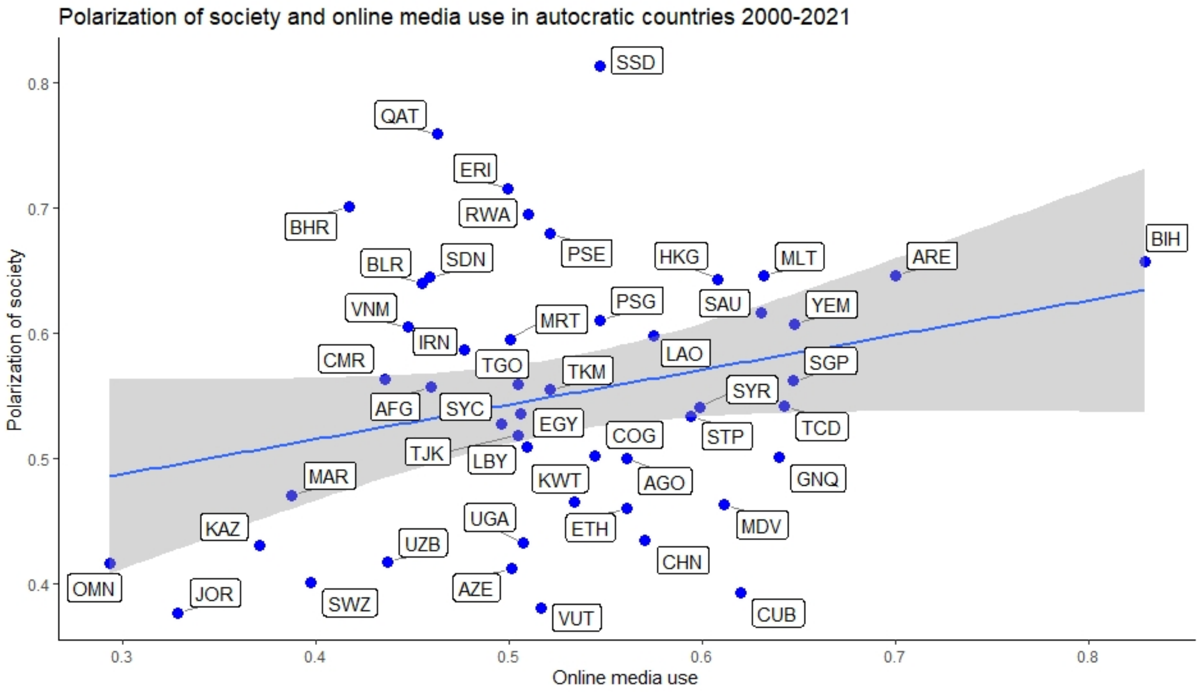

Figure 3.7 – *Polarization of society and online media use in autocratic countries (polity score ≤ 2) 2000-2021.*

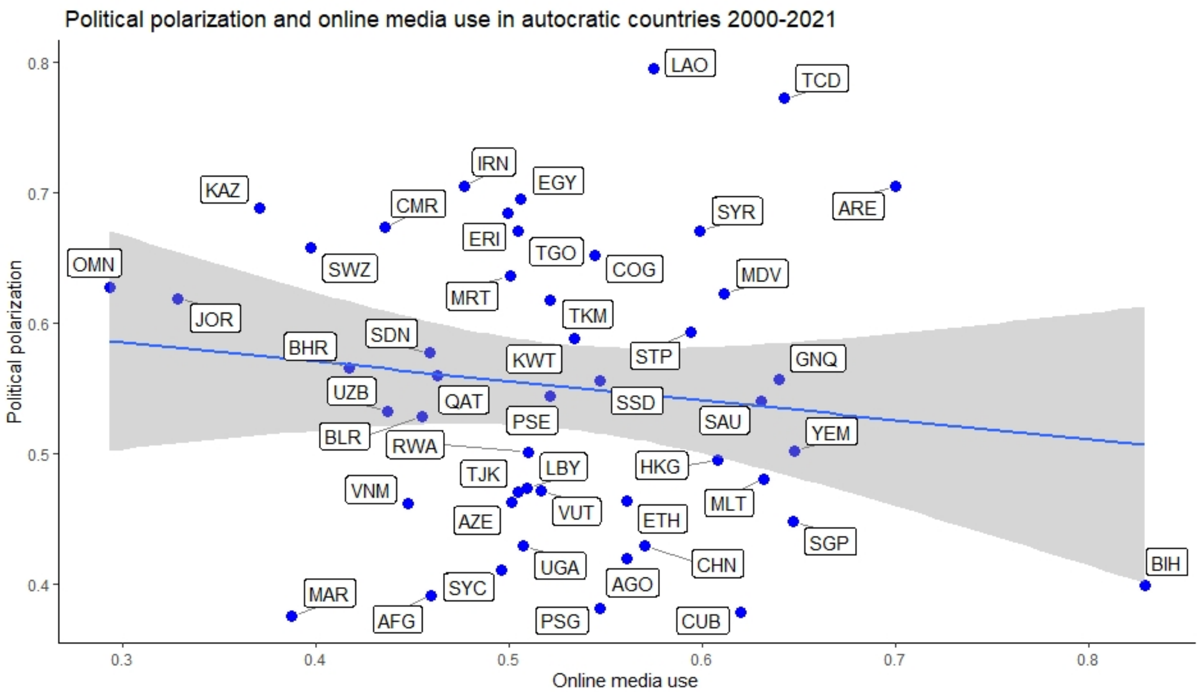

Figure 3.8 – *Political polarization and online media use in autocratic countries (polity score ≤ 2) 2000-2021.*

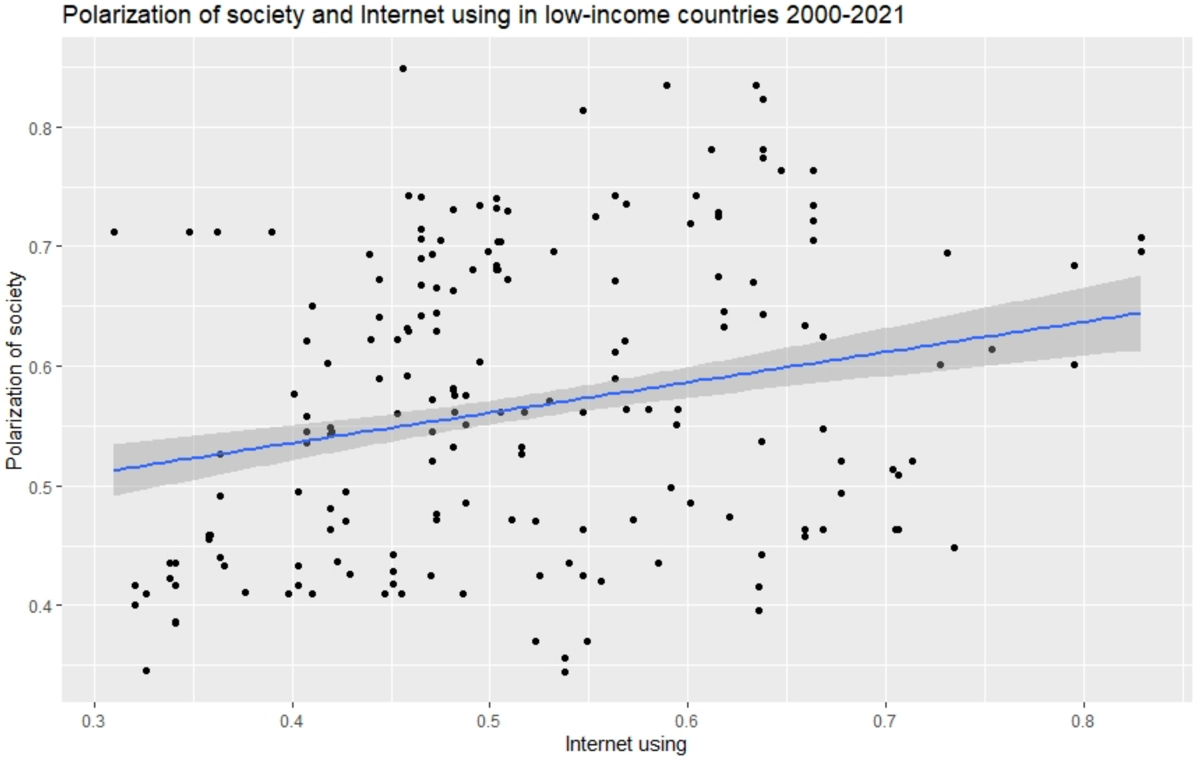

Figure 3.9 – *Internet using and social polarization in low-income countries.*

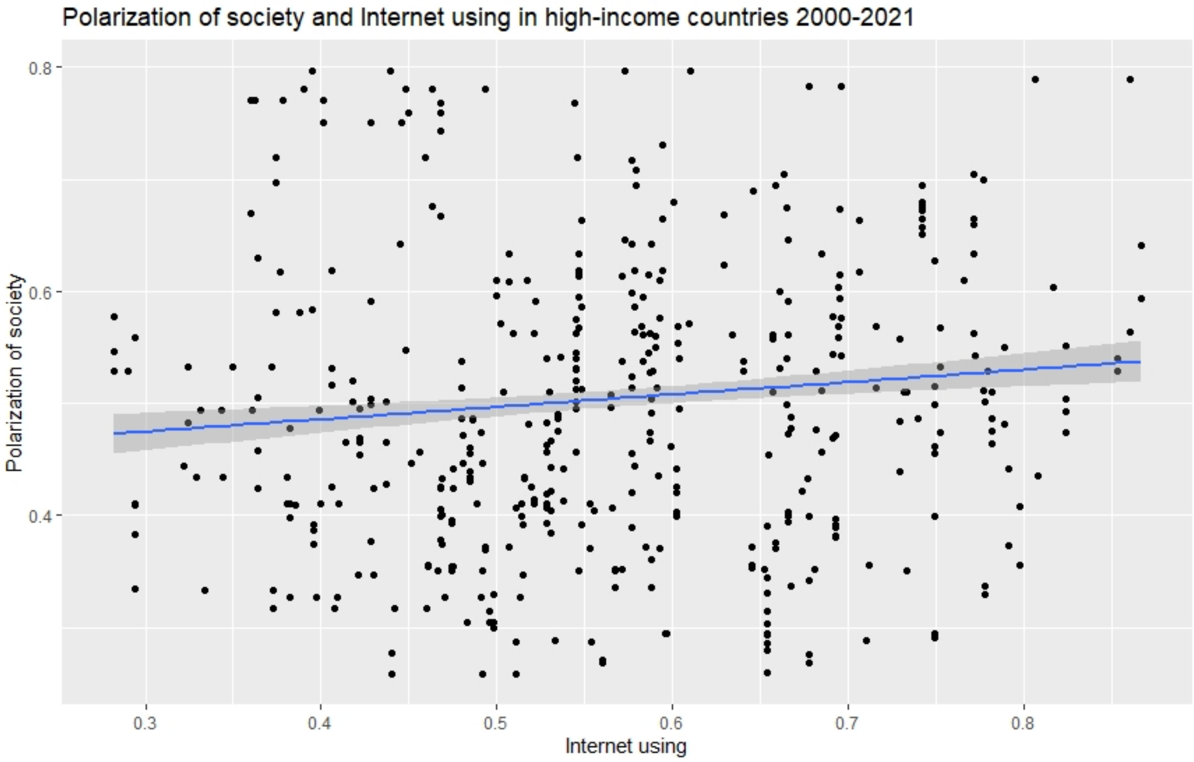

Figure 3.10 – *Internet using and social polarization in high-income countries.*

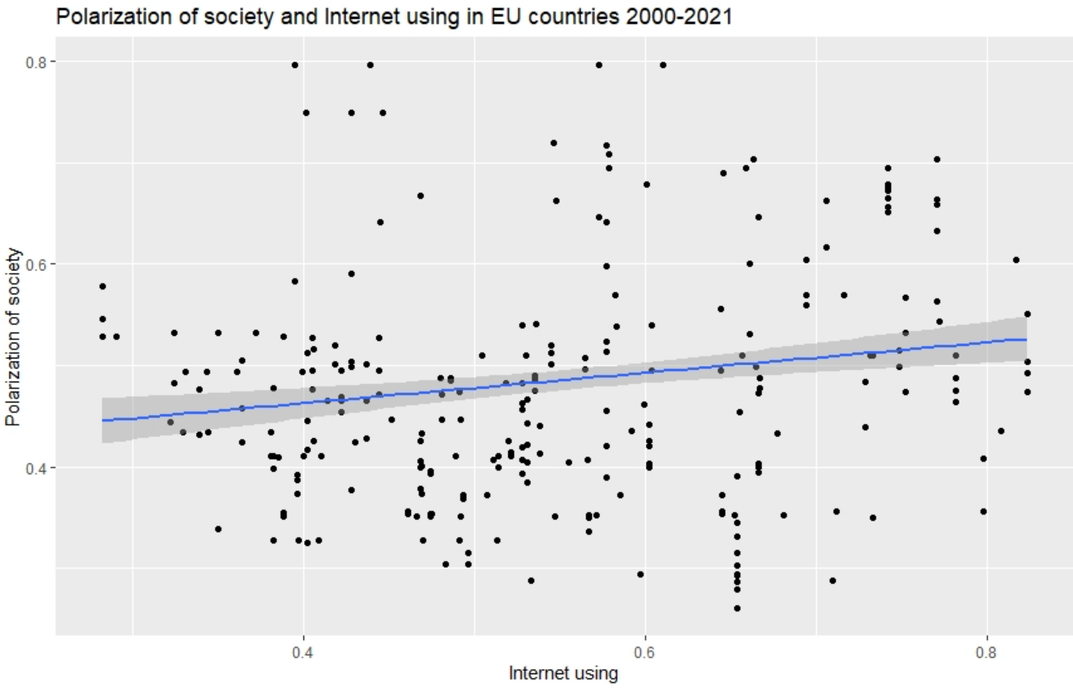

Figure 3.11 – *Internet using and polarization of society in European Union countries.*

From these figures, we can have the following predictions :

Hypothesis 1 : The use of online media has a positive effect on social and political polarization.

Hypothesis 2 : The magnitude of this effect differs from countries according to their level of income and democracy.

Hypothesis 3 : There is a higher level of polarization in countries with a higher level of income inequality, less government spending, and a lower level of globalization.

3.3.1.2 Estimation

We estimate the following regressions :

$$Polar_{i,t} = \alpha_1 + \beta_1 Media_{i,t} + \gamma_1 X_{i,t} + \delta_t + \theta_i + \varepsilon_{i,t} \tag{3.1}$$

where $Polar_{it}$ is the index of **"Polarization of Society"** (social polarization) or **"Political Polarization"** in the country i at year t, $Media_{it}$ is the variable of **"Online media existence"** of country i at year t, X_{it} is a vector of control variables (including income inequality, globalization, government expending...), δ_t are time fixed effects, θ_i are country fixed effects, and ε_{it} is the error term.

The measure of polarization

To measure polarization, we take two indexes from the V-Dem data base (Mechkova et al. 2019, Coppedge et al. 2021) : "Political Polarization" and "Polarization of Society" (social polarization). The "Polarization of Society" index measures social polarization, ranging from 0 ("serious polarization") to 4 ("no polarization"). It measures the extent to which political opinions affect "social relationships, major clashes of views and polarization in the society"(Coppedge et al. 2021). The "Political Polarization" indicator measures whether political camps interact in hostile manners : 0 means "not at all" and 4 means "yes, to a large extent".

Explanatory variables

The main explanatory variable

Online media use. Media has an important role in political polarization (DellaVigna et Kaplan 2007, Bernhardt, Krasa et Polborn 2008, Prior 2013, Duca et Saving 2017, Melki et Sekeris 2019). Whether the use of social media has a positive effect on the polarization remains unclear (Holt et al. 2013, Barberá 2014, Boxell, Gentzkow et Shapiro 2017, Lee, Shin et Hong 2018). We use the "Online media existence" [4] from the V-Dem data set (Coppedge et al. 2021) as the main independent variable.

Other explanatory factors

Income inequality (Gini index). The income inequality is most frequently proved to be

4. Ranging from 0 ("no one consumer's online media") to 3 ("almost everyone consumes domestic online media")

associated with political polarization in the existing literature [5]. We use the Gini coefficient index from the Standardized World Income Inequality Database (SWIID) of Solt 2020 to measure income inequality.

The size of government : GDP *per capita* and government expenditure (% of GDP). The size of government is also proved to be strongly correlated to polarization (Lindqvist et Östling 2010, Fetzer 2019). Higher GDP and government spending are reckoned to decrease political polarization (Lindqvist et Östling 2010, Becker, Fetzer et Novy 2017, Fetzer 2019, Jha et Gozgor 2019). We use **the real gross domestic product (GDP) *per capita*** from World Bank and **government expenditure** (% of GDP) from UNdata (Calculated by "General government final consumption expenditure" and "Gross Domestic Product (GDP)" from the table of "Government final consumption expenditure by function at current prices") to measure the size of government.

Globalization. The effects of globalization on polarization are mixed. Globalization may increase the polarization as it can lead to inequality between the incomes of workers from different sectors, but a high level of globalization can also bring wealth to a country that will spend more on public expenditures, thus decreasing the polarization (Colantone et Stanig 2018b, Adam et Ftergioti 2019, Dorn, Hanson, Majlesi et al. 2020, Pleninger et Sturm 2020, Bergh et Kärnä 2021,Heimberger 2021). The four globalization indices are taken from the Revisited KOF Globalisation data set (Gygli et al. 2019) : overall globalization, political globalization, economic globalization, and social globalization(Gygli et al. 2019, Fang, Gozgor et Yan 2021).

Democracy. The impacts of explanatory factors on polarization are different in democratic countries compared to undemocratic countries (Lindqvist et Östling 2010). The "Polity Score" from the Polity5 Project (Marshall et Gurr 2021) is used to measure the degree of democracy, ranging from -10 ("autocracy") to 10 ("democracy").

Socio-cultural variables. We also include **the total population** from the V-Dem data-set to

5. See Pontusson et Rueda 2008, Grechyna 2016, Duca et Saving 2017, Winkler 2019

measure the impact of social networks on polarization (Baldassarri et Bearman 2007, Grechyna 2016, Iversen et Soskice 2015), the index of **civil conflicts** from Marshall 2019's "Major Episodes of Political Violence Variables", and the historical index of **ethnic fractionalization** of Dražanová 2020 to measure the impact of cultural, religious, and ethnic diversity and conflicts (Esteban et Ray 2011, Pleninger et Sturm 2020) as explanatory variables. The percentage of **young people** defined as the population ages 15-64 (% of the total population) and the **unemployment rate** of young people in a country of the World Bank are also included.

