Université Panthéon - Assas

Ecole doctorale de sciences économiques et de gestion

Thèse de doctorat en sciences économiques
soutenue le 24 septembre 2013

Thèse de doctorat septembre/ 2013

Monopole naturel, marchés bifaces, différenciation tarifaire: trois essais sur la régulation de télécommunications

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Avertissement

À mes parents

Remerciements

Je tiens tout d'abord à remercier le Professeur Laurent Benzoni d'avoir accepté la direction de cette thèse, d'avoir partagé son expérience et sa connaissance, pour ses conseils avisés et pour la confiance qu'il m'a accordée tout au long de ce travail.

Je souhaite exprimer au Professeur Nicolas Curien toute ma gratitude pour les précieux conseils qu'il m'a prodigués lors de notre collaboration scientifique. Sa rigueur scientifique, sa créativité et son enthousiasme m'ont beaucoup appris. Je lui suis reconnaissante de m'avoir fait l'honneur de rapporter cette thèse.

Je suis reconnaissante au Professeur Marc Bourreau de m'avoir fait l'honneur de rapporter cette thèse.

J'adresse mes remerciements au Professeur Bruno Deffains pour ses remarques pertinentes et de m'avoir fait l'honneur de faire partie du jury.

Je remercie également le Professeur Pierre Kopp de m'avoir fait l'honneur de faire partie de ce jury de thèse.

J'aimerais remercier l'équipe de TERA Consultants d'avoir partagé leur expérience de modélisation numérique et leur connaissance du domaine de télécommunications, et de m'avoir permis l'application des théories développées sur des cas d'études réels.

Je tiens à remercier les participants de la conférence sur la recherche appliquée sur l'infrastructure Infraday 2011 pour les retours que j'ai pu avoir lors de ma présentation.

Ma reconnaissance va également à Julien Pellefigue, Paul Le Coz et Timofey Zakrevskiy qui m'ont apporté un indispensable soutien dans leurs domaines respectifs.

Monopole naturel, marchés bifaces, différenciation tarifaire: trois essais sur la régulation de télécommunications

Résumé : La thèse s'intéresse à l'économie de l'industrie des télécommunications et à sa régulation. *La première partie* est dédiée au déploiement du réseau fixe de fibre optique. L'étude de différentes méthodes de régulation permet de comparer les approches en termes de vitesse et d'efficacité du déploiement ainsi que de bien-être de consommateurs. Un modèle technico-économique est construit afin d'estimer les coûts du réseau d'accès de fibre en France et de comparer les résultats des différentes approches de régulation en termes quantitatifs. *La deuxième partie* applique la théorie de marchés bifaces au domaine des communications électroniques. Elle aborde le sujet de la régulation concurrentielle de marchés bifaces et montre en quoi leur traitement doit être spécifique, en s'appuyant sur des résultats théoriques et études de cas. Un modèle de la discrimination par les prix sur des marchés bifaces est proposé qui révèle les facteurs qui déterminent le caractère favorable ou défavorable de l'impact de la discrimination. *La troisième partie* étudie la question de l'impact de la différenciation tarifaire en fonction de la destination d'appel sur le marché des communications mobiles. Un modèle théorique est construit et ensuite calibré sur la base de l'exemple du marché français en 2003. Il est montré que des baisses all-net des tarifs vers tous les réseaux simultanément entreprises par tous les opérateurs sont plus avantageux pour les consommateurs que des baisses on-net du tarif intra-réseau.

Descripteurs : télécommunications, régulation, politique de concurrence, marchés bifaces.

Natural monopoly, two-sided markets, price differentiation: three essays on the regulation of telecommunications

Abstract: The thesis focuses on the economics of the telecommunications industry and on its regulation. *The first part* is dedicated to the deployment of the fixed network of the optical fibre. The study of different regulation methods allows to compare the approaches in terms of the speed and efficiency of deployment as well as the consumers' welfare. We construct a technico-economic model of the fibre access network in France in order to compare the results of different regulation approaches in quantitative terms. *The second part* applies the theory of two-sided markets to the field of electronic communications. It deals with the issue of competition regulation on two-sided markets and shows in what way their treatment should be specific, based on theoretic results and case studies. A model of price discrimination on two-sided markets is proposed that reveals the factors determining favourable or unfavourable impact of discrimination. *The third part* studies the impact of the price differentiation depending on the call destination on the mobile communications market. A theoretic model is constructed and then calibrated based on the example of the French market in 2003. It is shown that the all-net reduction of the tariffs towards all the networks and by all the operators is more beneficial for consumers than the on-net reduction of the intra-network tariffs.

Keywords: telecommunications, regulation, competition policy, two-sided markets.

Principales abréviations

ARCEP – Autorité de régulation des communications électroniques et des postes

BEREC – Body of European Regulators of Electronic Communications

CAPEX – Capital Expenditure

CCA – Current Cost Accounting

FDC (FAC) – Fully Distributed (Allocated) Cost

FTTH – Fibre To The Home

HCA – Historical Cost Accounting

LR(A)IC – Long Run (Average) Incremental Cost

NGN – Next Generation Network

ODF – Optical fibre Distribution Frame

OPEX – Operational Expenditure

PON – Passive Optical Network

TSM – Two-Sided Markets

WACC – Weighted Average Capital Cost

Sommaire

Introduction

Depuis une cinquantaine d'année, l'économie des télécommunications s'est progressivement constituée comme un champ spécifique de la microéconomie et de l'économie industrielle. Son programme de recherche est pluridisciplinaire, à l'intersection de l'économie de la concurrence et de la régulation, de l'économie des contrats et de l'analyse économique du droit[1]. Il existe aujourd'hui un très vaste corpus de travaux dans ce domaine, qui recouvre à la fois des articles purement théoriques ainsi que des analyses empiriques de problématiques concrètes (allocation des coûts dans des entreprises multiservices, mécanismes d'enchères optimales, etc.)

L'un des enjeux principaux de l'économie des télécommunications concerne l'efficience des mécanismes de marché, et, lorsque cette efficience est prise en défaut, l'identification des modalités d'interventions réglementaires optimales. Cette question a, par exemple, conduit à de multiples travaux de recherche sur la tarification efficiente du prix des interconnexions, sur les « justes » moyens réglementaires de forcer l'introduction de la concurrence tout en maximisant l'efficience productive, sur les conditions de l'accès aux infrastructures essentielles pour empêcher un opérateur d'altérer la concurrence sur les marchés aval, sur les formes de la régulation des prix de détail nécessaire pour empêcher dans certains cas les opérateurs d'augmenter les prix jusqu'à un niveau préjudiciable aux consommateurs (notamment pour le service universel).

Cette focalisation sur les questions de défaillance du marché et de systèmes d'intervention hors-marché s'explique naturellement par les caractéristiques économiques du secteur des télécommunications : externalités positives de consommation, intensité capitalistique de certains segments, progrès technique et obsolescence rapide tant des inputs que des outputs, utilisation de ressources « rares » (fréquences), fonction de coûts sous-additive, etc. D'un point de vue théorique, ces caractéristiques doivent être prises en compte lors de la modélisation des marchés de télécommunications.

D'un point de vue pratique, ces caractéristiques ont justifié l'instauration, dans tous les pays du monde, d'une régulation centralisée *ex ante* pour compenser les défaillances structurelles du marché. De même, une attention particulière est généralement accordée

[1]Les premiers travaux dédiés à l'économie des télécommunications sont apparus dans les années 1970. Voir par exemple : Littlechild, Stephen C. *Elements of telecommunications economics*. P. Peregrinus, 1979 ; Herring, James Morton, and Gerald Connop Gross. *Telecommunications : Economics and Regulation*. Arno Press, 1974. Pour une revue, voir par exemple Majumdar, Sumit, Ingo Vogelsang, and Martin Cave. *Handbook of Telecommunications Economics*. 2002 ; Nicolas Curien, Michel Gensollen. *Economie des telecommunications*. 1992.

au secteur des télécommunications par le régulateur *ex post*.

En France, la régulation *ex post* est ainsi placée sous l'égide de l'Autorité de la concurrence, qui applique le droit général de la concurrence concernant l'examen et les éventuelles sanctions des pratiques d'ententes et d'abus de position dominante (Titre II du Code de commerce). La régulation *ex ante* du secteur des télécommunications est quant à elle opérée par l'Autorité de régulation des communications électroniques et de la poste (ARCEP), qui applique le droit spécifique au secteur des télécommunications (le Code des postes et des communications électroniques).

Quelques exemples de problématiques nécessitant une intervention hors-marché (*ex ante* ou *ex post*) peuvent être détaillés ci-dessous pour illustrer notre propos.

- Certains segments des réseaux de télécommunications, par exemple la boucle locale ou les câbles transcontinentaux, présentent une fonction de coût caractérisée par de puissants rendements croissants et par des coûts d'entrée élevés. Dans cette circonstance, seule une ou quelques grandes entreprises peuvent coexister pour fournir en concurrence les services d'accès au réseau. Cette situation entraîne classiquement un risque de forte concentration du marché, ce qui peut, en soi, justifier parfois un besoin de régulation *ex ante*. Dans certains cas, il arrive que seule une entreprise puisse exister à long terme, c'est par exemple le cas des boucles locales (fixes ou mobiles) dans les zones à forte dispersion de population (zones rurales). Le marché se retrouve donc localement dans une situation classique de monopole naturel. Le réseau de l'opérateur unique joue alors le rôle d'un *bottleneck* ou d'une facilité essentielle pour tout opérateur désirant offrir des services de communication aux populations desservies par ce réseau. L'opérateur en monopole dispose alors d'un grand pouvoir de marché qui peut se traduire soit par le refus de donner l'accès à son réseau dont il se réservera l'exploitation, ce qui minimise les possibilités d'innovation et de diversification des services, soit par un accès à son réseau ouvert à des opérateurs de service moyennant l'application de *mark-up* très élevés sur les prix, par rapport à ceux qui sont pratiqués dans les activités en concurrence. En raison des économies d'échelle, la structure monopolistique est cependant efficiente et reste préférable à une situation de « laissez-faire » supposée déboucher sur une concurrence entre plusieurs réseaux. Il importe donc que le marché soit régulé.
- Dans les réseaux de communication, les fonctions de profit et d'utilité sont de surcroît