Table 3.1 shows the descriptive statistics of all the above-mentioned variables (Hlavac et Package 2018).

3.3.2 Regressions Results

We start by calculating the variance inflation factor (VIF) to test multicollinearity between the independent variables : Online media existence, Gini index, government expenditures % of GDP, the logarithmic growth rate of GDP *per capita*, polity score, the population, the four globalization indices (overall globalization, political globalization, economic globalization, and social globalization), government dissemination of false information domestic ("misinformation"), civil conflicts, ethnic fractionalization, mass mobilization, the level of freedom of expression, the percentage of young people ("young people (%)"). the unemployment rate of young people in a country. The VIF results indicate no serious problem of multicollinearity. Then we use different Breusch-Godfrey and Wooldridge tests for serial correlation tests. We first begin with fixed effect models after running different tests (Hausman Test, Chow test, and Lagrange Multiplier Test).

We then run fixed-effects regressions for both panel data and 3-year average data on controlling country-specific factors affecting both online media use and polarization by including country-fixed effects. To avoid the possible problems of endogeneity bias such as unobserved confoun-

Tableau 3.1 – Summary Statistics

Variable	N	Mean	Std. Dev.	Min	Pctl. 25	Pctl. 75	Max
Dependent variables :							
Political polarization	3854	2.148	1.157	0	1	3	4
Social polarization	3854	1.412	1.116	0	0	2	4
Main independent variables :							
online media existence	3854	2.018	0.697	1	2	3	3
Control variables :							
Gini index	2936	38.56	8.262	22.6	32.4	43.925	65.1
Government expenditures (%)	3315	0.182	0.076	0	0.13	0.223	0.75
GDP	3826	11.845	17.983	0.108	1.256	13.939	136.701
Polity score	3630	1.015	16.297	-88	-3	9	10
population	3795	4.24	14.975	0.009	0.338	2.929	148.256
overall globalization	3451	4.045	0.279	3.154	3.852	4.262	4.51
economic globalization	3434	3.97	0.429	0	3.791	4.229	4.553
social globalization	3451	3.973	0.39	2.4	3.721	4.291	4.522
political globalization	3451	4.101	0.404	2.306	3.93	4.401	4.586
civil conflicts	3143	0.485	1.361	0	0	0	9
ethnic fractionalization	3410	0.489	0.484	0.015	0.226	0.7	8.559
mass mobilisation	3854	1.937	1.313	0	1	3	4
misinformation	3854	2.612	1.081	0	2	3	4
freedom of expression	3854	0.599	0.005	0.586	0.595	0.602	0.613
unemployment rate	3788	17.256	12.676	0.379	8.218	23.214	81.061
young	3800	62.562	6.996	47.183	56.451	67.407	86.398
Instrumental variables :							
privatization	2750	10.442	13.813	0	0	17	61
liberalization	2728	11.588	11.681	0	0	17	59
separation	3080	13.178	9.366	0	6	20	45
depoliticization	2552	7.751	9.96	0	0	15	61

ders, reverse causality, and measurement error, we report the results of instrumental variable estimations in table 3.2 and 3.3. Following Winkler 2019 and Xu et Reed 2021, we use data on telecommunications reforms as instrumental variables for online media use. More precisely, we take four reforming policy variables : "private" ("privatizing the national service provider"), "separate" ("separating the regulatory authority from direct control of the executive branch of government"), and "depolit" ("depoliticizing the appointment of regulators") created by Howard et Mazaheri 2009 as instrumental variables.

3.3.2.1 Overall effects

The results of baseline models measuring the relationship between online media use and social polarization are reported in table 3.2 for annual data (in columns (1) and (2)) and for 3-year average data (in columns (3) and (4)). Columns (5) and (6) are the results using two-stage least-squares methods with the above-mentioned instrumental variables.

Table 3.2 presents a positive and statistically significant result for the relationship between the main explanatory variable - online media use - and social polarization. Note that a higher value of the "polarization of society" from the V-Dem data means a lower level of social polarization. The results show that a one-point increase in the use of online media leads to a 0.22-point increase in social polarization. The effects drop a little but remain significant when we include more factors such as mass mobilization, misinformation from the government, and the level of freedom of expression in one country. As for other control variables, social polarization is more evident in countries with more population, more government spending, more civil conflicts, more mass mobilizations, higher ethnical fractionalization, and higher unemployment rates. Society is less polarized in countries with a higher level of GDP, a higher polity score, a higher level of political globalization, lower income inequality, more young people, or more freedom of expression. The results in columns (5) and (6) and the over-identification test reject severe endogeneity issues.

Tableau 3.2 – Social polarization and online media

	Dependent variable :					
	Social polarization					
	panel linear				*instrumental variable*	
	(1)	(2)	(3)	(4)	(5)	(6)
online media	0.222***	0.215***	0.241***	0.228**	0.594***	1.418***
	(0.027)	(0.027)	(0.093)	(0.093)	(0.229)	(0.298)
GDP	−0.009***	−0.008***	−0.003	−0.002	−0.023***	−0.038***
	(0.002)	(0.002)	(0.005)	(0.005)	(0.004)	(0.005)
Polity score	−0.004***	−0.004***	−0.006**	−0.006**	−0.009***	−0.010***
	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)	(0.003)
log(population)	0.365***	0.389***	0.363	0.381	−0.003	0.050
	(0.120)	(0.118)	(0.375)	(0.375)	(0.025)	(0.032)
log(Government expenditures)	0.096***	0.088**	0.101	0.097	−0.021	−0.025
	(0.035)	(0.034)	(0.114)	(0.114)	(0.057)	(0.069)
political globalization	−0.641***	−0.628***	−1.056***	−1.051***	0.541***	0.093
	(0.104)	(0.103)	(0.344)	(0.344)	(0.187)	(0.242)
Gini index	−0.248***	−0.220***	0.033	0.048	−0.011	−0.058
	(0.057)	(0.057)	(0.188)	(0.189)	(0.041)	(0.048)
civil conflicts	0.066***	0.061***	0.002	0.012	0.152***	0.189***
	(0.011)	(0.011)	(0.037)	(0.038)	(0.025)	(0.028)
ethnic fractionalization	0.244***	0.205***	0.067	0.028	0.152**	−0.004
	(0.031)	(0.031)	(0.104)	(0.108)	(0.069)	(0.086)
young people	−0.020***	−0.019***	−0.018	−0.015	−0.031***	−0.049***
	(0.006)	(0.006)	(0.019)	(0.019)	(0.007)	(0.009)
unemployment rate	0.005***	0.005***			0.021***	0.015***
	(0.002)	(0.002)			(0.002)	(0.003)
mass mobilisation		0.068***		−0.061		
		(0.012)		(0.047)		
misinformation		−0.057***		−0.102		
		(0.022)		(0.079)		
freedom of expression		−8.559***		−17.929		
		(3.255)		(12.427)		
unemployment rate(ˆ2)			0.0001	0.0002		
			(0.0001)	(0.0001)		
Constant					0.744	2.445**
					(0.791)	(1.000)
Observations	2,363	2,363	841	841	1,948	2,109
R^2	0.128	0.148	0.039	0.047	0.016	−0.486
Adjusted R^2	0.060	0.080	−0.188	−0.182	0.010	−0.494
Residual Std. Error					1.070 (df = 1936)	1.324 (df = 2097)
F Statistic	29.339*** (df = 11 ; 2189)	27.197*** (df = 14 ; 2186)	2.488*** (df = 11 ; 680)	2.392*** (df = 14 ; 677)		

Table 3.3 shows similar results for the relationship between online media use and political polarization. Columns (1) to (2) use the annual data, columns (3) to (4) are results for 3-year average data, and columns (5) and (6) use two-stage least-squares methods. A 9.6% increase in political polarization is caused by the increase in online media use. The impact of online media use on political polarization is less significant than on political polarization. What's more, more population and a higher level of the unemployment rate of young people will decrease the level of political polarization, which is contrary to the results in table 3.2.

Tableau 3.3 – Political polarization and online media.

	Dependent variable :					
	Political Polarization					
	panel linear				*instrumental variables*	
	(1)	(2)	(3)	(4)	(5)	(6)
online media existence	0.096^{***} (0.030)	0.082^{***} (0.029)	0.116^{**} (0.052)	0.084^{*} (0.049)	0.591^{**} (0.260)	0.857^{***} (0.238)
GDP	-0.005^{***} (0.002)	-0.003^{*} (0.002)	-0.007^{**} (0.003)	−0.005 (0.003)	-0.033^{***} (0.005)	-0.039^{***} (0.004)
Polity score	-0.005^{***} (0.001)	-0.004^{***} (0.001)	-0.006^{***} (0.002)	-0.005^{***} (0.001)	-0.021^{***} (0.003)	-0.020^{***} (0.003)
population	-0.031^{**} (0.015)	-0.026^{*} (0.014)	-0.044^{**} (0.022)	-0.045^{**} (0.021)	−0.002 (0.002)	-0.005^{*} (0.002)
log(Government expenditures)	0.097^{**} (0.039)	0.081^{**} (0.037)	0.065 (0.065)	0.038 (0.062)	0.115^{*} (0.061)	0.133^{**} (0.063)
political globalization	-0.509^{***} (0.118)	-0.491^{***} (0.112)	-0.677^{***} (0.196)	-0.653^{***} (0.185)	0.036 (0.154)	0.212 (0.155)
Gini index	-0.106^{*} (0.064)	−0.054 (0.061)	−0.111 (0.106)	−0.070 (0.101)	−0.057 (0.043)	-0.123^{**} (0.050)
civil conflicts	0.085^{***} (0.012)	0.072^{***} (0.012)	0.106^{***} (0.021)	0.085^{***} (0.021)	0.038 (0.026)	0.040 (0.026)
ethnic fractionalization	0.269^{***} (0.034)	0.188^{***} (0.034)	0.310^{***} (0.059)	0.194^{***} (0.058)	0.183^{**} (0.073)	0.200^{***} (0.077)
young people	−0.010 (0.007)	−0.007 (0.006)	−0.004 (0.010)	−0.0001 (0.010)	-0.013^{*} (0.007)	-0.024^{***} (0.009)
unemployment rate	-0.003^{*} (0.002)		-0.006^{*} (0.003)	−0.003 (0.003)	0.006^{**} (0.002)	−0.002 (0.003)
log(unemployment rate)		-0.111^{***} (0.031)				
mass mobilisation		-0.143^{***} (0.024)		-0.175^{***} (0.043)		
freedom of expression		-9.897^{***} (3.509)		-16.132^{**} (6.654)		
Constant					2.037^{***} (0.672)	1.679^{**} (0.775)
Observations	2,363	2,363	841	841	1,948	1,895
R^2	0.087	0.180	0.132	0.227	0.018	−0.044
Adjusted R^2	0.015	0.114	−0.072	0.040	0.013	−0.050
Residual Std. Error					1.127 (df = 1936)	1.194 (df = 1883)
F Statistic	18.982^{***} (df = 11 ; 2189)	34.274^{***} (df = 14; 2186)	9.393^{***} (df = 11 ; 680)	14.161^{***} (df = 14 ; 677)		

3.3.2.2 Asymmetric effects by groups of country

Table 3.2 and 3.3 show some interesting findings about the different effects of some control variables on social polarization and political polarization. To explore the asymmetric effects and to examine our hypotheses, we divide the data into five different groups in table 3.4 and table 3.5 : the autocratic countries for countries whose polity score is ≤ 2, the democratic countries for polity score ≥ 8, then the high-income countries, the middle-income countries, and the low-income countries according to the World Bank.

Tableau 3.4 – Online media use and social polarization by groups of countries

	Dependent variable :				
	Social polarization				
	(1) Autocracy	(2) Democracy	(3) High-income	(4) Middle-income	(5) Low-income
online media	0.201***	0.300***	0.467***	0.179***	0.151*
	(0.042)	(0.035)	(0.046)	(0.035)	(0.090)
GDP	−0.011***	−0.010***	−0.009***		
	(0.003)	(0.002)	(0.002)		
log(GDP)				−0.207*	0.214
				(0.116)	(0.261)
Polity score	−0.004***	−0.022***	−0.168***	−0.005***	−0.002
	(0.001)	(0.003)	(0.035)	(0.001)	(0.001)
population		0.128***	−0.071	0.028*	
		(0.027)	(0.048)	(0.015)	
log(population)	0.632***				3.987***
	(0.173)				(0.655)
Government expenditures		0.548*	1.021**	−0.255	
		(0.301)	(0.446)	(0.289)	
log(Government expenditures)	0.107*				0.211**
	(0.056)				(0.099)
political globalization	−0.653***	−0.822***	−0.737**	−0.243*	−1.186***
	(0.136)	(0.166)	(0.302)	(0.135)	(0.303)
Gini index	−0.243***	−0.223**	−0.227*	−0.088	
	(0.078)	(0.087)	(0.125)	(0.075)	
log(Gini index)					−0.855
					(0.574)
civil conflicts	0.028**	0.068**	0.203	0.074***	0.011
	(0.013)	(0.029)	(0.298)	(0.013)	(0.027)
ethnic fractionalization	−1.656**	0.190***		0.400***	−6.287**
	(0.786)	(0.035)		(0.054)	(2.746)
log(ethnic fractionalization)			0.132***		
			(0.046)		
young people	0.009	−0.044***	0.019*	−0.027***	−0.026
	(0.010)	(0.008)	(0.010)	(0.010)	(0.031)
unemployment rateˆ2	0.0001***	0.0001***	0.0002***	0.0001**	
	(0.0001)	(0.00003)	(0.00004)	(0.00004)	
unemployment rate					−0.034***
					(0.010)
Observations	986	1,133	718	1,303	309
R^2	0.115	0.213	0.270	0.133	0.279
Adjusted R^2	0.018	0.144	0.192	0.055	0.139
F Statistic	10.455*** (df = 11 ; 888)	25.562*** (df = 11 ; 1042)	21.758*** (df = 11 ; 648)	16.666*** (df = 11 ; 1194)	9.063*** (df = 11 ; 258)

For social polarization, table 3.4 shows similar results as table 3.2, with the coefficient a little higher in high-income countries (hypothesis 1). In terms of other control variables : a higher level of GDP and a lower level of unemployment rate decrease the social polarization in all groups except for the low-income countries. More government spending is supposed to alleviate polarization, but not in middle-income countries as shown in table 3.4 (hypothesis 3 is partially confirmed). More population induces less social polarization in high-income countries, which is exactly the contrary in other countries. Ethnical fractionalization increases the level of social polarization, but not in autocratic countries.

Tableau 3.5 – Online media use and political polarization by groups of countries.

	Dependent variable :				
	Political polarization				
	(1) Autocracy	(2) Democracy	(3) High-income	(4) Middle-income	(5) Low-income
online media existence	-0.083	0.179^{***}	0.097^{**}	0.111^{***}	0.029
	(0.051)	(0.036)	(0.049)	(0.042)	(0.060)
GDP	-0.001	-0.007^{***}	-0.007^{***}	0.044^{***}	-0.001
	(0.004)	(0.002)	(0.002)	(0.011)	(0.015)
Polity score	-0.004^{***}	-0.011^{***}	0.018	-0.006^{***}	-0.003^{***}
	(0.001)	(0.003)	(0.038)	(0.001)	(0.001)
population	-0.045^{**}	0.155^{***}	0.216^{***}	-0.054^{***}	-0.158^{***}
	(0.020)	(0.028)	(0.051)	(0.018)	(0.056)
Government expenditures	0.658	0.514^{*}	-0.331	0.604^{*}	0.506
	(0.468)	(0.305)	(0.478)	(0.349)	(0.522)
political globalization	-0.378^{**}	-0.486^{***}	-0.622^{*}	-0.400^{**}	-0.757^{***}
	(0.166)	(0.168)	(0.322)	(0.156)	(0.206)
Gini index	0.017	-0.130	0.167	-0.086	0.086
	(0.095)	(0.088)	(0.132)	(0.094)	(0.115)
civil conflicts	0.105^{***}	0.148^{***}	0.131	0.118^{***}	0.048^{***}
	(0.015)	(0.029)	(0.319)	(0.016)	(0.018)
ethnic fractionalization	-0.316	0.247^{***}	0.159^{***}	0.411^{***}	1.421
	(0.983)	(0.035)	(0.046)	(0.065)	(1.887)
young people	0.015	-0.048^{***}	-0.013	-0.041^{***}	0.074^{***}
	(0.012)	(0.008)	(0.011)	(0.012)	(0.024)
unemployment rate	-0.006	-0.002	0.001	-0.008^{**}	0.021^{***}
	(0.005)	(0.002)	(0.002)	(0.003)	(0.008)
Observations	986	1,133	718	1,303	309
R^2	0.098	0.165	0.091	0.132	0.208
Adjusted R^2	-0.001	0.093	-0.006	0.053	0.054
F Statistic	8.747^{***} (df = 11 ; 888)	18.726^{***} (df = 11 ; 1042)	5.889^{***} (df = 11 ; 648)	16.453^{***} (df = 11 ; 1194)	6.157^{***} (df = 11 ; 258)

As for political polarization (in table 3.5), there are no significant effects of online media use on political polarization in autocratic or low-income countries as predicted in hypothesis 2. Political polarization decreases with the GDP level, but it's not the case in middle-income countries. A higher level of democracy will alleviate political polarization in all countries except for the high-income countries. More population will decrease political polarization but not in democratic or high-income countries. More government spending will slightly increase political polarization only in democratic and middle-income countries, which corresponds to the existing findings (Lindqvist et Östling 2010). More population induces less social polarization in the high-income countries, which is exactly the contrary in other countries. Globalization will alleviate political polarization across all countries. In the country, political polarization has little relationship with income inequality. Political polarization is much more evident in countries with more civil conflicts except for the high-income countries. Ethnical fractionalization increases the level of political polarization except for autocratic or low-income countries. Political polarization is more evident in the low-income countries with more young people but it is not the case in the democratic and the middle-income countries. A higher unemployment rate increases political polarization in low-income countries but decreases political polarization in middle-income countries.

3.4 Conclusions

The rising use of online media as a source of information raises concerns for many countries. Does the use of online media make our society more polarized ? This paper sheds light on this question by investigating the relationship between the use of online media and the polarization in our society. We examine the relationship between the use of online media and polarization using V-Dem data from 2000 to 2021. Empirical results find evidence of the impact of the use of social media on both social and political polarization. The conclusion that the use of online media increases polarization in society is robust to an instrumental variable approach that addresses the endogeneity of the use of online media.