caractérisées par l'existence d'externalités positives. Les utilisateurs d'un réseau de télécommunications fixe ou mobile bénéficient par exemple des appels reçus des autres utilisateurs ainsi que du contenu accessible sur Internet. En l'absence d'interventions hors-marché, rien ne garantit cependant que ces externalités soient totalement internalisées par les concurrents. Par ailleurs, lorsque les externalités positives sont croissantes avec les tailles des parcs d'utilisateurs d'un même réseau, elles procurent un avantage aux opérateurs disposant des parcs plus importants qui sont généralement ceux qui sont entrés en premier sur le marché : les consommateurs accordent une « prime » aux grands parcs, donc aux grands opérateurs, et ils auront alors tendance à rejoindre le plus grand opérateur et à engendrer par ce comportement une externalité encore plus grande du réseau choisi accélérant ainsi l'utilité des utilisateurs de ce réseau qui entraîne en retour une croissance rapide de son parc d'abonnés (l'effet « boule de neige »). L'existence de ces externalités positives justifie aussi le recours à une subvention de l'accès au réseau pour les consommateurs des zones à forte dispersion de la population par des mécanismes internes au secteur (subventions croisées entre différentes zones et/ou catégories de consommateurs) plutôt que par des mécanismes de subventions étatiques.

- Sur les marchés de télécommunications fixe ou mobile, les consommateurs supportent des coûts significatifs pour changer d'opérateur (« switching costs »). Les opérateurs peuvent agir stratégiquement sur ces coûts pour maintenir la « rigidité » du marché afin d'augmenter les prix au-dessus du niveau concurrentiel. Pour cette raison, les régulateurs peuvent adopter des mesures pour fluidifier le marché afin de minimiser les coûts de changement en imposant par exemple la portabilité des numéros, en limitant la durée des clauses d'engagement contractuel, etc.
- Le secteur des télécommunications se caractérise également par des innovations technologiques fréquentes qui imposent parfois le renouvellement rapide des réseaux et des terminaux et crée une obsolescence accélérée des actifs tout en engendrant une forte incertitude sur les possibilités de rentabilisation des nouveaux actifs. Il peut alors arriver qu'un investissement ne paraisse pas rentable à court terme pour les opérateurs, alors que, du point de vue de la société et du bien-être général à long terme, le bénéfice associé est bien supérieur aux coûts des investissements à réaliser. La régulation peut donc inciter à l'investissement, par exemple en faisant participer au financement différents types d'acteurs d'un marché donné, tels que les opérateurs concurrents, les consommateurs, les fournisseurs de services sur le réseau, ou encore

les fonds publics.

- Pour finir, les réseaux de télécommunications sont le support de l'économie numérique, un domaine indispensable au développement économique, à la satisfaction de besoins multiples et plus généralement au fonctionnement de la société. L'accessibilité la plus large possible de l'accès à des réseaux de communications électroniques constitue alors un enjeu politique majeur. La régulation intègre donc dans ses objectifs des dimensions qui dépassent amplement les seuls mécanismes microéconomiques de bon fonctionnement des marchés. Ainsi, la loi française prévoit que le régulateur sectoriel en charge des communications électroniques, l'ARCEP, doive, au-delà de la concurrence, veiller à ce que son action contribue à promouvoir l'innovation, à développer l'emploi dans le secteur, à contribuer à l'aménagement numérique du territoire. Ces objectifs macroscopiques doivent parfois le conduire à intégrer dans ses décisions de régulation des mécanismes qui, selon les circonstances, modèrent ou durcissent l'intensité concurrentielle sur les marchés en cause.

Face à ces enjeux concrets, l'économie des télécommunications a joué un rôle important en mettant au point l'appareil théorique permettant de concevoir des dispositifs réglementaires efficaces. Ainsi, en dépit de quelques échecs ou déconvenues, la libéralisation et la privatisation du marché des télécommunications en Europe ont stimulé l'innovation et la croissance que ce soit au niveau des réseaux ou des services. L'efficience générale du secteur a ainsi considérablement augmenté : les prix ont significativement baissé tandis que les produits et les services se sont considérablement diversifiés et ont vu leur performance croître dans des proportions gigantesques[2].

L'évolution technologique et économique du secteur des télécommunications fait cependant sans cesse évoluer les problématiques susceptibles de préoccuper les régulateurs *ex ante* et *ex post*, et requiert la mise au point de nouveaux cadres conceptuels permettant d'y apporter des solutions efficaces. Depuis quelques années, trois nouveaux thèmes d'interrogation sont ainsi apparus dans le champ réglementaire :

- Face au développement de nouvelles technologies radicales dans les boucles locales (fibre optique, 3G et 4G dans les mobiles), comment les régulateurs doivent-ils stimu-

[2]Le succès de la liberalization des telecommunications est ainsi relevé par la Commission européenne : « In the two markets which were opened up to competition first (air transport and telecommunications), average prices have dropped substantially. » (`http://ec.europa.eu/competition/liberalisation/overview_en.html`)

ler les investissements dans ces réseaux dits de nouvelle génération ? Comment inciter les opérateurs à déployer des solutions efficaces en termes de coûts ? Comment préserver une concurrence active et loyale entre tous les acteurs lors de la transition des anciens réseaux vers les nouvelles technologies ?

Cette problématique apparaît comme un enjeu essentiel de politique publique, comme le souligne la Commission Européenne : « La connectivité à haut débit revêt une importance stratégique en Europe, pour la croissance et l'innovation dans tous les secteurs de l'économie ainsi que pour la cohésion sociale et territoriale. La stratégie Europe 2020 souligne l'importance du déploiement du haut débit, qui s'inscrit dans le cadre de la stratégie de croissance poursuivie par l'UE pour la prochaine décennie, et elle fixe des objectifs ambitieux pour le développement du haut débit (. . .) Toute intervention de l'État doit limiter le plus possible le risque que l'aide supplante les investissements privés, dénature les incitations à réaliser des investissements commerciaux et, en fin de compte, fausse la concurrence dans une mesure contraire à l'intérêt commun de l'Union européenne. » [3]

- Face à l'augmentation du pouvoir économique des grandes entreprises opérant sur le secteur des services en ligne (souvent qualifiés *d'over the top*), faut-il laisser-faire, corriger d'éventuels abus ex post ou aller jusqu'à proposer une régulation ex ante de nouveaux marchés ?

  Quelques exemples récents de cas d'abus de position dominante concernant ces acteurs *over the top*, et notamment Google[4], incitent en effet à s'interroger sur l'opportunité de mettre en oeuvre des instruments réglementaires les concernant.
- Avec la diversification des offres commerciales et des moyens de tarification des opérateurs de télécommunications, comment identifier les pratiques tarifaires potentiellement anticoncurrentielles ?

  Selon le BEREC (*Body of European Regulators of Electronic Communications*), les stratégies tarifaires des opérateurs ont été identifiées comme d'importants obstacles à la migration des clients entre opérateurs. Plus spécifiquement, les régulateurs se sont récemment beaucoup intéressés aux pratiques de différentiation tarifaire *on-net/off-net* quand les appels *on-net* (c'est-à-dire les appels entre deux abonnés du même réseau) sont moins chers que les appels *off-net* (appels inter-réseaux).[5]

[3] EU Guidelines for the application of State aid rules in relation to the rapid deployment of broadband networks (2013/C 25/01) 26 January 2013

[4] http://europa.eu/rapid/press-release_IP-10-1624_en.htm

[5] BEREC report on best practices to facilitate consumer switching, October 2010

L'objet de cette thèse est d'apporter des éléments de réflexion permettant d'esquisser des réponses à ces différentes questions, qui constituent autant de sujets centraux pour la régulation des télécommunications dans les années à venir. L'approche suivie sera principalement théorique et formalisée, mais en tâchant d'en tirer certains enseignements utiles pour l'instauration de mécanismes de régulation efficients du point de vue du bien-être collectif et du surplus des consommateurs.

Les trois thèmes seront abordés successivement : la question du déploiement optimal de la boucle locale fixe de nouvelle génération (réseau FTTH), l'appréhension du marché des services sur Internet à travers la théorie des marchés bifaces et enfin la différenciation tarifaire sur le marché des communications mobiles.

Le premier chapitre de la thèse est dédié au déploiement du réseau fixe de nouvelle génération en fibre optique. C'est une question d'actualité pressante car les réseaux sont en cours de déploiement partout en Europe et dans le monde. Face à un enjeu commun, on observe pourtant une multiplicité d'approches accompagnée d'une grande divergence d'opinions sur la nature de la régulation optimale, que ce soit dans les travaux théoriques menés sur cette question ou dans les décisions effectives prises par les autorités de régulation.

Ce premier chapitre se fonde sur la théorie du monopole naturel et des incitations à l'investissement qu'il convient d'adopter dans ce contexte. Nous y étudions les différents aspects de la transition d'une ancienne technologie (boucle locale cuivre) vers la nouvelle technologie (boucle locale fibre). Une synthèse des travaux théoriques existants et de leurs principaux résultats sera tout d'abord réalisée, de même qu'une analyse comparative internationale des pratiques de régulation. Nous construirons ensuite un modèle technico-économique de déploiement du réseau de boucle locale en fibre optique pour couvrir l'ensemble du territoire métropolitain français afin de comparer les résultats des différentes approches de régulation possibles. Des conclusions seront finalement tirées quant au dispositif le plus avantageux en termes de vitesse et d'efficacité du déploiement ainsi que de maximisation du bien-être collectif et du surplus des consommateurs.