Among all the determinants of social polarization and political polarization, this paper emphasizes the role of online media in our society across all countries. Using the survey data of the V-Dem project from 2000 to 2021, this paper shows that the rising use of online media does have positive effects on polarization in society all over the world. What's more, the relationship between online media use and social (political) polarization differs from countries. The effects of online media use on social or political polarization are stronger in the democratic (or the high-income) countries than in the autocratic (or the low-income) countries. In terms of the relationship between other factors and polarization, it is also different across countries. For instance, more government spending alleviates social and political polarization in democratic countries, but not in low-income countries, which corresponds to the existing findings of Lindqvist et Östling 2010.

The use of online media does make our society more polarized. The polarization in our society is also related to other factors such as democracy, government spending, and globalization. Nevertheless, the relationship between some factors such as government spending differs across countries. These findings shed light on the policy implementations, for example, increasing government spending to alleviate the polarization in low-income countries may be not effective.

We acknowledge that the results of this paper are limited to the measurement of polarization in the survey data. Another caveat of using panel data is its cross-country level measurement. Further research on the effects of social media and polarization using individual-level data should be required. How to measure polarized opinions at the individual level remains a challenge. It will be interesting to explore the impact of individual-level factors such as their sources of information on their polarized opinions.

Conclusion Générale

News media play a vital role in our lives as they provide information for citizens to make political and social decisions. The market for news is different from other markets in different ways. Moreover, the rise of new technologies such as the Internet and social media presents new challenges such as media biases, the polarization of society…This thesis explores the reasons and consequences of media biases from economic and political perspectives.

The first chapter discusses the impacts of competition in the news market on the differentiation of its products – news. We consider product differentiation in competitive news markets, as determined by the characteristics of demand confronting basic informational non-convexities in the activities of news reporting. Profit-maximizing news media imperfectly report the information they draw from some normally distributed flow of source data. A natural measure of information loss due to the media is the Kullback-Leibler divergence between the normal distributions of news and raw data. We show that reporting distortions depend on (i) *bias*, defined as the difference between the means of the probability distributions of news and raw data ; and (ii) *noise*, defined as the difference between the standard deviations of these distributions. We show that expected utility-maximizing consumers with concave Bernoulli utility functions are noise-averse. Distortion-averse consumers are both bias- and noise-averse. We show that the news products supplied at equilibrium are identical in terms of accuracy, as measured by their Kullback-Leibler divergence to raw data. These products make a one-dimensional locus in the mean-standard deviation space. This locus consists of horizontally differentiated products, ranging from "conventional" news products, characterized by large biases and by noise levels reduced to some incompressible minimum, to "noisy" news products, which set the bias to zero at the expense of some maximum noise level. The frontier confronts distortion-averse consumers with a basic non-convexity. Non-convexity results in maximal product differentiation, the "conventional" and "noisy" extremes being the only news products actually demanded at equilibrium in some natural configurations of the latter. We moreover show that most types of noise-averse consumers choose their news providers in the close vicinity of the conventional end of the market. The model thus provides a rationale and partial explanation for the common distinction between mainstream and alternative news media.

The second chapter examines the effects of introducing a public-interest firm on reducing media bias in a duopolistic newspaper market. Two newspaper firms have both print and online versions, and users can interact with each other online (”UGC”). Media bias comes from both the supply side and the demand side. The socially optimal reporting position of the duopoly is the mean value of the opinions of their readers. When the third public-interest firm is introduced, the prices of the duopolistic newspapers drop and so as the level of the slanting duo to the competition pressure. If the data source is accurate, the reporting position of the two private newspapers is less biased than the duopoly case in the model of Yildirim, Gal-Or et Geylani 2013, and also less biased than the monopoly case in the model of Mullainathan et Shleifer 2005. However, the effectiveness of introducing a public-interest newspaper to reduce slanting requires that the source of the data has to be accurate. This finding emphasizes the importance of fact-checking, which is at the center of the public debate. Then we examine two other policies : price-cap and taxation (or subsidy) in the extension part. We find that the print newspapers get less biased but the online newspapers become more biased under price-cap regulation. This result is intuitive as the online newspaper is less costly, hence, online newspapers bear less competition pressure. In terms of taxation or subsidy, the level of slanting decreases with the taxation, put it the other way, the reports for truth increase with the subsidy. These findings will shed light on some policy implementations such as the competition law and the digital tax in the current policy debate.

The third chapter studies the impact of the use of online media on social polarization and political polarization in a voting game and by panel data. Using panel data of 198 countries between 2000 and 2021 from the V-Dem data set, we find that a higher level of use of online media in a country does increase the level of polarization in society (both social polarization and political polarization). The results are robust to a number of specifications, including an instrumental variable approach that addresses the endogeneity of internet penetration. What's more, the relationship between the use of online media and social polarization or political polarization differs from the countries according to their income level. The results also show different relationships between other economic and social explanatory factors and polarization, such as income inequality, government expenditures, and globalization.

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Annexe A

Informational non-convexities and demand-driven product differentiation in competitive news markets

A.1 Kullback-Leibler divergence and the maximum likelihood criterion

We illustrate the well-known connection between K-L divergence minimization and likelihood maximization through the following basic textbook argument. Suppose that a media of type j collects, from the flow of raw data d, a sample of N pairwise distinct, identically independently distributed observations $S = \{d_1, \ldots, d_N\}$. The empirical law of d built from sample S is $\hat{p}(s) = \frac{1}{N} \sum_{i=1}^{N} \delta(s - d_i)$, where $\delta : \mathbb{R} \to \mathbb{R}$ denotes the Dirac measure (i.e. $\delta(s - d_i)$ is equal to 0 everywhere except at 0 where it is equal to 1). The firm believes that the true distribution is parametric, with unknown parameters θ. Let p_θ denote the corresponding distribution. The K-L divergence of p_θ relative to $\hat{p}$ reads : $D(\hat{p} \mid\mid p_\theta) = \sum_{s \in S} \hat{p}(s) \log \frac{\hat{p}(s)}{p_\theta(s)}$. A simple calculation yields : $D(\hat{p} \mid\mid p_\theta) = \sum_{s\in S} \hat{p}(s) \log \hat{p}(s) - \frac{1}{N} \sum_{s\in S} \log p_\theta(s)$. Let $H(\hat{p}) = -\sum_{s\in S} \hat{p}(s) \log \hat{p}(s)$ denote the Shannon entropy of the empirical distribution. The first term in the difference above is equal to $-H(\hat{p})$. The second term in the difference, $\frac{1}{N} \sum_{s\in S} \log p_\theta(s)$, is the log-likelihood of the parametric distribution (divided by the number of observations). For a firm of type j that wants to estimate the parameters θ from sample S, it is equivalent, in particular, to derive θ from the maximization of the likelihood of p_θ or to compute it from the minimization of $D(\hat{p} \mid\mid p_\theta)$.

A.2 Examples of calculable supply equilibria

Example 2 - Competitive supply equilibrium with convex costs :

We suppose technically separable data-processing and broadcasting activities as in Example 1, and moreover suppose parabolic costs for each of them, that is, $c(q_j, z_j) = q_j^2 + z_j^2$. The necessary first-order condition (f.o.c.) for profit maximization of Proposition 2-(i) readily implies that $p = 2$, that is, the competitive equilibrium price is determined by technology in this case. The necessary second-order condition (s.o.c.) of Proposition 2-(ii) is then satisfied, as $p = 2 = \partial^2_{qz} c(q_j^*, z_j^*) + \sqrt{\partial^2_{qq} c(q_j^*, z_j^*) \cdot \partial^2_{zz} c(q_j^*, z_j^*)}$. The f.o.c. also implies that : $\frac{z_j^*}{q_j^*} = 1$, that is, any profit-maximizing quality-scale mix (q_j^*, z_j^*) must be located on ray $\{(q_j, z_j) \in \mathbb{R}^2_+ : z_j = q_j\}$ (see Figure **??**) ; and also $p \cdot q_j^* \cdot z_j^* = \partial_q c(q_j^*, z_j^*) \cdot q_j^* = \partial_z c(q_j^*, z_j^*) \cdot z_j^*$. Moreover, Euler's identity for homogeneous functions implies $2c(q_j, z_j) = \partial_q c(q_j, z_j) \cdot q_j + \partial_z c(q_j, z_j) \cdot z_j$ for all (q_j, z_j), and therefore $p \cdot q_j^* \cdot z_j^* - c(q_j^*, z_j^*) = 0$; that is, the equilibrium profit is null. One easily verifies that $2 \cdot q_j \cdot z_j - c(q_j, z_j) = -(q_j - z_j)^2$ is null everywhere along ray $\{(q_j, z_j) \in \mathbb{R}^2_+ : z_j = q_j\}$ and negative otherwise. To sum up : the unique competitive equilibrium price of this example is $p = 2$; any quality-scale mix (q_j^*, z_j^*) of $\{(q_j, z_j) \in \mathbb{R}^2_+ : z_j = q_j\}$ maximizes type j's profit at this price ; the equilibrium profit is null.

Example 3 - Symmetric log-linear supply function :

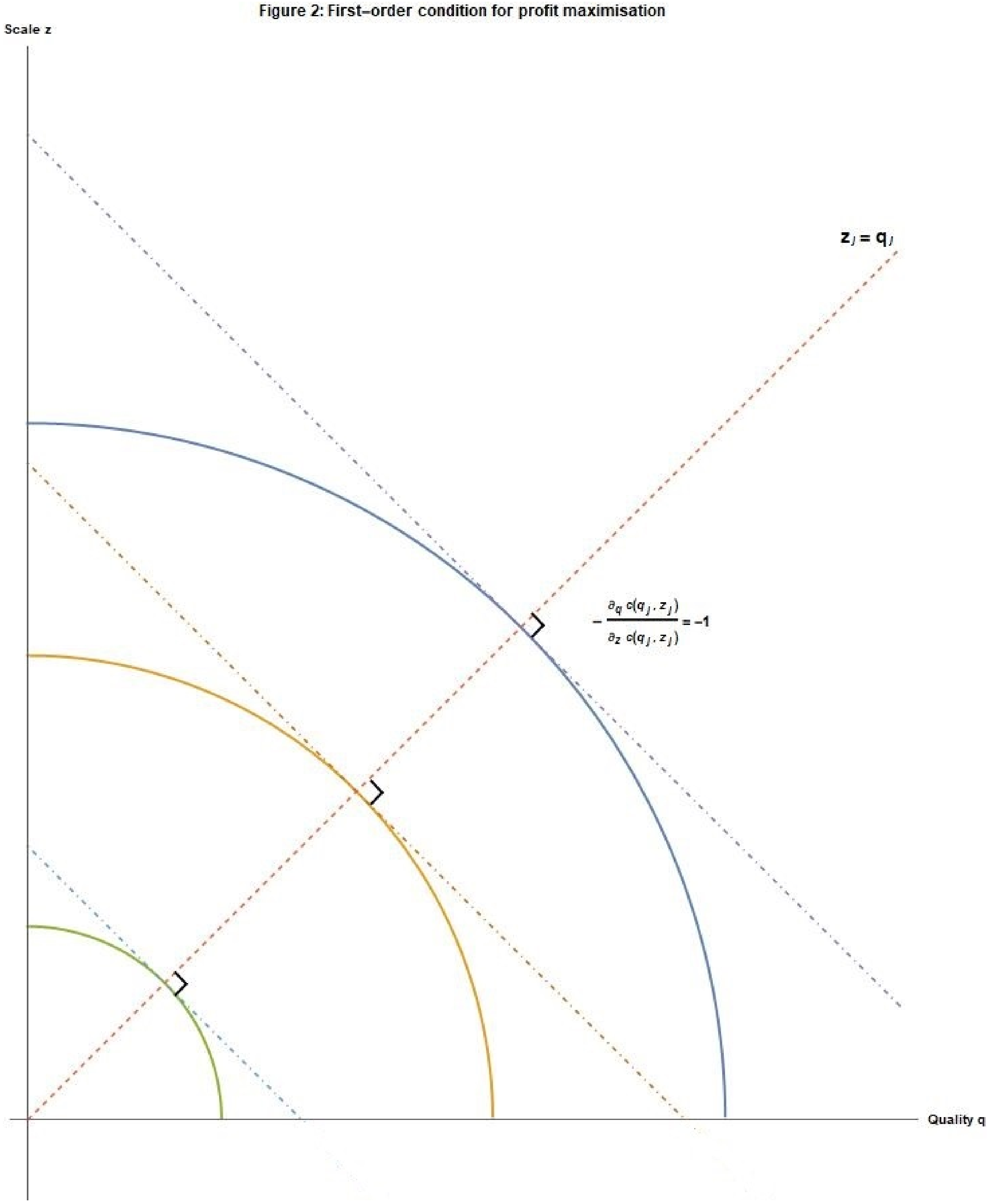


Figure A.1 – *First-order condition for profit maximisation*

We consider here a variant of Example 2, with an additively separable, symmetric, strictly convex cost function of the type $c(q_j, z_j) = q_j^\alpha + z_j^\alpha, \alpha > 2$. The f.o.c. for profit-maximization readily implies $\frac{z_j^*}{q_j^*} = 1$ and $q_j^* = z_j^* = (\frac{p}{\alpha})^{\frac{1}{\alpha-2}}$. We obtain $\partial_{qz}^2 c(q_j^*, z_j^*) + \sqrt{\partial_{qq}^2 c(q_j^*, z_j^*) \cdot \partial_{zz}^2 c(q_j^*, z_j^*)} = (\alpha - 1) \cdot p > p$ for all $p > 0$, which implies that $(q_j^*, z_j^*) = \left((\frac{p}{\alpha})^{\frac{1}{\alpha-2}}, (\frac{p}{\alpha})^{\frac{1}{\alpha-2}}\right)$ is the unique profit-maximizing quality-scale mix. If $p = 0$, then the unique profit-maximizing quality-scale mix is obviously the null supply (0,0), generating a null profit. That is, the supply function of each firm of type j is well-defined over $\mathbb{R}_+$. It reads $(q_j(p), z_j(p)) = \left((\frac{p}{\alpha})^{\frac{1}{\alpha-2}}, (\frac{p}{\alpha})^{\frac{1}{\alpha-2}}\right)$. Euler's identity for homogeneous functions and the f.o.c. together imply $\alpha \cdot c(q_j^*, z_j^*) = \partial_q c(q_j^*, z_j^*) \cdot q_j^* + \partial_z c(q_j^*, z_j^*) \cdot z_j^* = 2 \cdot p \cdot q_j^* \cdot z_j^*$, and therefore $p \cdot q_j^* \cdot z_j^* - c(q_j^*, z_j^*) > p \cdot q_j^* \cdot z_j^* - \frac{\alpha}{2} c(q_j^*, z_j^*) = 0$ for all $p > 0$. That is, the maximized profit is positive if (and only if) the price is positive. [1]

A.3 Proofs

Proof of Proposition 1 : This follows, as a special case, from Kullback 1997, Theorem 3.1 of chapter 2.

Proof of Proposition 2 : Propositions 2-(i) and 2-(ii) are clear enough. The proof of the remainder is a simple consequence of the computation of the following first and second derivatives of function φ. We get $\partial_x \varphi(x, y) = \frac{x^2 - \sigma^2 - (y-\mu)^2}{x^3}$, which readily implies Propositions 2-(iii) and 2-(iv). We have $\partial_{yy}^2 \varphi(x, y) = \frac{1}{x^2} > 0$ for all $(x, y) \in \mathbb{R}_{++}\mathbb{R}$. This entails the strict concavity of partial functions $x \to \varphi(x, y)$. And we have $\partial_{yy}^2 \varphi(x, y) = \frac{1}{x^2}$ for all $(x, y) \in \mathbb{R}_{++}\mathbb{R}$. This implies the strict convexity of partial functions $y \to \varphi(x, y)$ for all $x \in \mathbb{R}_{++}$.

1. Note that $\frac{z_j}{q_j} = \frac{\partial_q c(q_j, z_j)}{\partial_z c(q_j, z_j)}$ at firm's equilibrium, which means that "proportion" $\frac{z_j}{q_j}$ is equal to the marginal rate of substitution $\frac{\partial_q c(q_j, z_j)}{\partial_z c(q_j, z_j)}$ at any profit-maximizing quality-scale mix (q_j, z_j). It seems reasonable to expect, under real conditions, a small marginal cost of broadcasting $\partial_z c(q_j, z_j)$, relative to the marginal cost of quality $\partial_q c(q_j, z_j)$, that is, a large marginal rate of substitution at equilibrium. Equilibrium conditions then imply a large ratio $\frac{z_j}{q_j}$, corresponding to the wide broadcasting of information sheets of equilibrium quality q_j. Naturally, this feature of actual mass-media markets is not captured through the symmetric cost functions of the former two examples.

Proof of Proposition 3 : Recall that we assume that the cost function is C^2 in $\mathbb{R}^2_{++}$ and strictly convex.

The differentiability assumption implies that the first-order necessary conditions and the second-order conditions for an interior solution to $\max\{p \cdot q_j \cdot z_j - c(q_j, z_j) : (q_j, z_j) \in [0, +\infty[[0, +\infty[\}$ hold true at (q_j^*, z_j^*) (e.g. Mas-Colell 1985, D1 and D2).

The first-order necessary conditions read $p \cdot z_j^* - \partial_q c(q_j^*, z_j^*) = p \cdot q_j^* - \partial_z c(q_j^*, z_j^*) = 0$. They entail Proposition 3-(i).

The Hessian matrix of $(q_j, z_j) \to p \cdot q_j \cdot z_j - c(q_j, z_j)$ at (q_j^*, z_j^*) reads $H(q_j^*, z_j^*) = \begin{pmatrix} -\partial^2_{qq}c(q_j^*, z_j^*) & p-\partial^2_{qz}c(q_j^*, z_j^*) \\ p-\partial^2_{zq}c(q_j^*, z_j^*) & -\partial^2_{zz}c(q_j^*, z_j^*) \end{pmatrix}$. Its diagonal elements are < 0, by strict convexity of the cost function. Its determinant reads $\mid H(q_j^*, z_j^*) \mid = \partial^2_{qq}c(q_j^*, z_j^*) \cdot \partial^2_{zz}c(q_j^*, z_j^*) - (p - \partial^2_{qz}c(q_j^*, z_j^*))^2$. Sylvester's criterion implies therefore that the matrix is negative semi-definite (resp. negative definite) if and only if $\mid H(q_j^*, z_j^*) \mid \geq 0$ (resp.
$\mid H(q_j^*, z_j^*) \mid < 0$).

The second-order necessary condition for an interior solution to
$\max\{p \cdot q_j \cdot z_j - c(q_j, z_j) : (q_j, z_j) \in [0, +\infty[[0, +\infty[\}$ (i.e. a negative semi-definite $H(q_j^*, z_j^*)$ entails Proposition 3-(ii).

Finally, suppose that $\mid p - \partial^2_{qz}c(q_j^*, z_j^*) \mid < \sqrt{\partial^2_{qq}c(q_j^*, z_j^*) \cdot \partial^2_{zz}c(q_j^*, z_j^*)}$. Then $H(q_j^*, z_j^*)$ is negative definite. Moreover, it remains so in some open neighborhood V of (q_j^*, z_j^*) in $\mathbb{R}^2_{++}$, by continuity of function $(q_j, z_j) \to \mid H(q_j, z_j) \mid$. This implies in turn that $(q_j, z_j) \to p \cdot q_j \cdot z_j - c(q_j, z_j)$ is strictly concave in V. Let us prove that (q_j^*, z_j^*) is the unique solution to $\max\{p \cdot q_j \cdot z_j - c(q_j, z_j) : (q_j, z_j) \in [0, +\infty[[0, +\infty[\}$. Suppose the contrary, that is, suppose that there exists $(\tilde{q}_j, \tilde{z}_j) \neq (q_j^*, z_j^*)$ that solves $\max\{p \cdot q_j \cdot z_j - c(q_j, z_j) : (q_j, z_j) \in [0, +\infty[[0, +\infty[\}$, and let us derive a contradiction. By assumption, we have $p \cdot \tilde{q}_j \cdot \tilde{z}_j - c(\tilde{q}_j, \tilde{z}_j) = p \cdot q_j^* \cdot z_j^* - c(q_j^*, z_j^*)$. For any number $\lambda \in [0, 1]$, let $(q_j^\lambda, z_j^\lambda)$ denote convex combination $\lambda \cdot (\tilde{q}_j, \tilde{z}_j) + (1 - \lambda) \cdot (q_j^*, z_j^*)$. We have $(q_j^\lambda, z_j^\lambda) \in V$ for any λ picked sufficiently close to 0. The strict concavity of $(q_j, z_j) \to$

$p \cdot q_j \cdot z_j - c(q_j, z_j)$ in V then implies : $p \cdot q_j^\lambda \cdot z_j^\lambda - c(q_j^\lambda, z_j^\lambda) > \lambda(p \cdot \tilde{q}_j \cdot \tilde{z}_j - c(\tilde{q}_j, \tilde{z}_j)) + (1 - \lambda)(p \cdot q_j^* \cdot z_j^* - c(q_j^*, z_j^*)) = p \cdot q_j^* \cdot z_j^* - c(q_j^*, z_j^*)$, the wished contradiction.

Proof of Proposition 4 : we have

$$V_i(\sigma_j, \mu_j) = \int_{-\infty}^{+\infty} u_i(n_e^j) \frac{1}{\sigma_j \sqrt{2\pi}} exp\Big(-\frac{(n_e^j - \mu_j)^2}{2\sigma_j^2}\Big) dn_e^j$$

Let $v_e^j = \frac{n_e^j - \mu_j}{\sigma_j}$ and $g(v_e^j) = \frac{1}{\sqrt{2\pi}} exp\Big(-\frac{(v_e^j)^2}{2}\Big)$, and apply the following change of variable :

$$V_i(\sigma_j, \mu_j) = \int_{-\infty}^{+\infty} u_i(v_e^j \sigma_j + \mu_j) g(v_e^j) dv_e^j$$

Differentiating with respect to σ_j, we get :

$$\partial_{\sigma_j} V_i(\sigma_j, \mu_j) = \int_{-\infty}^{+\infty} \partial u_i(v_e^j \sigma_j + \mu_j) v_e^j g(v_e^j) dv_e^j$$

Function g is positive and symmetrical, that is, $g(v_e^j) > 0$ and $g(v_e^j) = g(-v_e^j)$ for all $v_e^j \in \mathbb{R}$. Function ∂u_i is decreasing, by strict concavity of u_i. Therefore, for all $v_e^j > 0$, we have $v_e^j g(v_e^j) = v_e^j g(-v_e^j) > 0$ and $\partial u_i(-v_e^j \sigma_e^j + \mu_j) > \partial u_i(v_e^j \sigma_e^j + \mu_j)$. These inequalities together imply $\partial u_i(-v_e^j \sigma_e^j + \mu_j) v_e^j g(-v_e^j) > \partial u_i(v_e^j \sigma_e^j + \mu_j) v_e^j g(v_e^j)$ for all $v_e^j > 0$. Integrating both sides of the latter inequality, we get :

$$\int_0^{+\infty} \partial u_i(-v_e^j \sigma_e^j + \mu_j) v_e^j g(-v_e^j) dv_e^j > \int_0^{+\infty} \partial u_i(v_e^j \sigma_e^j + \mu_j) v_e^j g(v_e^j) dv_e^j$$

The left-hand side of this inequality is equal to $-\int_{-\infty}^0 \partial u_i(v_e^j \sigma_e^j + \mu_j) v_e^j g(v_e^j) dv_e^j$. Therefore we get $0 > \partial_{\sigma_j} V_i(\sigma_j, \mu_j) = \partial_{\sigma_j} U_i(\sigma_j, \mu_j, p)$.

Differentiating with respect to μ_j, we get :

$$\partial_{\mu_j} U_i(\sigma_j, \mu_j, p) = \partial_{\mu_j} V_i(\sigma_j, \mu_j) = \int_{-\infty}^{+\infty} \partial u_i(v_e^j \sigma_j + \mu_j) g(v_e^j) dv_e^j$$

Since the sign of $\partial u_i(v_e^j \sigma_j + \mu_j)$ is indeterminate, the sign of $\partial_{\mu_j} U_i(\sigma_j, \mu_j, p)$ is indeterminate as well.

Proof of Proposition 5 : We suppose that $\sigma < \bar{\sigma} < \sigma \cdot exp(\frac{1}{q^*})$.

(i) We have $\partial h(x) = 4(\frac{1}{q^*} - \log(\frac{x}{\sigma})) \cdot x$. Therefore $\partial h(x)$ is > 0 over $[\bar{\sigma}, \sigma \cdot exp(\frac{1}{q^*})[$, =0 at $exp(\frac{1}{q^*})$, and < 0 over $]\sigma \cdot exp(\frac{1}{q^*}), +\infty[$. In particular, function h reaches a maximum at $x = \sigma \cdot exp(\frac{1}{q^*})$ over $[\bar{\sigma}, +\infty[$. Moreover, we have $h(\sigma \cdot exp(\frac{1}{q^*})) = (\sigma \cdot exp(\frac{1}{q^*}))^2 - \sigma^2 > 0$ and $\lim_{x \to +\infty} h(x) = -\infty$. The continuity of h then implies the existence of at least one $x \in]\sigma \cdot exp(\frac{1}{q^*}), +\infty[$ such that $h(x) = 0$. Since h is (strictly) decreasing over $]\sigma \cdot exp(\frac{1}{q^*}), +\infty[$, the latter is unique. It is denoted by $\sigma(q^*)$ below.

(ii) We have $h(\sigma) = (1 + \frac{2}{q^*})\sigma^2 - \sigma^2 > 0$ and $\partial h(x) > 0$ for all $x \in [\sigma, \sigma \cdot exp(\frac{1}{q^*})[$. Therefore, function h is positive over $x \in [\sigma, \sigma \cdot exp(\frac{1}{q^*})[$. We established above that h is positive also over $[\sigma \cdot exp(\frac{1}{q^*}), \sigma(q^*)[$, and that $h(\sigma(q^*)) = 0$. Therefore $\sqrt{h}$ is well-defined over $[\bar{\sigma}, \sigma(q^*)]$, positive over $[\bar{\sigma}, \sigma(q^*)[$, increasing over $[\bar{\sigma}, \sigma \cdot exp(\frac{1}{q^*})[$, and decreasing over $[\sigma \cdot exp(\frac{1}{q^*}), \sigma(q^*)[$. It is clearly C^∞ over $[\bar{\sigma}, \sigma(q^*)[$.

(iii) We have $\partial^2 h(x) = -4(1 - \frac{1}{q^*} + \log(\frac{x}{\sigma}))$. This implies that $\partial^2 h(x) < 0$ for all $x \in [\sigma \cdot exp(\frac{1}{q^*}), +\infty[$. Since $\sigma \cdot exp(\frac{1}{q^*} - 1) < \sigma \cdot exp(\frac{1}{q^*})$, there exists a positive real number $\delta = (1 - \frac{1}{e})\sigma \cdot exp(\frac{1}{q^*})$ such that $\partial^2 h(x) < 0$ for all $x \in] - \delta + \sigma \cdot exp(\frac{1}{q^*}), +\infty[$.

We have $\partial^2 \sqrt{h(x)} = \frac{1}{2\sqrt{h(x)}}(\partial^2 h(x) - \frac{(\partial^2 h(x))^2}{2h(x)})$ wherever it is well-defined. We established above that $\partial^2 h(x)$ is negative over $] - \delta + \sigma \cdot exp(\frac{1}{q^*}), \sigma(q^*)]$, and that h is positive over $[\bar{\sigma}, \sigma(q^*)[$. Therefore, there exists a positive real number $\varepsilon = \min\{\delta, \sigma \cdot exp(\frac{1}{q^*}) - \bar{\sigma}\}$ such that $\partial^2 \sqrt{h(x)} < 0$ for all $] - \varepsilon + \sigma \cdot exp(\frac{1}{q^*}), \sigma(q^*)[$.

(iv) We have $\partial \sqrt{h(x)} = \frac{\partial h(x)}{2\sqrt{h(x)}}$ wherever it is well-defined. We established above that ∂h is negative over $]\sigma \cdot exp(\frac{1}{q^*}), \sigma(q^*)]$, that h is positive over $[\sigma \cdot exp(\frac{1}{q^*}), \sigma(q^*)[$, and that $h(\sigma(q^*)) = 0$. Therefore $\lim_{x \to \sigma(q^*)^-} \partial \sqrt{h(x)} = -\infty$.

(v) Recall that $F(p^*) = \left\{(\sigma_j, \mu_j) \in [\overline{\sigma}, +\infty[\mathbb{R} : \varphi(\sigma_j, \mu_j) = \frac{1}{q^*}\right\}$. Function φ being C^∞ and such that $\partial_x \varphi(\sigma(q^*), \mu) = \frac{\sigma(q^*)^2 - \sigma^2}{\sigma(q^*)^3} \neq 0$, the implicit function theorem implies the existence of $\varepsilon \in \mathbb{R}_{++}$ and a function $g :]\mu - \varepsilon, \mu + \varepsilon[\to \mathbb{R}$ that is C^∞, and such that $g(\mu) = \sigma(q^*)$ and $\varphi(g(y), y) = \frac{1}{q^*}$ and $\partial g(y) = -\frac{\partial_y \varphi(g(y),y)}{\partial_x \varphi(g(y),y)}$ for all $y \in]\mu - \varepsilon, \mu + \varepsilon[$. It will be sufficient, therefore, to establish that $\partial^2 g(\mu) < 0$.

We have $\partial_x \varphi(x, y) = \frac{x^2 - \sigma^2 - (y-\mu)^2}{x^3}$ and $\partial_y \varphi(x, y) = \frac{y-\mu}{x^2}$, and therefore $\partial g(y) = -\frac{y-\mu}{g(y)\left(g(y)^2 - \sigma^2 - (y-\mu)^2\right)}$ for all $y \in]\mu - \varepsilon, \mu + \varepsilon[$. Differentiating the latter identity, and observing that $\partial g(\mu) = 0$, we get $\partial^2 g(\mu) = -\frac{1}{\sigma(q^*)(\sigma(q^*)^2 - \sigma^2)} < 0$.

Proof of Theorem 1 :

(i) We know from Proposition 5 that $F(p^*)$ is nonempty and compact under the assumptions of Theorem 1. The continuity of utility functions therefore implies the existence of at least one maximum of U_i in $F(p^*)$ for all i.

(ii) We know from Proposition 4 that, under the assumptions of Theorem 1, U_i exhibits absolute distortion aversion in $F(p^*)$ for all i, that is, utility functions are decreasing both in $\mid \mu_j - \mu \mid$ and in σ_j over $F(p^*)$. Proposition 5-(ii)-(a) then implies that functions $\sigma_j \to U_i(\sigma_j, \psi_1(\sigma_j), p^*)$ and $\sigma_j \to U_i(\sigma_j, \psi_2(\sigma_j), p^*)$ are decreasing over $[\overline{\sigma}, \sigma \cdot exp(\frac{1}{q^*})]$. Therefore, the set of maxima of U_i in $F(p^*)$ is contained in $\{(\overline{\sigma}, \psi_1(\overline{\sigma}), (\overline{\sigma}, \psi_2(\overline{\sigma})\} \bigcup \left\{(\sigma_j, \mu_j) \in F(p^*) : \sigma_j > \sigma \cdot exp(\frac{1}{q^*})\right\}$.

(iii) In this third part of the proof, we assume that U_i is quasi-concave and displays relative noise aversion.

Let (σ^*, μ^*) denote a maximum of U_i in $F(p^*)$.

We first establish that (σ^*, μ^*) must be either a local maximum of U_i in $\left\{(\sigma_j, \mu_j) \in \mathbb{R}\mathbb{R} : \sigma_j \geq \overline{\sigma}, \varphi(\sigma_j, \mu_j) \geq \frac{1}{q^*}\right\}$ or a local maximum of U_i in $\left\{(\sigma_j, \mu_j) \in \mathbb{R}\mathbb{R} : \sigma_j \geq \overline{\sigma}, \varphi(\sigma_j, \mu_j) \leq \frac{1}{q^*}\right\}$. Suppose the contrary. Then there exist $(\hat{\sigma_j}, \hat{\mu_j}) \in \mathbb{R}\mathbb{R}$ and $(\tilde{\sigma}_j, \tilde{\mu_j}) \in \mathbb{R}\mathbb{R}$ such that : $\hat{\sigma_j} \geq \overline{\sigma}, \varphi(\hat{\sigma_j}, \hat{\mu_j}) > \frac{1}{q^*}$ and $U_i(\hat{\sigma_j}, \hat{\mu_j}) > U_i(\sigma^*, \mu_j^*)$; and $\tilde{\sigma}_j \geq \overline{\sigma}, \varphi(\hat{\sigma_j}, \hat{\mu_j}) < \frac{1}{q^*}$ and $U_i(\tilde{\sigma}_j, \tilde{\mu_j}) >$

$U_i(\sigma^*, \mu^*)$. By continuity of φ, there exists some real number $\lambda \in]0,1[$ such that $\varphi(\lambda\hat{\sigma_j} + (1-\lambda)\tilde{\sigma_j}, \lambda\hat{\mu_j} + (1-\lambda)\tilde{\mu_j}) = \frac{1}{q^*}$. We have $\lambda\hat{\sigma_j} + (1-\lambda)\tilde{\sigma_j} \geq \overline{\sigma}$. And the quasi-concavity of U_i implies $U_i(\lambda\hat{\sigma_j} + (1-\lambda)\tilde{\sigma_j}, \lambda\hat{\mu_j} + (1-\lambda)\tilde{\mu_j}) > U_i(\sigma^*, \mu^*)$, a contradiction.

We suppose from now on that $\sigma^* > \overline{\sigma}$ and we derive a contradiction.

Suppose first that $\sigma^* > \overline{\sigma}$ and (σ^*, μ^*) is a maximum of U_i in $\left\{(\sigma_j, \mu_j) \in \mathbb{RR} : \varphi(\sigma_j, \mu_j) \geq \frac{1}{q^*}\right\}$. The first-order necessary conditions (f.o.c.) for a local maximum of U_i in $\left\{(\sigma_j, \mu_j) \in \mathbb{RR} : \varphi(\sigma_j, \mu_j) \geq \frac{1}{q^*}\right\}$ such that $\sigma^* > \overline{\sigma}$ read as follows (e.g. Mas-Colell 1985, D1) : There are $(\lambda, \nu) \in \mathbb{R}_+\mathbb{R}_+$, such that

(a) $(\lambda, \nu) \neq 0$,

(b) $\nu(\varphi(\sigma^*, \mu^*) - \frac{1}{q^*}) = 0$,

(c) and $\lambda\partial_\sigma U_i(\sigma^*, \mu^*, p^*) + \nu \cdot \partial_x \varphi(\sigma^*, \mu^*) = \lambda\partial_\mu U_i(\sigma^*, \mu^*, p^*) + \nu \cdot \partial_y \varphi(\sigma^*, \mu^*) = 0$.

Since (σ^*, μ^*) is a maximum of U_i in $F(p^*)$ such that $\sigma^* > \overline{\sigma}$, we must have $\sigma^* > \sigma \cdot exp(\frac{1}{q^*})$ by part (ii) of the proof above. Therefore $\partial_x\varphi(\sigma^*, \mu^*) \neq 0$. Moreover, absolute noise aversion implies $\partial_\sigma U_i(\sigma^*, \mu^*, p^*) < 0$. The f.o.c. (a) and (c) above then imply that multipliers λ and ν are both > 0.

The same conclusions apply, without obvious adaptations, if we suppose that $\sigma^* > \overline{\sigma}$ and (σ^*, μ^*) is a local maximum of U_i in $\left\{(\sigma_j, \mu_j) \in \mathbb{RR} : \varphi(\sigma_j, \mu_j) \leq \frac{1}{q^*}\right\}$ (simply substitute f.o.c. (c') $\lambda\partial_\sigma U_i(\sigma^*, \mu^*, p^*) - \nu\partial_x\varphi(\sigma^*, \mu^*) = \lambda\partial_\mu U_i(\sigma^*, \mu^*, p^*) - \nu\partial_y\varphi(\sigma^*, \mu^*) = 0$ for f.o.c. (c) in the argument above).