Le deuxième chapitre applique la théorie de marchés bifaces au domaine des communications électroniques.

Le concept de « marché biface » a été explicitement introduit dans la théorie de l'économie industrielle au début des années 2000. Depuis la création du concept, l'étude des marchés bifaces a suscité une production théorique très riche et très fructueuse. Les résultats de la théorie des marchés bifaces ont en effet dépassé le pur champ de la recherche économique pour être appliqués par des autorités de la concurrence lors de cas concrets de contentieux ou d'opérations de concentration notamment dans le domaine de communications électroniques. On peut citer, pour les cas les plus récents, une décision de la Commission européenne concernant le rachat par Google de DoubleClick[6] et une décision sur la prise de contrôle exclusif par le groupe TF1 du groupe AB sur le marché de média[7]. La Commission européenne recommande même désormais de prendre en compte que les marchés de communications électroniques sont souvent de nature biface [8].

La théorie de marchés bifaces permet de trouver une nouvelle interprétation au comportement des agents sur les marchés des télécommunications, puis d'expliquer pourquoi et dans quels cas la régulation de ces marchés est nécessaire. Ce chapitre traitera tout d'abord de la régulation concurrentielle *ex post* des marchés bifaces, s'agissant des problématiques de fusions, de pratiques unilatérales et de pratiques coordonnées. Dans un deuxième temps, une étude de cas concernant une affaire de tarification asymétrique sera proposée. Enfin, un modèle de discrimination par les prix sur des marchés bifaces sera proposé avec comme objectif de révéler les facteurs qui déterminent le caractère favorable ou défavorable de l'impact de la discrimination sur le surplus des consommateurs. Ce modèle sera utilisé pour tirer des conclusions pratiques utiles à la régulation des services en ligne.

Le troisième chapitre étudie quant à lui la question de l'impact de la différenciation tarifaire sur le marché des communications mobiles.

Les pratiques de différenciation tarifaire entre les appels *on-net* (intra-réseau) et *off-net* (inter-réseaux) sont actuellement la source de plusieurs contentieux concurrentiels. En 2009, l'Autorité de la concurrence a sanctionné Orange Caraïbe et France Télécom à hauteur de 63 millions d'euros pour avoir freiné le développement de la concurrence en mettant en place diverses pratiques abusives, dont une pratique de différenciation tarifaire

[6]Commission decision of 11/03/2008 declaring a concentration to be compatible with the common market and the functioning of the EEA Agreement (Case No COMP/M.4731 - Google/ DoubleClick).

[7] Autorité de la concurrence. Décision n° 10-DCC-11 du 26 janvier 2010 relative à la prise de contrôle exclusif par le groupe TF1 de la société NT1 et Monte-Carlo Participations (groupe AB).

[8]Commission Recommendation of 17 December 2007 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services. C(2007) 5406. 2007/879/EC

entre les appels *on-net* et *off-net* [9]. Par ailleurs, en 2009, à La Réunion et à Mayotte, l'opérateur mobile français SRR a été contraint par l'Autorité de la concurrence, à titre conservatoire, de s'assurer que l'écart entre ses tarifs *on-net* et *off-net* ne dépasse pas l'écart entre les coûts correspondants [10]. En France métropolitaine, un cas similaire a été jugé par l'Autorité de la concurrence et fait actuellement l'objet d'un recours devant la Cour d'appel de Paris [11].

Sur le même sujet, en juillet 2007, le troisième opérateur mobile allemand KPN a déposé une plainte auprès de la Commission européenne contre la différenciation *on-net/off-net* opérée par T-mobile et Vodafone. Bien que le *Federal Cartel Office* n'ait finalement pas donné suite à cette action, des plaintes semblables ont été portées dans d'autres pays, notamment en Belgique[12], en Autriche, en Italie et en Nouvelle Zélande[13].

Un grand nombre de travaux théoriques porte sur la concurrence entre réseaux de communication électronique. Soit parce qu'ils reposaient sur des hypothèses très particulières, soit au contraire parce qu'ils utilisaient un cadre de modélisation très général et donc très complexe, les modèles développés jusqu'ici n'ont pas permis de mener une analyse exhaustive de l'impact d'une différenciation *on-net/off-net* sur le bien-être social et sur ses composantes.

Le modèle théorique du troisième chapitre s'attache précisément à cet objectif en représentant une concurrence entre plusieurs opérateurs de téléphonie mobile dans le cadre de laquelle les opérateurs sont capables de différencier le prix d'un appel en fonction de sa destination. Le modèle est ensuite calibré sur la base de l'exemple du marché français des services de téléphonie mobile en 2003. Une simulation numérique permet finalement d'étu-

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[9] Autorité de la concurrence. Décision n° 09-D-36 du 9 décembre 2009 relative à des pratiques mises en oeuvre par Orange Caraïbe et France Télécom sur différents marchés de services de communications électroniques dans les départements de la Martinique, de la Guadeloupe et de la Guyane.