Suppose now that $\sigma^* < \sigma(q^*)$. We established in Proposition 5 that, then, $-\frac{\partial_x\varphi(\sigma^*,\mu^*)}{\partial_y\varphi(\sigma^*,\mu^*)}$ is well-defined and $\neq 0$. Since $\lambda, \nu, \partial_x\varphi(\sigma^*, \mu^*)$ and $\partial_y\varphi(\sigma^*, \mu^*)$ are all $\neq 0$, $\partial_\sigma U_i(\sigma^*, \mu^*, p^*)$ and $\partial_\mu U_i(\sigma^*, \mu^*, p^*)$ must be $\neq 0$ as well by f.o.c.(c) and (c'). F.o.c.(c) and (c') implies then in turn that $\mid -\frac{\partial_\sigma U_i(\sigma^*,\mu^*,p^*)}{\partial_\mu U_i(\sigma^*,\mu^*,p^*)} \mid = \mid -\frac{\partial_x\varphi(\sigma^*,\mu^*)}{\partial_y\varphi(\sigma^*,\mu^*)} \mid$, which contradicts relative noise aversion. Therefore $\sigma^* = \sigma(q^*)$.

Up to this point, we have established that $\sigma^* > \overline{\sigma}$ implies $\sigma^* = \sigma(q^*)$. We now prove that

$(\sigma(q^*), \mu)$ is a local *minimum* of U_i in $F(p^*)$.

From Proposition 5-(v), there exists $\varepsilon \in \mathbb{R}_{++}$ and a C^∞ function $g :]\mu - \varepsilon, \mu + \varepsilon[\to \mathbb{R}$ such that $g(\mu) = \sigma(q^*)$ and $(g(y), y) \in F(p^*)$ for all $y \in]\mu - \varepsilon, \mu + \varepsilon[$. The implicit function theorem implies $\partial g(y) = -\frac{\partial_y \varphi(g(y),y)}{\partial_x \varphi(g(y),y)}$ for all $y \in]\mu - \varepsilon, \mu + \varepsilon[$. Consider function $W_i :]\mu - \varepsilon, \mu + \varepsilon[\to \mathbb{R}$ defined by $W_i(y) = U_i(g(y), y, p^*)$. Il will suffice to prove that $(\sigma(q^*), \mu)$ is a minimum of the latter function.

For all $y \in]\mu - \varepsilon, \mu + \varepsilon[$, we have :

$$\partial W_i(y) = \partial_\sigma U_i(g(y), y, p^*) \cdot \partial g(y) + \partial_\mu U_i(g(y), y, p^*)$$

Absolute noise aversion implies $\partial_\sigma U_i(g(y), y, p^*) < 0$ for all $y \in]\mu - \varepsilon, \mu + \varepsilon[$. Absolute bias aversion implies $\partial_\mu U_i(g(y), y, p^*) < 0$ for all $y \in]\mu, \mu + \varepsilon[$ and $\partial_\mu U_i(g(y), y, p^*) > 0$ for all $y \in]\mu - \varepsilon, \mu[$ (and therefore $\partial_\mu U_i(g(\mu), \mu, p^*) = 0$ by continuity of the first derivative and of function g).

Function g is the local inverse of function $\psi_1 = \mu + \sqrt{h}$ (resp. $\psi_2 = \mu - \sqrt{h}$) over $]\mu, \mu + \varepsilon[$ (resp. $]\mu - \varepsilon, \mu[$), and we have in particular $\partial g(y) = -\frac{\partial_y \varphi(g(y),y)}{\partial_x \varphi(g(y),y)} = \frac{1}{\partial \psi_1(g^{-1}(y))}$ for all $y \in]\mu, \mu + \varepsilon[$ and $\partial g(y) = -\frac{\partial_y \varphi(g(y),y)}{\partial_x \varphi(g(y),y)} = \frac{1}{\partial \psi_2(g^{-1}(y))}$ for all $y \in]\mu - \varepsilon, \mu[$. We deduce from this fact and Proposition 5 that $-\frac{\partial_y \varphi(g(y),y)}{\partial_x \varphi(g(y),y)} < 0$ for all $y \in]\mu, \mu + \varepsilon[$ and $-\dfrac{\partial_y \varphi(g(y), y)}{\partial_x \varphi(g(y), y)} > 0$ for all $y \in]\mu - \varepsilon, \mu[$.

Relative noise aversion then implies that $\partial W_i(y) < 0$ for all $y \in]\mu - \varepsilon, \mu[$ and $\partial W_i(y) > 0$ for all $y \in]\mu, \mu + \varepsilon[$. This fact and the continuity of W_i imply in turn that $W_i(\mu) \geq W_i(y)$ for all $y \in]\mu - \varepsilon, \mu + \varepsilon[$, with a strict inequality for all $y \neq \mu$, the contradiction we were looking for. This concludes the proof of part (iii).

(iv)The reasoning developed in part (iii) above applies identically to the proof of part (iv), with obvious adjustments implying that $(\sigma(q^*), \mu)$ is a local *maximum* of U_i in $F(p^*)$ (relative bias aversion implies that $\partial W_i(y) > 0$ for all $y \in]\mu-\varepsilon, \mu[$ and $\partial W_i(y) < 0$ for all $y \in]\mu, \mu+\varepsilon[$.■

Proof of Theorem 2 :

Part (i) is established as in part (i) of the proof of Theorem 1. Let us prove part (ii). We assume that U_i is quasi-concave and prone-to-bias. And we let (σ^*, μ^*) denote a maximum of U_i in $F(p^*)$. We have to prove that $\sigma^* \in [\overline{\sigma}, \sigma \exp{(\frac{1}{q^*})}[$.

If $\sigma^* = \overline{\sigma}$ there is nothing to prove. We therefore suppose from there on that $\sigma^* > \overline{\sigma}$.

We first establish that $\sigma^* \neq \sigma(q^*)$. This is done by means of a variant of the argument developed in the last part of the proof of part (iii) of Theorem 1. Let W_i be defined as in part (iii) of Theorem 1, and recall that $\partial W_i(y) = \partial_\sigma U_i(g(y), y, p^*)\partial g(y) + \partial_\mu U_i(g(y), y, p^*)$ for all $y \in]\mu - \varepsilon, \mu + \varepsilon[$ for some $\varepsilon > 0$ and some C^∞ function $g :]\mu - \varepsilon, \mu + \varepsilon[\to \mathbb{R}$ such that $g(\mu) = \sigma(q^*), \partial g(y) < 0$ for all $y \in]\mu, \mu+\varepsilon[$ and $\partial g(y) > 0$ for all $y \in]\mu-\varepsilon, \mu[$. Absolute noise aversion implies $\partial_\sigma U_i(g(y), y, p^*) < 0$ for all $y \in]\mu, \mu+\varepsilon[$. Prone to bias preferences imply that either $\partial_\mu U_i(g(y), y, p^*) > 0$ for all $y \in]\mu, \mu + \varepsilon[$ or $\partial_\mu U_i(g(y), y, p^*) < 0$ for all $y \in]\mu - \varepsilon, \mu[$. We have therefore either $\partial W_i(y) > 0$ for all $y \in]\mu, \mu + \varepsilon[$ or $\partial W_i(y) < 0$ for all $y \in]\mu - \varepsilon, \mu[$. This fact and the continuity of W_i imply in turn that either $U_i(g(y), y, p^*) > U_i(\sigma(q^*), \mu, p^*)$ for all $y \in]\mu, \mu+\varepsilon[$ or $U_i(g(y), y, p^*) > U_i(\sigma(q^*), \mu, p^*)$ for all $y \in]\mu-\varepsilon, \mu[$. Therefore $\sigma^* \neq \sigma(q^*)$.

At the beginning of the proof of part (iii) of Theorem 1, we established that, as a consequence of the quasi-concavity of U_i, any maximum of U_i in $F(p^*)$ must be either a local maximum of U_i in $\left\{(\sigma_j, \mu_j) \in \mathbb{R}\mathbb{R} : \sigma_j \geq \overline{\sigma}, \varphi(\sigma_j, \mu_j) \geq \frac{1}{q^*}\right\}$ or local maximum of U_i in $\left\{(\sigma_j, \mu_j) \in \mathbb{R}\mathbb{R} : \sigma_j \geq \overline{\sigma}, \varphi(\sigma_j, \mu_j) \leq \frac{1}{q^*}\right\}$.

Suppose first that (σ^*, μ^*) is a maximum of U_i in $\left\{(\sigma_j, \mu_j) \in \mathbb{R}\mathbb{R} : \sigma_j \geq \overline{\sigma}, \varphi(\sigma_j, \mu_j) \geq \frac{1}{q^*}\right\}$. Since we assume $\sigma^* > \overline{\sigma}$, we can suppose, equivalently, that (σ^*, μ^*) is a local maximum of U_i in $\left\{(\sigma_j, \mu_j) \in \mathbb{R}\mathbb{R} : \varphi(\sigma_j, \mu_j) \geq \frac{1}{q^*}\right\}$. Therefore (σ^*, μ^*) verifies the following set of first-order necessary conditions : There are $(\lambda, \nu) \in \mathbb{R}_+\mathbb{R}_+$, such that

(a) $(\lambda, \nu) \neq 0$,

(b) $\nu(\varphi(\sigma^*, \mu^*) - \frac{1}{q^*}) = 0$,

(c) and $\lambda \partial_\sigma U_i(\sigma^*, \mu^*, p^*) + \nu \cdot \partial_x \varphi(\sigma^*, \mu^*) = \lambda \partial_\mu U_i(\sigma^*, \mu^*, p^*) + \nu \cdot \partial_y \varphi(\sigma^*, \mu^*) = 0$.

Since $\sigma^* \neq \sigma(q^*)$, we have $\partial_y \varphi(\sigma^*, \mu^*) \neq 0$ and $\mu^* \neq \mu$ by Proposition 5. Moreover : absolute noise aversion implies $partial_\sigma U_i(\sigma^*, \mu^*, p^*) < 0$; and prone-to-bias preferences imply either $\partial_\mu U_i(\sigma^*, \mu^*, p^*) > 0$ if $\mu^* > \mu$ or $\partial_\mu U_i(\sigma^*, \mu^*, p^*) < 0$ if $\mu^* < \mu$. The f.o.c. (a) and (c) above then imply that multipliers λ and ν are both > 0.

The same conclusions apply, without obvious adaptations, if we suppose that $\sigma^* > \overline{\sigma}$ and (σ^*, μ^*) is a local maximum of U_i in $\left\{(\sigma_j, \mu_j) \in \mathbb{RR} : \varphi(\sigma_j, \mu_j) \leq \frac{1}{q^*}\right\}$ (simply substitute f.o.c. (c') $\lambda \partial_\sigma U_i(\sigma^*, \mu^*, p^*) - \nu \partial_x \varphi(\sigma^*, \mu^*) = \lambda \partial_\mu U_i(\sigma^*, \mu^*, p^*) - \nu \partial_y \varphi(\sigma^*, \mu^*) = 0$ for f.o.c. (c) in the argument above).

Form f.o.c. (c) and (c') we deduce that $-\frac{\partial_\sigma U_i(\sigma^*, \mu^*, p^*)}{\partial_\mu U_i(\sigma^*, \mu^*, p^*)} = -\frac{\partial_x \varphi(\sigma^*, \mu^*)}{\partial_y \varphi(\sigma^*, \mu^*)}$. Noise aversion and prone-to-bias preferences then imply that either $-\frac{\partial_x \varphi(\sigma^*, \mu^*)}{\partial_y \varphi(\sigma^*, \mu^*)} > 0$ if $\mu^* > \mu$ or $-\frac{\partial_x \varphi(\sigma^*, \mu^*)}{\partial_y \varphi(\sigma^*, \mu^*)} < 0$ if $\mu^* < \mu$. From this fact and Proposition 5 we deduce that $\sigma^* \in]\overline{\sigma}, \sigma \cdot \exp\left(\frac{1}{q^*}\right)[$.

Annexe B

How to fight media bias ?

The public firm as an instrument for regulating a duopolistic newspaper market

B.1 Proof of the utility function from reading an unbiased public newspaper

According to "Appendix A : LEMMAS" in the model of MS 2005 [1], the slant strategy of a newspaper which biases around point B is defined as $s_B(d) = \frac{\varphi}{\chi+\varphi}(B-d)$.

The expected utility of a reader from reading an unbiased newspaper *i* is :

$$E_d[U\left(s_B(d)\right)] = \overline{u} - \chi \int_d \frac{\varphi}{\chi+\varphi}(B-d)^2 - \varphi \int_d \left(d + \frac{\varphi}{\chi+\varphi}(B-d) - b\right)^2 - P_i.$$

When a newspaper is unbiased, it always reports the truth, i.e. the expectation of the slant is zero

1. From (A1) to (A11), pp. 1043–1044, Sendhil Mullainathan and Andrei Shleifer. "The market for news". In :American Economic Review95.4 (2005), pp. 1031–1053.

($E_d[s(d)] = 0$). The expected utility of a reader reading an unbiased newspaper then changes to :

$$E_d[U\,(s_B(d))] = \overline{u} - \varphi \int_d (d-b)^2 - P_i = \overline{u} - \varphi(v_d + b^2) - P_i$$

$$E_d[U\,(s_0(d))] = \overline{u} - \varphi E(d-b)^2 - P_i = \overline{u} - \varphi(v_d + b^2) - P_i$$

For a public-interest firm with government subsidy, the price P_i for consumers is the co-payment $(1-\tau)P_3$, so we have $E[U_3] = \overline{u} - \varphi(v_d + b^2) - (1-\tau)P_3$.

To determine the equilibrium value of newspapers' positions B^*, we first compute the boundaries of outlets' market shares as functions of given market prices and newspapers' positions. Next, we compute equilibrium prices as functions of newspapers' positions. And finally, we compute equilibrium positions.

B.2 Proofs of marginal readers indifferent between contiguous outlets on the market line

1) We first compute the belief $\hat{b}_i$ of a reader who is indifferent between the print and online versions of private newspaper *i*. It is determined by equation $E[U_i^o] = E[U_i^p]$, *i*= $\{1, 2\}$: *i*= $\{1, 2\}$:

$$\begin{aligned} E[U_i^p] &= E[U_i^o] \\ \overline{u} - \frac{\varphi^2}{(\chi+\varphi)}(B_i - \hat{b}_i)^2 - \frac{\chi\varphi}{(\chi+\varphi)}(\hat{b}^2 + v_d) - P_i & \\ = \overline{u} - \frac{\varphi^2}{(\chi+\varphi)}(B_i^o - \hat{b})^2 - \frac{\chi\varphi}{(\chi+\varphi)}(\hat{b}^2 + v_d) - K_i & \\ \Leftrightarrow \hat{b} = \frac{(B_i^o + B_i)}{2} + \frac{(\varphi+\chi)}{2\varphi^2}\frac{(P_i - K_i)}{(B_i - B_i^o)}(= \hat{b}_i) & \end{aligned} \qquad \text{(Eq.(A.1))}$$

Recall that :

$$B_1^o = B_1 + \frac{\alpha(-b_o + \hat{b}_1)}{2} \quad \text{and} \quad B_2^o = B_2 + \frac{\alpha(b_o + \hat{b}_2)}{2}$$

Substituting the former into (Eq.(A.1)), we get : [2]

$$\hat{b}_1^* = \frac{2B_1^* + (2-\alpha)b_0 - 2\sqrt{\Delta_1}}{(4-\alpha)}, \Delta_1 = (b_0 - B_1^*)^2 - \frac{(4-\alpha)(\varphi+\chi)}{\alpha\varphi^2}(P_1^* - K_1^*),$$

and similarly : (Eq.(A.2))

$$\hat{b}_2^* = \frac{2B_2^* - (2-\alpha)b_0 + 2\sqrt{\Delta_2}}{(4-\alpha)}, \Delta_2 = (b_0 + B_2^*)^2 - \frac{(4-\alpha)(\varphi+\chi)}{\alpha\varphi^2}(P_2^* - K_2^*).$$

2). Next we compute the belief b_{ind}^i of the readers who are indifferent between the print versions of the public outlet and newspaper *i* :

$$E[U_i^p] = E[U_3]$$

$$\overline{u} - \frac{\varphi^2}{(\chi+\varphi)}(B_i - b)^2 - \frac{\chi\varphi}{(\chi+\varphi)}(b^2 + v_d) - P_i = \overline{u} - \varphi(v_d + b^2) - (1-\tau)P_3$$

$$\Leftrightarrow b = \frac{{B_i}^2 - v_d}{2B_i} + \frac{(P_i - (1-\tau)P_3)}{2B_i}\frac{(\varphi+\chi)}{\varphi^2}(= \hat{b}_{ind}^i).$$

So we get :

$$(\hat{b}_{ind}^1)^* = \frac{((B_1^*)^2 - v_d)}{2B_1^*} + \frac{(P_1^* - (1-\tau)P_3^*)}{2B_1^*}\frac{(\varphi+\chi)}{\varphi^2};$$
$$(\hat{b}_{ind}^2)^* = \frac{((B_2^*)^2 - v_d)}{2B_2^*} + \frac{(P_2^* - (1-\tau)P_3^*)}{2B_2^*}\frac{(\varphi+\chi)}{\varphi^2}. \quad \text{(Eq.(A.3))}$$

B.3 Proofs of the prices choices at equilibrium

1) The prices of the print newspapers.

The payoff functions for the three newspapers are :

2. Assume that $B_1 < B_2$ and $-b_0 < \hat{b}_1 < \hat{b}_2 < b_0$.

$$\Pi_1 = \frac{(\hat{b}_1 + b_0)}{2b_0}(K_1 - c\delta) + \frac{(\hat{b}^1_{ind} - \hat{b}_1)}{2b_0}(P_1 - c);$$
$$\Pi_2 = \frac{(b_0 - \hat{b}_2)}{2b_0}(K_2 - c\delta) + \frac{(\hat{b}_2 - \hat{b}^2_{ind})}{2b_0}(P_2 - c);$$
$$\Pi_3 = \frac{(\hat{b}^2_{ind} - \hat{b}^1_{ind})}{2b_0}(P_3 - c).$$

Considering newspaper 1 first, the first-order conditions for the maximization of (Π_1) with respect to P_1 and K_1 read :

$$\frac{\partial \Pi_1}{\partial P_1^*} = \frac{1}{2b_0}\left(\frac{\partial \hat{b}_1^*}{\partial P_1^*}(K_1^* - c\delta) + (\frac{\partial (\hat{b}^1_{ind})^*}{\partial P_1^*} - \frac{\partial \hat{b}_1^*}{\partial P_1^*})(P_1^* - c) + ((\hat{b}^1_{ind})^* - \hat{b}_1^*)\right) = 0$$
$$\frac{\partial \Pi_1}{\partial K_1^*} = \frac{1}{2b_0}\left(\frac{\partial \hat{b}_1^*}{\partial K_1^*}(K_1^* - c\delta) + (\hat{b}_1^* + b_0) - \frac{\partial \hat{b}_1^*}{\partial K_1^*}(P_1^* - c)\right) = 0$$

Notice that : from(Eq.(A.2)), we get $\frac{\partial \hat{b}_i^*}{\partial P_i^*} = -\frac{\partial \hat{b}_i^*}{\partial K_i^*}$, and from (Eq.(A.3)), we get $\frac{\partial \hat{b}^1_{ind}}{\partial P_1^*} = \frac{(\chi+\varphi)}{2B_1^*\varphi^2}$. Adding up the right- and left-hand sides of the former first-order conditions, and substitute $\frac{\partial \hat{b}^1_{ind}}{\partial P_1^*}$ with $\frac{(\chi+\varphi)}{2B_1^*\varphi^2}$, we get :

$$\frac{\partial \Pi_1}{\partial P_1^*} + \frac{\partial \Pi_1}{\partial K_1^*} = \frac{1}{2b_0}\left(\frac{\partial \hat{b}^1_{ind}}{\partial P_1^*}(P_1^* - c) + (\hat{b}^1_{ind})^* + b_0\right) = 0$$

and

$$P_1^* = c - (\hat{b}^1_{ind} + b_0)\frac{2B_1\varphi^2}{(\chi + \varphi)}$$

Using (Eq.(A.3)), substituting the right-hand side of (Eq.(A.3)) for $(\hat{b}^1_{ind})^*$ in equation above, we get :

$$P_1^* = \frac{c + (1-\tau)P_3^*}{2} - \frac{\varphi^2}{2(\chi+\varphi)}((B_1^*)^2 + 2b_0B_1^* - v_d)$$

By similarity, we get : (Eq.(A.4))

$$P_2^* = \frac{c + (1-\tau)P_3^*}{2} - \frac{\varphi^2}{2(\chi+\varphi)}((B_2^*)^2 - 2b_0B_2^* - v_d)$$

In order to get P_3^*, we maximize the social welfare function with respect to P_3.