[10] Autorité de la concurrence. Décision n° 09-MC-02 du 16 septembre 2009 relative aux saisines au fond et aux demandes de mesures conservatoires présentées par les sociétés Orange Réunion, Orange Mayotte et Outremer Télécom concernant des pratiques mises en oeuvre par la société SRR dans le secteur de la téléphonie mobile à La Réunion et à Mayotte.

[11] Autorité de la concurrence. Décision n° 12-D-24 du 13 décembre 2012 relative à des pratiques mises en oeuvre dans le secteur de la téléphonie mobile à destination de la clientèle résidentielle en France métropolitaine.

[12] Conseil de la concurrence. Décision n° 2009- P/K-10 du 26 mai 2009. Affaire CONC-P/K-05/0065 : Base/BMB.

[13] cf. J. Haucap et U. Heimeshoff. Consumer behavior towards on-net/off-net price differentiation. Dans : *Telecommunications Policy* 35.4 (2011), p.325-332.

dier l'impact de la différenciation sur tous les participants du marché et sur le bien-être collectif.

Part I

Regulating transition from old to new infrastructure in fixed telecommunications

Introduction

The fixed telecommunications industry possesses characteristics that make pure competition inefficient and may lead to market failure; the standard competitive models cannot be applied to this industry and centralised regulation may turn out to be necessary:

- The cost function is characterised by the increasing scale effect which may lead to natural monopoly.
- The positive externality effect is generated between the customers.
- Telecommunications services have a positive effect on the global economic and social development on the macroeconomic level.

All these characteristics call for a special treatment of the industry: the government should ensure the broad availability of the service and the market's efficiency. The objective of this work is to study economic features of the telecommunications industry and to propose a policy that takes them into account; the specific case of the next generation fixed network is used. The question of its deployment is of importance today. Indeed, telecommunication operators worldwide are currently building their next generation access networks (NGN) that will allow to significantly increase the Internet connection speed at fixed locations. The broadly adopted technology is the fibre to the home (FTTH) technology; it stipulates usage of optical fibre cables instead of copper cables in the access network, where fibre reaches the boundary of the building. Its deployment is one of important objectives set by the European Commission[14], and most European countries have developed a plan for very fast broadband deployment.

[14] A Digital Agenda for Europe. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Brussels, 19 May 2010 COM(2010) 245.

Country	Penetration	Mbit/s	Year
Austria	100%	25	2013
Czech Republic	30%	30	2015
Germany	75%	50	2014
Spain	100%	50	2015
Portugal	100%	50	2015
Netherlands	100%	75	2020
Belgium	60%	100	2011
Sweden	40%	100	2014
Estonia	100%	100	2015
Finland	100%	100	2015
Greece	50%	100	2018
Denmark	100%	100	2020
Italy	50%	100	2020
France	70%	100	2020
Slovenia	90%	100	2020
Sweden	90%	100	2020
France	100%	100	2025
Greece	50%	100	2018

Table 0.1: National plans objectives of NGN deployment in Europe: temporal horizon, speed and coverage.
Source: BEREC, Next Generation Access - Collection of factual information and new issues of NGA roll-out - February 2011

It may be difficult to accomplish these objectives because Europe is late in its fibre network adoption, especially compared to other countries. In Asia, and particularly in South Korea and Japan, FTTH has supplanted the DSL, with 58% and 62% correspondingly. North America and Europe are a step back: very fast broadband deployment is not a priority in the USA and most European countries have manifested only a late interest for FTTH.

Country	Total fibre penetration
Belgium	0.1%
Greece	0.1%
New Zealand	0.3%
Austria	0.4%
Ireland	0.5%
Germany	0.6%
Australia	0.7%
Luxembourg	0.8%
France	0.9%
Canada	1.2%
Spain	1.6%
Finland	1.6%
Italy	2.1%
Poland	2.4%
Switzerland	2.5%
Turkey	3.5%
Netherlands	4.2%
Portugal	10.6%
Hungary	12.6%
Czech Republic	13.5%
Denmark	14.8%
Iceland	15.7%
Norway	18.1%
Sweden	29.7%
Slovak Republic	30.0%
Korea	58.2%
Japan	62.8%

Table 0.2: Percentage of fibre connections in total broadband among countries reporting fibre subscribers, December 2011.
Note: Includes fibre-to-the-home (FTTH) and fibre-to-the-building (FTTB or apartment LAN) connections. Source: OECD Broadband Portal

These numbers on penetration levels show that in Europe there is a need for a more efficient regulation of the NGN deployment: the regulation pattern should ensure a quick transition from the old copper network to the optical fibre one. Determined at the early stage, such pattern will provide dynamic consistency and policy commitment in future; also, it will allow to avoid future errors.