Social welfare is calculated by the sum of the utilities of consumers, the profits of three newspapers, minus the subsidy from the government, i.e :

$$SW = \overbrace{U}^{\text{consumers' utilities}} + \overbrace{\sum_{i=1}^{3}\Pi_i}^{\text{newspapers' profits}} \overbrace{-\tau p_3 \frac{(\hat{b}_{ind}^2 - \hat{b}_{ind}^1)}{2b_0}}^{\text{subsidy}}$$

$$= U + \Pi_1 + \Pi_2 + \frac{(\hat{b}_{ind}^2 - \hat{b}_{ind}^1)}{2b_0}((1-\tau)P_3 - c) =$$

$$\int_{-b_0}^{\hat{b}_1} \frac{U_1^0}{2b_0} db + \int_{\hat{b}_1}^{b_{ind}^1} \frac{U_1^p}{2b_0} db + \int_{b_{ind}^1}^{b_{ind}^2} \frac{U_3}{2b_0} db + \int_{b_{ind}^2}^{\hat{b}_2} \frac{U_2^p}{2b_0} db + \int_{\hat{b}_2}^{b_0} \frac{U_2^0}{2b_0} db +$$

$$\Pi_1 + \Pi_2 + \frac{(\hat{b}_{ind}^2 - \hat{b}_{ind}^1)}{2b_0}((1-\tau)P_3 - c)$$

$$= \frac{1}{2b_0}\int_{-b_0}^{\hat{b}_1}\left(\overline{u} - \frac{(\varphi)^2}{(\varphi+\chi)}(B_1^0 - b)^2 - \frac{\chi\varphi}{(\varphi+\chi)}(b^2+v_d) - K_1\right) db$$

$$+\frac{1}{2b_0}\int_{\hat{b}_1}^{b_{ind}^1}\left(\overline{u} - \frac{(\varphi)^2}{(\varphi+\chi)}(B_1 - b)^2 - \frac{\chi\varphi}{(\varphi+\chi)}(b^2+v_d) - P_1\right) db$$

$$+\frac{1}{2b_0}\int_{b_{ind}^1}^{b_{ind}^2}\left(\overline{u} - \varphi(b^2+v_d) - (1-\tau)P_3\right) db$$

$$+\frac{1}{2b_0}\int_{b_{ind}^2}^{\hat{b}_2}\left(\overline{u} - \frac{(\varphi)^2}{(\varphi+\chi)}(B_2 - b)^2 - \frac{\chi\varphi}{(\varphi+\chi)}(b^2+v_d) - P_2\right) db$$

$$+\frac{1}{2b_0}\int_{\hat{b}_2}^{b_0}\left(\overline{u} - \frac{(\varphi)^2}{(\varphi+\chi)}(B_2^0 - b)^2 - \frac{\chi\varphi}{(\varphi+\chi)}(b^2+v_d) - K_2\right) db$$

$$+\frac{(\hat{b}_1+b_0)(K_1 - c\delta) + (b_{ind}^1 - \hat{b}_1)(P_1 - c)}{2b_0} + \frac{(b_0 - \hat{b}_2)(K_2 - c\delta) + (\hat{b}_2 - b_{ind}^2)(P_2 - c)}{2b_0}$$

$$+\frac{(\hat{b}_{ind}^2 - \hat{b}_{ind}^1)}{2b_0}((1-\tau)P_3 - c)$$

$$= \overline{u} - \frac{1}{2b_0}\frac{\varphi^2}{(\varphi+\chi)}\Big(\int_{-b_0}^{\hat{b}_1}(B_1^0 - b)^2 db + \int_{\hat{b}_1}^{b_{ind}^1}(B_1 - b)^2 db + \int_{b_{ind}^2}^{\hat{b}_2}(B_2 - b)^2 db + \int_{\hat{b}_2}^{b_0}(B_2^0 - b)^2 db\Big)$$

$$-\frac{1}{2b_0}\frac{\chi\varphi}{(\varphi+\chi)}\Big(\int_{-b_0}^{b_{ind}^1}(b^2+v_d)db + \int_{b_{ind}^1}^{b_{ind}^2}\frac{(\varphi+\chi)}{\chi}(b^2+v_d)db + \int_{b_{ind}^2}^{b_0}(b^2+v_d)db\Big)$$

$$-\frac{c\delta(\hat{b}_1 + 2b_0 - \hat{b}_2) + c(\hat{b}_2 - \hat{b}_1)}{2b_0}$$

(Eq.(A.5))

Note the above equation (Eq.(A.5)) as :

$$SW = \overline{u} - \frac{1}{2b_0}\frac{\varphi^2}{(\varphi+\chi)}\Bigg(F(B_i, B_i^0, \hat{b}_i, b_0) + B_1(b_{ind}^1)^2 - B_2(b_{ind}^2)^2 - b_{ind}^1\Big((B_1)^2 - v_d\Big) + b_{ind}^2\Big((B_2)^2 - v_d\Big)\Bigg) \text{with} \quad \frac{\partial F(B_i, B_i^0, \hat{b}_i, b_0)}{\partial P_3} = 0.$$

The first order condition (FOC) reads :

$$\frac{\partial SW}{\partial P_3} = \frac{\varphi^2}{2b_0(\varphi+\chi)}\Big(2B_1 b_{ind}^1 \frac{\partial b_{ind}^1}{\partial P_3} - 2B_2 b_{ind}^2 \frac{\partial b_{ind}^2}{\partial P_3} - ((B_1)^2 - v_d)\frac{\partial b_{ind}^1}{\partial P_3} + ((B_2)^2 - v_d)\frac{\partial b_{ind}^2}{\partial P_3}\Big) = 0$$

Notice that from (Eq.(A.3)), we can deduct that $\frac{\partial b_{ind}^i}{\partial P_3} = \frac{(\tau-1)(\varphi+\chi)}{2B_i\varphi^2}$, $i = 1,2$. Substitute $\frac{\partial b_{ind}^i}{\partial P_3}$ into the FOC, we get :

$$P_3^* = \frac{P_1^* B_2^* - P_2^* B_1^*}{(1-\tau)(B_2^* - B_1^*)} \qquad \text{(Eq.(A.5))}$$

(Eq.(A.4)) and (Eq.(A.5)) make a linear system of equations with three variables P_1^*, P_2^*, and P_3^*. Solving the system, we get :

$$\begin{aligned}
P_1^* &= c - \frac{\varphi^2}{2(\chi+\varphi)}\left((B_1^*)^2 + 2b_0 B_1^* - 2v_d + \frac{4b_0}{(\frac{1}{B_1^*} - \frac{1}{B_2^*})} - B_1^* B_2^*\right)\\
P_2^* &= c - \frac{\varphi^2}{2(\chi+\varphi)}\left((B_2^*)^2 - 2b_0 B_2^* - 2v_d + \frac{4b_0}{(\frac{1}{B_1^*} - \frac{1}{B_2^*})} - B_1^* B_2^*\right)\\
P_3^* &= \frac{1}{(1-\tau)}\left(c - \frac{\varphi^2}{(\chi+\varphi)}\left(\frac{4b_0}{(\frac{1}{B_1^*} - \frac{1}{B_2^*})} - v_d - B_1^* B_2^*\right)\right)
\end{aligned} \qquad \text{(Eq.(A.6))}$$

2) The prices of the digital newspapers.

Maximizing the payoff function of newspaper i (Π_i) as to K_i, $i = \{1, 2\}$, we get :

$$\begin{aligned}
\frac{\partial \Pi_1}{\partial K_1^*} &= \frac{1}{2b_0}\left(\frac{\partial \hat{b}_1^*}{\partial K_1^*}(K_1^* - c\delta) + (\hat{b}_1^* + b_0) - \frac{\partial \hat{b}_1^*}{\partial K_1^*}(P_1^* - c)\right) = 0\\
\frac{\partial \Pi_2}{\partial K_2^*} &= \frac{1}{2b_0}\left(-\frac{\partial \hat{b}_2^*}{\partial K_2^*}(K_2^* - c\delta) + (b_0 - \hat{b}_2^*) + \frac{\partial \hat{b}_2^*}{\partial K_2^*}(P_2^* - c)\right) = 0
\end{aligned}$$

Taking K_1 for example :

$$\frac{\partial \Pi_1}{\partial K_1^*} = \frac{1}{2b_0}\left(\frac{\partial \hat{b}_1^*}{\partial K_1^*}(K_1^* - c\delta) + (\hat{b}_1^* + b_0) - \frac{\partial \hat{b}_1^*}{\partial K_1^*}(P_1^* - c)\right) = 0$$

$$\Rightarrow K_1^* - P_1^* = c\delta - c - \frac{(\hat{b}_1^* + b_0)}{\frac{\partial \hat{b}_1^*}{\partial K_1^*}}$$

And from (Eq.(A.2)) :

$$\frac{\partial \hat{b}_1^*}{\partial K_1^*} = \frac{2(\chi + \varphi)}{\alpha\varphi^2\Big((2-\alpha)b_0 - (4-\alpha)\hat{b}_1 + 2B_1^*\Big)}$$

Then substitute the above equation of $\frac{\partial \hat{b}_1}{\partial K_1}$ into $K_1^* - P_1^*$, we finally get :

$$K_1^* - P_1^* = c(\delta - 1) + \frac{\alpha\varphi^2}{2(\chi+\varphi)}(b_0 + \hat{b}_1^*)\Big((2-\alpha)b_0 - (4-\alpha)\hat{b}_1 + 2B_1^*\Big)$$

Similarly, we can have : (Eq.(A.7))

$$K_2^* - P_2^* = c(\delta - 1) + \frac{\alpha\varphi^2}{2(\chi+\varphi)}(b_0 - \hat{b}_2^*)\Big((2-\alpha)b_0 + (4-\alpha)\hat{b}_2 - 2B_2^*\Big)$$

B.4 Proof of Proposition 1 - Socially optimal slanting level

Social welfare is the total surplus of the newspaper firms and their readers, i.e :

$$\begin{aligned}
SW = &\int_{-b_0}^{\hat{b}_1} \frac{U_1^0}{2b_0}db + \int_{\hat{b}_1}^{b_{ind}} \frac{U_1^p}{2b_0}db + \int_{b_{ind}}^{\hat{b}_2} \frac{U_2^p}{2b_0}db + \int_{\hat{b}_2}^{b_0} \frac{U_2^0}{2b_0}db + \Pi_1 + \Pi_2 \\
&= \overline{u} - \frac{1}{2b_0}\frac{\varphi^2}{(\varphi+\chi)}\Bigg(\int_{-b_0}^{\hat{b}_1}(B_1^o - b)^2 db + \int_{\hat{b}_1}^{b_{ind}}(B_1 - b)^2 db + \\
&\int_{b_{ind}}^{\hat{b}_2}(B_2 - b)^2 db + \int_{\hat{b}_2}^{b_0}(B_2^o - b)^2 db\Bigg) - \frac{\chi\varphi}{(\varphi+\chi)}\int_{-b_0}^{b_0}(b^2 + v_d)db
\end{aligned} \qquad \text{(Eq.(A.10))}$$

Note the result of (Eq.(A.10)) as :

$$SW = \overline{u} - \frac{1}{2b_0}\frac{\varphi^2}{(\varphi+\chi)}F(B_i, B_i^0) - \frac{\chi\varphi}{(\varphi+\chi)}\int_{-b_0}^{b_0}(b^2+v_d)db, \text{ with}$$
$$F(B_i, B_i^0) = \int_{-b_0}^{\hat{b}_1}(B_1^o - b)^2 db + \int_{\hat{b}_1}^{b_{ind}}(B_1 - b)^2 db + \int_{b_{ind}}^{\hat{b}_2}(B_2 - b)^2 db + \int_{\hat{b}_2}^{b_0}(B_2^o - b)^2 db$$

Then optimize SW as respect to B_i and B_i^0, and as $\frac{\partial SW}{\partial B_i} = \frac{\partial SW}{\partial B_i}, \frac{\partial SW}{\partial B_i^0} = \frac{\partial SW}{\partial B_i^0}$, we finally get :

$$\frac{\partial SW}{\partial (B_1^0)} = \frac{\partial F(B_i, B_i^0)}{\partial B_1^0} = 2B_1^0(\hat{b}_1 + b_0) - \left((\hat{b}_1)^2 - (b_0)^2\right) = 0$$
$$\frac{\partial SW}{\partial B_1} = \frac{\partial F(B_i, B_i^0)}{\partial B_1} = 2B_1(b_{ind} - \hat{b}_1) - \left((b_{ind})^2 - (\hat{b}_1)^2\right) = 0$$
$$\frac{\partial SW}{\partial B_2} = \frac{\partial F(B_i, B_i^0)}{\partial B_2} = 2B_2(\hat{b}_2 - b_{ind}) - \left((\hat{b}_2)^2 - (b_{ind})^2\right) = 0$$
$$\frac{\partial SW}{\partial (B_2^0)} = \frac{\partial F(B_i, B_i^0)}{\partial B_2^0} = 2B_2^0(b_0 - \hat{b}_2) - \left((b_0)^2 - (\hat{b}_2)^2\right) = 0$$

And the first-order conditions are :

$$(B_1^0)^{(sw)} = \frac{(\hat{b}_1 - b_0)}{2}, B_1^{(sw)} = \frac{(b_{ind} + \hat{b}_1)}{2}, B_2^{(sw)} = \frac{(b_{ind} + \hat{b}_2)}{2}, (B_2^0)^{(sw)} = \frac{(b_0 + \hat{b}_2)}{2}.$$

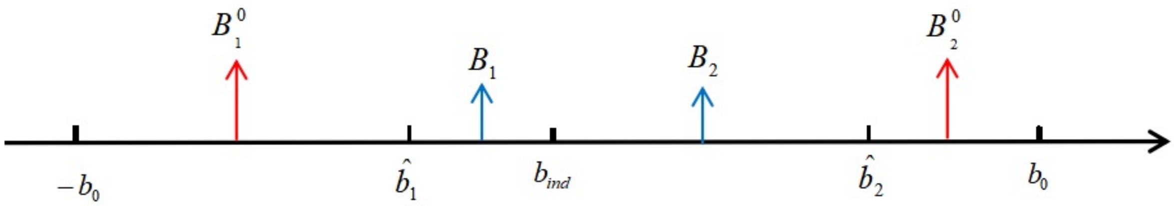
We need to discuss different scenarios of these results :

B.4.0.1 Scenario 1 : The impact of UGC on the online variant of a digital newspaper is not dominant ($0 < \alpha < 1$).

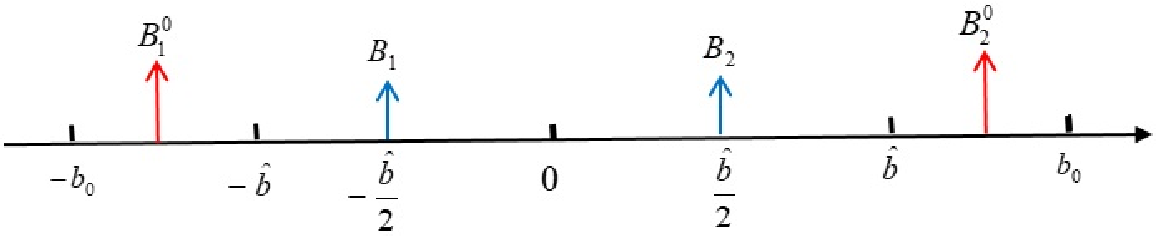
If we follow the assumption in the model of Esther Gal-or *et al.* 2013, i.e. :

$B_1^o = B_1 + \frac{\alpha(-b_o+\hat{b}_1)}{2}, B_2^o = B_2 + \frac{\alpha(b_o+\hat{b}_2)}{2}$ with $0 < \alpha < 1$, then the above FOC does not change too much, except for $b_0 = \frac{\alpha}{2(1-\alpha)}(\hat{b}_2 - \hat{b}_1)$.

At symmetric equilibrium, where $-B_1^{(sw)} = B_2^{(sw)} = B^{(sw)}$, the reporting positions of the



(a) *The optimal (first-best) reporting location choices ($0 < \alpha < 1$).*



(b) *The symmetric solutions for optimal (first-best) reporting location choices ($0 < \alpha < 1$).*

Figure B.1 – *The optimal (first-best) reporting location choices.*

print and online newspapers which maximize the social welfare are :

$$-B_1^{(sw)} = B_2^{(sw)} = \frac{\hat{b}}{2} = \frac{(\alpha-1)}{2\alpha}b_0,$$
$$-(B_1^o)^{(sw)} = (B_2^o)^{(sw)} = \frac{\hat{b}}{2(1-\alpha)} = \frac{1}{2\alpha}b_0.$$

$\frac{\partial B_i}{\partial b_0} = \frac{(\alpha-1)}{2\alpha}b_0 < 0, \frac{\partial B_i^o}{\partial b_0} = \frac{1}{2\alpha}$

B.4.0.2 Scenario 2 : The impact of UGC on an online variant of a digital newspaper is dominant.

Now if we suppose that UGC has a dominant power in deciding the online variant of a digital newspaper's content, i.e. :

$B_1^o = B_1 + \frac{(-b_o+\hat{b}_1)}{2}, B_2^o = B_2 + \frac{(b_o+\hat{b}_2)}{2}.$

Then we can get :

$$\begin{cases} -B_1^{(sw)} &= B_2^{(sw)} = 0, \\ (B_1^o)^{(sw)} &= \frac{-\hat{b}_{ind}-b_0}{2} = \frac{\hat{b}_1-b_0}{2}, \\ (B_2^o)^{(sw)} &= \frac{-\hat{b}_{ind}+b_0}{2} = \frac{\hat{b}_2+b_0}{2}. \end{cases}$$

The symmetric equilibrium results are then : $-B_1^{(sw)} = B_2^{(sw)} = 0, -(B_1^o)^{(sw)} = (B_2^o)^{(sw)} = \frac{-b_0}{2}$.

B.5 Proofs of Lemma 1 and Proposition 2

To get the reporting position choices at the equilibrium, we need to maximize the profit B_2^* for example, we have :

$$\frac{\partial \Pi_2}{\partial B_2^*} = \frac{1}{2b_0}\left((P_2^* - K_2^* - c + c\delta)\frac{\partial \hat{b}_2^*}{\partial B_2^*} - (P_2^* - c)\left(\frac{\partial (\hat{b}_{ind}^2)^*}{\partial B_2^*} + \frac{\partial (\hat{b}_{ind}^2)^*}{\partial P_3^*}\frac{\partial P_3^*}{\partial B_2^*}\right)\right) = 0 \quad \text{(Eq.(A.8))}$$

From (Eq.(A.2)), we can get :

$$\frac{\partial \hat{b}_2^*}{\partial B_2^*} = \frac{2}{(4-\alpha)}\left(1 + \frac{2(B_2^* + b_0)}{2\sqrt{\Delta_2}}\right) = \frac{2(\hat{b}_2^* + b_0)}{(4-\alpha)\hat{b}_2^* - 2B_2^* + (2-\alpha)b_0}$$ [3]

And from (Eq.(A.3)) and (Eq.(A.6)) :

$$\begin{aligned} \frac{\partial (\hat{b}_{ind}^2)^*}{\partial B_2^*} &= \frac{1}{2} + \frac{v_d}{2(B_2^*)^2} - \frac{(B_1^* + B_2^*)(2b_0 + B_1^* - B_2^*)}{4B_2^*(B_2^* - B_1^*)}; \\ \frac{\partial (\hat{b}_{ind}^2)^*}{\partial P_3^*} &= \frac{-(1-\tau)(\chi+\varphi)}{2B_2^*\varphi^2}; \\ \frac{\partial P_3^*}{\partial B_2^*} &= \frac{\varphi^2}{(1-\tau)(\chi+\varphi)}(B_1^* + \frac{4b_0(B_1^*)^2}{(B_2^* - B_1^*)^2}). \end{aligned}$$

Using the above values, the values of P_2^* from (Eq.(A.6)) and $P_2^* - K_2^*$ from (Eq.(A.7)) into

3. $2\sqrt{\Delta_2} = (4-\alpha)\hat{b}_2^* - 2B_2^* + (2-\alpha)b_0$.

(Eq.(A.8)), we obtain :

$$2\alpha\left((\hat{b}_2^*)^2-(b_0)^2\right)=\left(\frac{1}{2}+\frac{v_d}{2(B_2^*)^2}-\frac{(B_1^*+B_2^*)(2b_0+B_1^*-B_2^*)}{4B_2^*(B_2^*-B_1^*)}-\frac{1}{2B_2^*}(B_1^*+\frac{4b_0(B_1^*)^2}{(B_2^*-B_1^*)^2})\right)\left(B_1^*B_2^*-(B_2^*)^2+2b_0B_1^*-\frac{4b_0B_1^*B_2^*}{B_2^*-B_1^*}+2v_d\right)$$

To simplify the mathematical analyses, we only consider the symmetric solutions when $\alpha=1$ hereinafter.[4] Suppose that $-B_1^*=B_2^*=B^*,(-B_1^o)^*=(B_2^o)^*=(B^o)^*,(-\hat{b}_1)^*=(\hat{b}_2)^*=\hat{b}^*,(-\hat{b}_{ind}^1)^*=(\hat{b}_{ind}^2)^*=\hat{b}_{ind}^*$, suppose also that UGC has an important role in deciding the online position of the newspaper, i.e. $\alpha=1$. The symmetric equilibrium results read :

$$\begin{aligned}-(\hat{b}_{ind}^1)^*=(\hat{b}_{ind}^2)^*=\hat{b}_{ind}^*&=\frac{B^*-v_d}{2B^*};\\ -\hat{b}_1^*=\hat{b}_2^*=\hat{b}^*&==\frac{(4B^*+5b_0)}{7};\\ P_1^*=P_2^*=(1-\tau)P_3^*&=c-\frac{\varphi^2}{(\varphi+\chi)}\left((B^*)^2-2b_0B^*+v_d\right);\\ P_1^*-K_1^*=P_2^*-K_2^*&=c(1-\delta)-\frac{\varphi^2}{2(\chi+\varphi)}(b_0-\hat{b}^*)\left(b_0+3\hat{b}^*-2B^*\right).\\ (b_0)^2-(\hat{b}^*)^2&=\left(1+\frac{v_d}{2(B^*)^2}-\frac{b_0}{2B^*}\right)\left((B^*)^2-2b_0B^*-v_d\right)\end{aligned}$$

(symmetric results)

Using the relationship between B^* and $\hat{b}^*$, the symmetric equilibrium results for reporting position B^* can be rewritten as :

$$\frac{65}{49}(B^*)^4+\frac{5b_0}{2}(B^*)^3+(\frac{25(b_0)^2}{49}-\frac{v_d}{2})(B^*)^2-\frac{b_0v_d}{2}B^*-\frac{v_d}{2}=0 \qquad \text{(Eq.(A.8))}$$

Lemma 1 : Conditions to support the market segmentation

The market segmentation needs $\hat{b}_{ind}^*\le\hat{b}\le b_0$, which implies that :
$\frac{B^*-v_d}{2B^*}\le\frac{(4B^*+5b_0)}{7}\le b_0$. As $b_0\ge0, v_d\ge0$, and $B\ge0$, we can obtain the following

4. The asymmetric solutions are either too complicated or may not exist at all.

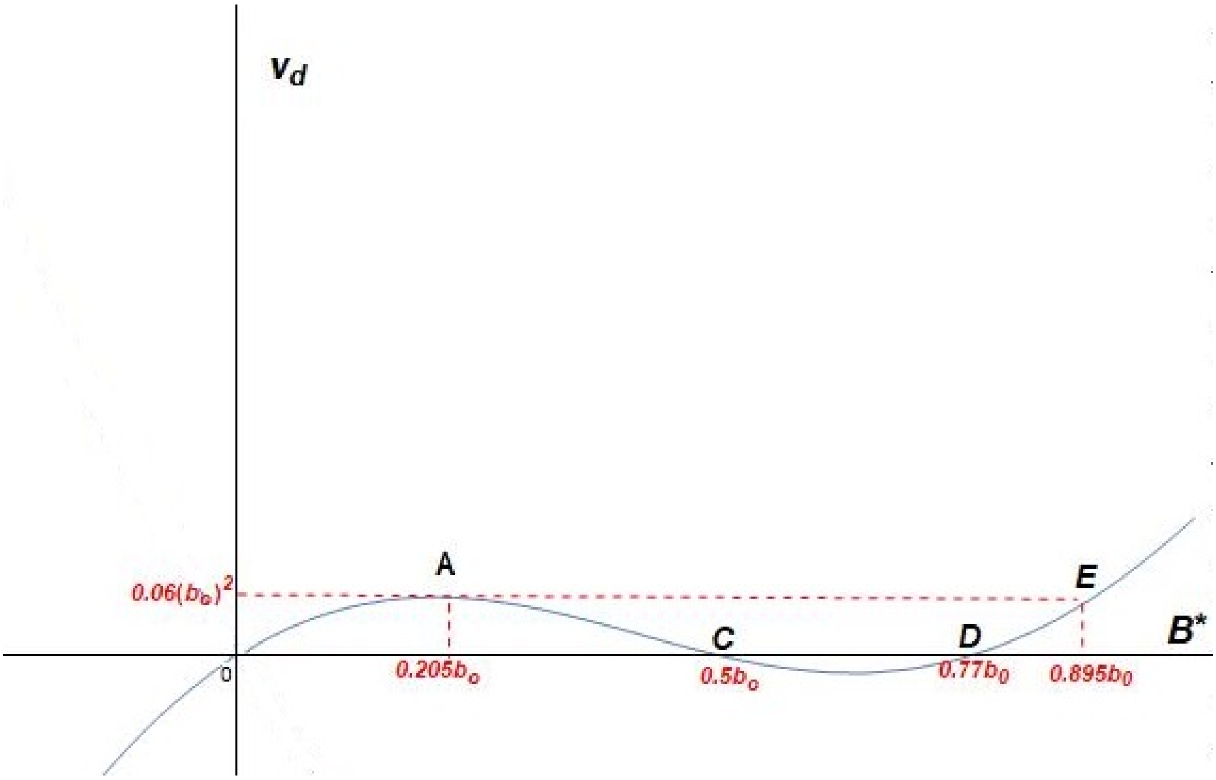


Figure B.2 – *The symmetric solutions for reporting location choice* $B^* = B^*(v_d, b_0)$.

conditions to support market segmentation at the symmetric equilibrium :

$$\frac{(-10b_0B - 8B^2 + 7B)}{7} \leq v_d \leq B \leq \frac{b_0}{2}. \qquad \text{(Lemma 3.1)}$$

Proposition 1 : Changes in reporting positions and prices at equilibrium

From Lemma 3.1 and figure B.2, we can find that for a given value of v_d and b_0, there are several results of B^* :

For any $0 < v_d < 0.6037(b_0)^2$, there are three equilibrium values for $B^* > 0$, and two of them are located between 0 and $\frac{b_0}{2}$ (***OC***), and one between $0.77b_0$ and $0.895b_0$ (***DE***). $B^* = 0.2055148b_0$ (at point ***A***) or $B^* = 0.895392b_0$ (at point ***E***) if $v_d = 0.6037(b_0)^2$. $B^* > 0.895392b_0$ and $\frac{\partial B^*}{\partial v_d} > 0$ if $v_d > 0.6037(b_0)^2$. Thus we need $0 < v_d < 0.6037(b_0)^2$ for an effective regulation policy of introducing the third public-interest firm.

As for the changes in prices of online newspapers :

$$K_i^E - K_i^* = (P_i^E - P_i^*) + (K_i^E - P_i^E) - (K_i^* - P_i^*) =$$

$$\frac{\varphi^2}{(\varphi+\chi)}\big((B^*)^2 + 2b_0B^* - v_d\big) + \frac{\varphi^2}{(\varphi+\chi)}(b_0 - \hat{b}^*)(b_0 + 3\hat{b}^* - 2B) + \frac{\varphi^2}{(\chi+\varphi)}\big((\hat{b}^*)^2 - (b_0)^2\big)$$

$$= \frac{\varphi^2}{(\varphi+\chi)}\Big((B^* + \frac{(\hat{b}^* + b_0)}{2})^2 - \frac{(\hat{b}^* + b_0)^2}{4}) - \frac{(\hat{b}^* - b_0)^2}{2}) - v_d\Big)$$

Thus, for proposition 1 :

i). $\frac{\partial P_i^*}{\partial B^*} = -\frac{2\varphi^2}{(\varphi+\chi)}(B^* - b_0) \geq 0$. $P_i^E - P_i^* = \frac{\varphi^2}{(\varphi+\chi)}((B^*)^2 + 2b_0B^* - v_d)$. Then by simple calculation, we obtain $P_i^E - P_i^* \geq 0$ when $B \in [0, -b_0 + \sqrt{(b_0)^2 + v_d}]$; $P_i^E - P_i^* \leq 0$ when $B \in [-b_0 + \sqrt{(b_0)^2 + v_d}, b_0 + \sqrt{(b_0)^2 + v_d}]$.

ii) $P_1^* - K_1^* = P_2^* - K_2^* = c(1-\delta) - \frac{\alpha\varphi^2}{2(\chi+\varphi)}(b_0 - \hat{b}^*)\Big((2-\alpha)b_0 + (4-\alpha)\hat{b}^* - 2B^*\Big)$. When $B^* \geq \frac{2-\alpha)b_0 + (4-\alpha)\hat{b}^*}{2}$. $K_i^E - K_i^* \geq 0$ when $B^* \geq \sqrt{\frac{(\hat{b}^*+b_0)^2}{4}) + \frac{(\hat{b}^*-b_0)^2}{2}) + v_d} - \frac{(\hat{b}^*+b_0)}{2}$.

B.6 Proof of Proposition 3 - Price cap regulation

When there is a unique price $\overline{P}$ for the print newspapers and $\overline{K}$ for the digital versions, the new payoff functions of the two private newspapers become :

$$\overline{\Pi}_1 = \frac{(\hat{b}_1 + b_0)}{2b_0}\overline{K} + \frac{(b_{ind} - \hat{b}_1)}{2b_0}\overline{P};$$
$$\overline{\Pi}_2 = \frac{(b_0 - \hat{b}_2)}{2b_0}\overline{K} + \frac{(\hat{b}_2 - b_{ind})}{2b_0}\overline{P}.$$

Recall that in the model of Yildirim, Gal-Or et Geylani 2013 :

$b_{ind} = \frac{B_2+B_1}{2} + \frac{(P_2-P_1)}{(B_2-B_1)}\frac{(\chi+\varphi)}{2(\varphi)^2}$ and $\hat{b}_i = \frac{(B_i^o+B_i)}{2} + \frac{(\varphi+\chi)}{2\varphi^2}\frac{(P_i-K_i)}{(B_i-B_i^o)}$. As now under price regulation, $P_2 = P_1 = \overline{P}$ and $K_2 = K_1 = \overline{K}$, so $b_{ind} = \frac{B_2+B_1}{2}$ and $\hat{b}_i = \frac{(B_i^o+B_i)}{2} + \frac{(\varphi+\chi)}{2\varphi^2}\frac{(\overline{P}-\overline{K})}{(B_i-B_i^o)}$.

Replace b_{ind} and $\hat{b}_i$ into the payoff functions under price regulation, we have :

$$\begin{aligned}
\overline{\Pi}_1 &= \frac{(\overline{K}-c\delta)}{2b_0}\left(b_0+\frac{(B_1^o+B_1)}{2}+\frac{(\overline{P}-\overline{K})}{(B_1-B_1^o)}\frac{(\chi+\varphi)}{2(\varphi)^2}\right)\\
&+\frac{(\overline{P}-c)}{2b_0}\left(\frac{(B_1+B_2)}{2}-\frac{(B_1^o+B_1)}{2}+\frac{(\overline{P}-\overline{K})}{(B_1-B_1^o)}\frac{(\chi+\varphi)}{2(\varphi)^2}\right);\\
\overline{\Pi}_2 &= \frac{(\overline{K}-c\delta)}{2b_0}\left(b_0+\frac{(B_2^o+B_2)}{2}+\frac{(\overline{P}-\overline{K})}{(B_2-B_2^o)}\frac{(\chi+\varphi)}{2(\varphi)^2}\right)\\
&+\frac{(\overline{P}-c)}{2b_0}\left(-\frac{(B_1+B_2)}{2}+\frac{(B_2^o+B_2)}{2}+\frac{(\overline{P}-\overline{K})}{(B_2-B_2^o)}\frac{(\chi+\varphi)}{2(\varphi)^2}\right).
\end{aligned}$$

Then we get :

$$\begin{aligned}
\frac{\partial\overline{\Pi}_1}{\partial B_1} &= \frac{(\overline{K}-c\delta)}{2b_0}\left(\frac{1}{2}-\frac{(\chi+\varphi)}{2(\varphi)^2}\frac{(\overline{P}-\overline{K})}{(B_1-B_1^o)^2}\right)+\frac{(\overline{P}-c)}{2b_0}\frac{(\chi+\varphi)}{2(\varphi)^2}\frac{(\overline{P}-\overline{K})}{(B_1-B_1^o)^2};\\
\frac{\partial\overline{\Pi}_1}{\partial B_1^0} &= \frac{(\overline{K}-c\delta)}{2b_0}\left(\frac{1}{2}+\frac{(\chi+\varphi)}{2(\varphi)^2}\frac{(\overline{P}-\overline{K})}{(B_1-B_1^o)^2}\right)+\frac{(\overline{P}-c)}{2b_0}\left(-\frac{1}{2}-\frac{(\chi+\varphi)}{2(\varphi)^2}\frac{(\overline{P}-\overline{K})}{(B_1-B_1^o)^2}\right);\\
\frac{\partial\overline{\Pi}_2}{\partial B_2} &= \frac{(\overline{K}-c\delta)}{2b_0}\left(-\frac{1}{2}+\frac{(\chi+\varphi)}{2(\varphi)^2}\frac{(\overline{P}-\overline{K})}{(B_2-B_2^o)^2}\right)-\frac{(\overline{P}-c)}{2b_0}\frac{(\chi+\varphi)}{2(\varphi)^2}\frac{(\overline{P}-\overline{K})}{(B_2-B_2^o)^2};\\
\frac{\partial\overline{\Pi}_2}{\partial B_2^0} &= \frac{(\overline{K}-c\delta)}{2b_0}\left(-\frac{1}{2}-\frac{(\chi+\varphi)}{2(\varphi)^2}\frac{(\overline{P}-\overline{K})}{(B_2-B_2^o)^2}\right)+\frac{(\overline{P}-c)}{2b_0}\left(\frac{1}{2}+\frac{(\chi+\varphi)}{2(\varphi)^2}\frac{(\overline{P}-\overline{K})}{(B_2-B_2^o)^2}\right).
\end{aligned}$$

(Eq.(A.11))

We observe that $\frac{\partial\overline{\Pi}_1}{B_1^*}\geq 0$, and $\frac{\partial\overline{\Pi}_2}{B_2^*}\leq 0$ for any values of $\overline{P}$ or $\overline{K}$, and $\frac{\partial\overline{\Pi}_1}{(B_1^0)^*}\leq 0$ and $\frac{\partial\overline{\Pi}_2}{(B_2^0)^*}\geq 0$ when $\overline{P}-c\geq\overline{K}-c\delta$.