Regulators, industry participants and economic theorists are actively discussing which industry organisation would promote the quickest spread of fibre technology to the benefit of final users. However, as of today, there is no consensus on how the fibre should be coordinateded, and a wide array of policies is used by regulators in Europe and worldwide. Solutions proposed by different authors diverge considerably and there does not exist a unique answer. Often authors do not give precise answer on how the fibre network should be regulated, referring to different conditions on each individual territory. For example, Atkinson (2009) claims that the optimal market structure on each market will depend on specific circumstances such as density, availability and cost of existing infrastructure, etc. A similar conclusion was made by Soria and Hernández-Gil (2011), who claim that a market analysis should be performed on each sub-national territory separately with the objective of determining the optimal policy on this particular territory.

Since economic literature does not give an answer to the question of the optimal regulation strategy, the issue needs to be further developed. The objective of this work is to study the impact of various strategies of FTTH regulation and to conclude on their efficiency.

Telecommunications industry cost structure has many particular characteristics and purely theoretic modelling cannot account for all of them. That is why it was chosen to develop a more practice-oriented numerical model, taking into consideration the current level of technical development and socio-demographic factors.

We will proceed as follows. Chapter 1 deals with natural monopoly characteristics of the fixed telecommunications market and briefly discusses different approaches to regulating next generation networks. In chapter 2, we present our numerical model of fibre deployment and make simulations of two different regulatory policies. Based on these numerical results, on the theoretical analysis and on real-life examples from a European benchmark, chapter

3 compares different approaches to the regulation of the fibre network. It also studies different approaches to pricing regulation of access to infrastructure. The discussion allows to reveal regulation approaches beneficial to the total welfare and to the promotion of competition on the optical fibre market. The last chapter concludes.

1 Review of approaches to regulating next generation networks

1.1 Local loop as a natural monopoly

The concept of natural monopoly was developed in its present form in the 1970s.[1] A natural monopoly appears where the technology or the character of service are such that the customer can be served at a lesser cost by a single firm than by several firms. This property of the cost function of a typical firm is referred to as subadditivity. Suppose q – the output vector, $C(q)$ – the cost function. A single firm is less costly to the market if it holds that

$$C(q) < C(q_1) + \cdots + C(q_k), \quad \text{where } q = q_1 + \cdots + q_k.$$

The market may be characterised as a natural monopoly if the inequality holds for any decompositions of q.

Economies of scale, defined as average cost declining with the output, are often present on such market:

$$\frac{C(q)}{q} > \frac{C(q+\Delta q)}{q+\Delta q}.$$

For a single-product firm, if decreasing returns to scale apply for all the output values, it implies that the cost function is always subadditive and the market is a natural monopoly. However, economies of scale are not a necessary condition of subbaditivity. For a multiproduct firm, the scale effect is neither necessary nor sufficient for subadditivity, as

[1] See Zajac (1972), Faulhaber (1972), Faulhaber (1975), Baumol (1977).

have been shown by Baumol (1977).

Let us consider the case of the telecommunications industry and discuss to which extent it may be categorised as a natural monopoly.

As mentioned by Sharkey (1983), there is a need to delineate the market boundaries that separate natural monopoly sector from a closely related competitive sector of a given market. In this context, it is appropriate to divide the elements of the fixed telecommunications network into two parts: the access network, connecting a customer telephone termination point (the point at which a telephone connection reaches the customer) to a local telephone exchange, and the core network, providing the service to the exchange. The access network is characterised by stronger scale effect than the core network; the properties of the access network are closer to the natural monopoly. At the same time, once the access network is built, several operators may have access to it on a wholesale level. While the wholesale provision is a natural monopoly, the retail provision is closer to a competitive structure. Below we concentrate our attention solely on the access network, which constitutes a bigger part of the total cost.

Let us consider an operator's cost function $C(q)$, where the output q is measured by the number of customers connected by the operator. For an operator who has already provided a fibre network connection for a part of customers in an area, it wouldn't be very expensive to provide connection to remaining customers in the same area. For a new operator who penetrates the area, the cost of connecting an additional customer is much higher, since all the costs related to connecting the area will have to be incurred when the first customer is connected. Both incremental and average costs are higher for a new entrant than for an incumbent:

$$\frac{dC}{dq}(q+1) < \frac{dC}{dq}(q), \text{ and}$$

$$\frac{C(q+1)}{q+1} < C(1) \text{ (economies of scale apply).}$$

This rule can be applied to an area of closely located buildings, for example an agglomeration. It is not necessarily true for the whole national territory, especially if a country has a large territory with densely populated areas separated by less populated areas. To connect a new area, which is presented by a city and its agglomeration, an operator needs to make significant investments irrespective of operator's presence in another area. There may be an economy in the cost of the core network, but this cost is relatively small compared to the cost of the access network. In this case the average cost function may have the form of a ladder with a qjump in the average cost value when a new area is connected.