If we relax the assumption of $\overline{P}-c\geq\overline{K}-c\delta$, i.e. if $\overline{P}-c<\overline{K}-c\delta$, the above results still stand. We have $\frac{\partial\overline{\Pi}_1}{(B_1^o)^*}>0$ if $0<(\overline{K}-c\delta)-(\overline{P}-c)<\frac{(\varphi)^2}{(\chi+\varphi)}(B_1-B_1^o)^2$ (≤ 0 otherwise), and $\frac{\partial\overline{\Pi}_2}{(B_2^o)^*}<0$ if $0<(\overline{K}-c\delta)-(\overline{P}-c)<\frac{(\varphi)^2}{(\chi+\varphi)}(B_2-B_2^o)^2$ (≥ 0 otherwise). However, if $\frac{\partial\overline{\Pi}_1}{(B_1^o)^*}>0$ or $\frac{\partial\overline{\Pi}_2}{(B_2^o)^*}<0$, either we get $B_1^o=B_2^0=0$ or $\mid B_i^o-B^o\mid=b_0$, which is impossible as we always get $0<(\overline{K}-c\delta)-(\overline{P}-c)<0$.

As we suppose that $B_1<B_2$ at the beginning of this paper, the payoff of the print version of the newspaper i increases as its reporting position converges to the center, i.e. when $B_1=B_2=0$; while the digital newspapers' payoffs maximize when its reporting position online becomes

most extreme, i.e. when $-B_1^0 = B_2^0 = b_0$.

B.7 Proof of Proposition 4 - Tax Policy

With a tax for fake news - ***T***, the payoffs of the two private newspapers become :

$$\Pi_1^T = \frac{(\hat{b}_1 + b_0)K_1}{2b_0} + \frac{(b_{ind} - \hat{b}_1)P_1}{2b_0} - T\left(E_d(s_1(d_1)^2) + E_d({s_1}^0(d_1)^2)\right)$$
$$= \frac{(\hat{b}_1 + b_0)K_1}{2b_0} + \frac{(b_{ind} - \hat{b}_1)P_2}{2b_0} - \frac{T\varphi^2}{(\varphi+\chi)^2}\left((B_1)^2 + (B_1^0)^2\right);$$
$$\Pi_2^T = \frac{(b_0 - \hat{b}_2)K_2}{2b_0} + \frac{(\hat{b}_2 - b_{ind})P_2}{2b_0} - \frac{T\varphi^2}{(\varphi+\chi)^2}\left((B_2)^2 + (B_2^0)^2\right).$$

Maximize the payoff functions under tax regarding the prices P_i and K_i, and we get :

$$\begin{cases} P_1^T = c + \frac{\varphi^2}{(\varphi+\chi)}(B_2 - B_1)(\frac{(B_2+B_1)}{3} + 2b_0); \\ P_2^T = c + \frac{\varphi^2}{(\varphi+\chi)}(B_2 - B_1)(-\frac{(B_2+B_1)}{3} + 2b_0); \\ K_1^T - P_1^T = -c(1-\delta) + \frac{\varphi^2}{(\varphi+\chi)}\frac{(b_0+\hat{b}_1)(b_0-3\hat{b}_1+2B_1)}{2}; \\ K_2^T - P_2^T = -c(1-\delta) + \frac{\varphi^2}{(\varphi+\chi)}\frac{(b_0-\hat{b}_2)(b_0+3\hat{b}_2-2B_2)}{2} \end{cases}$$

To simplify, we only consider the symmetric equilibrium results with $-B_1 = B_2 = B$, and suppose that costs are zero. Then $P_1^T = P^T = \frac{\varphi^2}{(\varphi+\chi)}4b_0B$ Substitute the P_1^T and K_1^T into the payoff functions under tax and maximize the new payoff functions regarding B_i and B_i^0, taking B_2 for example :

$$\frac{\partial \Pi_2^T}{\partial B_2} = \frac{\partial \Pi_2}{\partial \hat{b}_2}\frac{\partial \hat{b}_2}{\partial B_2} + \frac{\partial \Pi_2}{\partial b_{ind}}\frac{\partial b_{ind}}{\partial B_2} + \frac{\partial \Pi_2}{\partial b_{ind}}\frac{\partial b_{ind}}{\partial P_1}\frac{\partial P_1}{\partial B_2} - 2B_2T\frac{\varphi^2}{(\varphi+\chi)^2} = 0$$
$$[(-B_1 = B_2 = B)](\text{Symmetric Solutions})B^T = \frac{\left((\hat{b})^2 + (b_0)^2\right)}{4b_0(\frac{T}{(\varphi+\chi)} + \frac{1}{3})}$$

B.8 Proof of Proposition 5 - The Average Bias Level

The average bias level (**ARB**) for the heterogeneous readers is defined as :

$$ARB = \int_b E_d[(n_i - d_i)^2]$$

$$= \frac{(\hat{b}_1 + b_0)}{2b_0} E[s_1^0(d_1)^2] + \frac{(b_{ind} - \hat{b}_1)}{2b_0} E[s_1(d_1)^2] + \frac{(\hat{b}_2 - b_{ind})}{2b_0} E[s_2(d_2)^2] + \frac{(b_0 - \hat{b}_2)}{2b_0} E[s_2^0(d_2)^2] =$$

$$\frac{\varphi^2}{2b_0(\varphi + \chi)^2} \left((\hat{b}_1 + b_0)(B_1^0)^2 + (b_{ind} - \hat{b}_1)(B_1)^2 + (\hat{b}_2 - b_{ind})(B_2)^2 + (b_0 - \hat{b}_2)(B_2^0)^2 \right)$$

Again, to better compare the different scenarios, we only consider the symmetric equilibrium :

1) Social optimally, $(-B_1^0, B_1, B_2, B_2^0) = (-\frac{b_0}{2}, 0, 0, \frac{b_0}{2})$, so :

$$(ARB)^{(SW)} = \frac{\varphi^2}{2b_0(\varphi + \chi)^2} \left((\hat{b}_1 + b_0)\frac{(b_0)^2}{4} + (b_0 - \hat{b}_2)\frac{(b_0)^2}{4} \right)$$
$$= \frac{\varphi^2}{(\varphi + \chi)^2} \frac{b_0(b_0 - \hat{b})}{4}$$

2) Under price regulation, $(-B_1^0, B_1, B_2, B_2^0) = (-b_0, 0, 0, b_0)$, so :

$$(ARB)^{(PR)} = \frac{\varphi^2}{2b_0(\varphi + \chi)^2} \left((\hat{b}_1 + b_0)(b_0)^2 + (b_0 - \hat{b}_2)(b_0)^2 \right) = \frac{\varphi^2}{(\varphi + \chi)^2} b_0(b_0 - \hat{b})$$

3) Under tax regulation :

$$(ARB)^T = \frac{\varphi^2}{(\varphi + \chi)^2} \left((B^T)^2 + \frac{((b_0)^2 - (\hat{b})^2)}{b_0} B^T + \frac{(b_0 - \hat{b})(b_0 + \hat{b})^2}{4b_0} \right)$$

For $(ARB)^T \leq (ARB)^{(PR)}$, we need :

$$
\begin{aligned}
&(B^T)^2 + \frac{((b_0)^2 - (\hat{b})^2)}{b_0} B^T + \frac{(b_0 - \hat{b})(b_0 + \hat{b})^2}{4b_0} \leq b_0(b_0 - \hat{b}) \\
&\Leftrightarrow (B^T)^2 + \frac{((b_0)^2 - (\hat{b})^2)}{b_0} B^T - \frac{(b_0 - \hat{b})^2(3b_0 + \hat{b})}{4b_0} \leq 0 \\
&\Leftrightarrow 0 \leq B^T \leq \frac{(\hat{b} - b_0)(\hat{b} + b_0 - \sqrt{(\hat{b})^2) + 3b_0\hat{b} + 4(b_0)^2})}{2b_0} \\
&\Leftrightarrow \frac{(\hat{b})^2 + (b_0)^2}{4b_0(\frac{T}{(\varphi+\chi)} + \frac{1}{3})} \leq \frac{(\hat{b} - b_0)(\hat{b} + b_0 - \sqrt{(\hat{b})^2 + 3b_0\hat{b} + 4(b_0)^2})}{2b_0} \\
&\Leftrightarrow 2(\frac{T}{(\varphi + \chi)} + \frac{1}{3}) \geq \frac{(\hat{b})^2 + (b_0)^2}{(\hat{b} - b_0)(\hat{b} + b_0 - \sqrt{(\hat{b})^2 + 3b_0\hat{b} + 4(b_0)^2})}
\end{aligned}
$$

This inequality always holds true because the right side is always negative.

Annexe C

Does social media make society more polarized ? Evidence from panel data.

C.1 Proofs for proposition 1 in the theoretical part

Using the viewing time at equilibrium $t*_l$ and $t*_r$ at stage 3, P_L and P_R at stage 2, we have the following functions of total viewing time for the two newspapers :

$$\begin{cases} T^A = (1 - w(1-\eta) - (1-w)\frac{n_R^B - n_R^A + \beta w(1-\eta)}{2+w})(\gamma + n_L^A - n_R^A) \\ T^B = (1 - w\eta - (1-w)\frac{n_L^A - n_L^B + \beta w\eta}{2+w})(\gamma + n_R^B - n_L^B) \end{cases}$$

Maximizing T^A and T^A with respect to their reporting ratios n_P^j, with $j \in \{A, B\}$ and $P \in \{L, R\}$, we have :

$$\begin{cases} \frac{\partial T^A}{\partial n_L^A} = \frac{2-(\beta+1)w+(\beta+2)w\eta+(1-\beta)w^2\eta-(1-\beta)w^2-(1-w)(n_R^B-n_R^A)}{2+w} \\ \frac{\partial T^A}{\partial n_R^A} = \frac{(1-w)(n_L^A+n_R^B-2n_R^A+\gamma)-((2-(\beta+1)w+(\beta+2)w\eta+(1-\beta)w^2\eta-(1-\beta)w^2)}{2+w} \\ \frac{\partial T^B}{\partial n_L^B} = \frac{(1-w)(n_L^A+n_R^B-2n_L^B+\gamma)-(2+w-(\beta+2)w\eta+(\beta-1)w^2\eta)}{2+w} \\ \frac{\partial T^B}{\partial n_R^B} = \frac{2+w-(\beta+2)w\eta+(\beta-1)w^2\eta-(1-w)(n_R^B-n_R^A)}{2+w} \end{cases}$$

Media outlets will choose $n_P^j = 1$ when $\frac{\partial T^j}{\partial n_P^j} \geq 0$ and $n_P^j = 0$ otherwise. Denote $\triangle L = n_L^A - n_L^B$, $\triangle R = n_R^B - n_R^A$, $\triangle A = n_L^A - n_R^A$, $\triangle B = n_R^B - n_L^B$, $f_A = \frac{2-(\beta+1)w+(\beta+2)w\eta+(1-\beta)w^2\eta-(1-\beta)w^2}{1-w}$, and $f_B = \frac{2+w-(\beta+2)w\eta+(\beta-1)w^2\eta}{1-w}$, conditions for choosing different reporting strategies of media outlets A and B at equilibrium are :

Strategies (n_L^j, n_R^j)	**conditions for** $j = A$	**conditions for** $j = B$
$(0, 0)$	$\gamma + \triangle A + \triangle R \leq f_A \leq \triangle R$	$f_B \leq \triangle L$
$(0, 1)$	$f_A \leq \triangle R$	$\triangle L \leq f_B \leq \triangle L + \triangle B + \gamma$
$(1, 0)$	$\gamma + \triangle A + \triangle R \leq f_A$	$\triangle L + \triangle B + \gamma \leq f_B \leq \triangle L$
$(1, 1)$	$\triangle R \leq f_A \leq \gamma + \triangle A + \triangle R$	$\triangle L + \triangle B + \gamma \leq f_B$

Tableau C.1 – Conditions for reporting strategies

There are 16 different possible combinations of different reporting strategies.

Firstly, taking $\beta = 1$ for example, we can rule out 12 extreme cases where the conditions for equilibrium are either $w = 1, \eta = 0$ or $w > 1$: all 8 cases where the strategies of media outlet A are (0,0) and (0,1), 3 cases where the strategies of media outlet A is (1,1) and B's is either (0,0) or (1,0) or (0,1), and one case where the strategies of media outlet A are (1,0) and B's are (0,0).

Then, more generally, when $0 \leq \beta \leq 1$, there remains the following four scenarios :

Strategies	**Conditions**	**Results**
$A(1,1)$ $B(1,1)$	$0 \leq f_A \leq \gamma$ $\gamma \leq f_B$	$\eta \leq \min\{\frac{2-\gamma+(\gamma+1)w}{(1-\beta)w^2+(\beta+2)w}, \frac{(1-\beta)w^2+(\beta+1)w+\gamma(1-w)-2}{(1-\beta)w^2+(\beta+2)w}\}$
$A(1,0)$ $B(0,1)$	$f_A \geq \gamma + 2$ $0 \leq f_B \leq \gamma + 2$	$\max\{\frac{3w-\gamma(1-w)}{(1-\beta)w^2+(\beta+2)w}, \frac{(1-\beta)w^2+(\beta-1)w+\gamma(1-w)}{(1-\beta)w^2+(\beta+2)w}\} \leq \eta \leq \frac{2+w}{(1-\beta)w^2+(\beta+2)w}$
$A(1,0)$ $B(1,0)$	$f_A \geq \gamma + 1$ $\gamma + 1 \leq f_B \leq 0$	$\max\{\frac{2+w}{(1-\beta)w^2+(\beta+2)w}, \frac{(1-\beta)w^2+\gamma(1-w)+-1}{(1-\beta)w^2+(\beta+2)w}\} \leq \eta \leq \frac{1+2w-\gamma(1-w)}{(1-\beta)w^2+(\beta+2)w}$
$A(1,0)$ $B(1,1)$	$f_A \geq \gamma + 2$ $f_B \geq \gamma$	$\eta \in [\frac{(1-\beta)w^2+(\beta-1)w+\gamma(1-w)}{(1-\beta)w^2+(\beta+2)w}, \frac{2-\gamma+(\gamma+1))w}{(1-\beta)w^2+(\beta+2)w}]$

Tableau C.2 – All possible scenarios when $0 \leq \beta \leq 1$

All the thresholds are functions that decrease with the value of β, which means that conditions are getting stricter when β increases. We focus on two scenarios where the two media outlets give full reports and where they are both biased. When two media outlets give full reporting, the proportion of left partisans can not surpass a certain level, namely, $\eta \leq \min\{\frac{2-\gamma+(\gamma+1)w}{(1-\beta)w^2+(\beta+2)w}, \frac{(1-\beta)w^2+(\beta+1)w+\gamma(1-w)-2}{(1-\beta)w^2+(\beta+2)w}\} \leq \frac{1}{2}$. When both media outlets are biased, there should be more than one half of left partisans among all partisans, that is, $\eta \geq \max\{\frac{3w-\gamma(1-w)}{(1-\beta)w^2+(\beta+2)w}, \frac{(1-\beta)w^2+(\beta-1)w+\gamma(1-w)}{(1-\beta)w^2+(\beta+2)w}\}$ $\geq \frac{1}{2}$.

Résumé :

Les médias jouent un rôle vital dans notre vie car ils offrent aux citoyens des informations leur permettant de prendre des décisions politiques et sociales. Le marché des informations diffère des autres marchés par bien des aspects. De plus, l'essor des nouvelles technologies telles qu'Internet et les médias sociaux fait apparaître de nouveaux défis tels que les biais médiatiques, la polarisation de la société…Cette thèse explore les raisons et les conséquences des biais médiatiques d'un point de vue économique et politique.

Le premier chapitre traite de la différentiation de produits sur un marché concurrentiel de l'information. L'information rapportée par les médias est imparfaite, caractérisée par un couple espérance-variance mesurant respectivement le biais et le bruit informationnels. La qualité des produits informationnels est mesurée synthétiquement par la divergence de Kullback-Leibler. On montre qu'à l'équilibre concurrentiel le marché se segmente en deux parties. Une partie conventionnelle, commercialisant des produits d'information très biaisés et peu bruités, attire la grande majorité des consommateurs. Certains consommateurs, dont l'aversion pour les biais l'emporte sur leur aversion pour le bruit, optent, à l'autre extrême, pour des produits informationnels sans biais mais très bruités.

Le deuxième chapitre examine les effets de trois politiques réglementaires sur la réduction des biais médiatiques dans un marché duopolistique de la presse : l'introduction d'd'un média public, la réglementation par contrôle des prix et la fiscalité. Les résultats montrent que l'introduction d'un média public et d'une politique fiscale bien conçue peut être efficace pour réduire les biais médiatiques.

Le troisième chapitre étudie la relation entre l'utilisation des médias en ligne et la polarisation sociale et politique dans un modèle et par les données de panel. Les résultats établissent l'existence d'une corrélation positive entre l'utilisation des médias en ligne et le niveau de polarisation (à la fois la polarisation de la société et la polarisation politique) à partir d'un panel

de données V-Dem portant sur plus de 200 pays sur la période 2000-2021.

Descripteurs :

Biais médiatique, divergence Kullback-Leibler, différenciation horizontale, vérification des faits, contenu généré par les utilisateurs, fiscalité, politique réglementaire, polarisation, données de panel.

Abstract :

Media play a vital role in our life as it offers information for citizens to make political and social decisions. The market for news differs from other markets in many different ways. Moreover, the development of mass technologies such as the Internet and social media fosters new challenges relative, notably, to media biases and the polarization of society. This thesis explores the reasons and consequences of media biases from economic and political perspectives.

The first chapter discusses the impacts of competition in the news market on the differentiation of its products – news. We show that most types of noise-averse consumers choose their news providers in the close vicinity of the conventional end of the market and that some "relative" bias-averse individuals will choose it at the noisy end.

The second chapter examines the effects of three regulatory policies on reducing media bias in a duopolistic newspaper market : introducing a public interest firm, price-cap regulation, and taxation. The results show that introducing a public-interest firm and a well-designed tax policy can be effective in reducing media bias.

The third chapter studies the relationship between the use of online media and polarization. The results show the existence of a positive correlation between the use of online media and the level of polarization (both the polarization of society and political polarization) using panel data of 198 countries between 2000 and 2021 from the V-Dem data set.

Keywords :

News media bias, Kullback-Leibler divergence, horizontal differentiation, fact-checking, user-generated content, taxation, regulatory policy, polarization, panel data.