The scale effect on the fixed network is stronger than the one on the mobile network and closer to that of the electricity network. While on the mobile network the infrastructure competition is promoted in the Member States, on the electricity network the infrastructure sharing is maintained.[2] It means that the principles of regulating mobile and fixed telecommunications should not be the same.

Sharkey (1983) gives the example of the fixed telecommunications industry dynamics in the USA to show the natural tendency to consolidation as a sign of natural monopoly. The industry was gradually consolidated and became dominated by AT&T, which lasted before the regulatory intervention in 1960s.

It can be concluded that due to its techno-economic conditions, the wholesale access market in fixed telecommunications is close to natural monopoly, and this property is especially strong in less dense areas.

Let us consider possible equilibrium configurations on a market with a sub-additive cost function. In the classical model, if the entry is free, the long-term equilibrium will be established in the cross-point between demand and long-run average costs (P_1, Q_1) and only one firm will serve the market. Indeed, for any price $P < P_1$ and $Q > Q_1$, the profit would be negative. At the same time, if $P < P_1$ then another firm may enter the market, drive the incumbent out of the market, and obtain a positive profit with a higher price. The only production level that precludes profitable entry by another firm is $P = P_1$ and $Q = Q_1$ (cf. Schmalensee (1989)).

[2] Lebourges (2011) compares fibre network to mobile network to prove that the absence of access regulation is more efficient in both industries. Still, cost characteristics differ significantly between these two types of technologies, with fibre network being closer to natural monopoly.

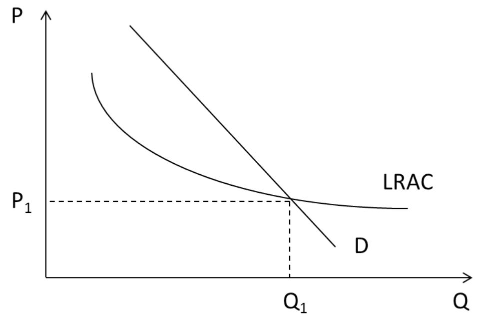

Figure 1.1: Market equilibrium in the case of natural monopoly

However, such stable equilibrium may be rarely found in practice. Even if a market is most efficiently served by only one firm, it does not mean that in equilibrium this efficient solution is achieved. An inefficient entry may occur because of a market failure. Unrestricted entry may lead to the destructive rivalry: it will bring down the price to the marginal cost, the fixed cost will not be covered, and the firms will not find it profitable to invest in the industry.

In the telecommunications industry an inefficient entry may lead to disincentives to invest in the new infrastructure based on the optical fibre. An inefficient entry may occur in the telecommunications industry because it is different from the classical theoretical model in several aspects such as switching costs, imperfect information, the stepped form of the cost curve, and non-negligible time of deployment.

The average cost of connecting a customer is significantly higher in less populated areas, that is why a risk of cream-skimming occurs. Competitors will enter only on the low-cost market segments and the price on these segments will decrease. That can be observed on the French market. As a result, the incumbent will not be able to use the gain earned in most profitable areas to decrease prices in less profitable areas, and may even cease to save it.

On a telecommunications market, even though it possesses natural monopoly characteristics, inefficient entry may happen due to sunk costs and to the dynamic process of equilibrium formation. The first operator who started to deploy the network cannot immediately serve all the customers; such operator is not protected against inefficient entry by another operator. Two operators may also start to deploy at the same time, so that their average cost levels will be close for the same coverage. In the classical model, the monopoly is already present on the market and this dynamic aspect is not accounted for.

Panzar and Willig (1977) construct a theoretical example of the case where the natural monopoly cannot protect itself against an entry because the average cost is not constantly decreasing with the output but is increasing in certain intervals. As a result of such entry, the market is served by more than one firm even though it is inefficient from the social viewpoint. Inefficient entry may lead to 'competitive destruction', where there is no sustainable equilibrium. In the telecommunications industry average cost may first decrease and then increase due to the network congestion, when as new customers join, it is necessary to expand the network's capacity. The average cost also increases due to an additional fixed cost when a new building or a new area is connected.

1.2 Main approaches to the fibre deployment regulation

There exist two main mechanisms to promote competition on a fixed telecommunications market: infrastructure-based and service-based competition. In the first case, each provider owns its network while in the second case providers use wholesale access to a common network. Unbundled access allows operators who do not possess their own network to provide services using the existing copper or fibre network of other operators. Two main technical approaches are possible:

1. passive unbundled access does not include active electronic equipment (it is referred to as 'black fibre' on NGN);
2. active or virtual unbundled access includes active electronic equipment.

Regulator may impose access obligations on the incumbent or another operator who owns the next generation network.

The table below presents solutions adopted in practice by different European regulators. In the case of monopoly, the unique network may be owned either by one operator, usually the incumbent, or by a consortium of several structures.

Table 1.1: Benchmark of fibre access regulation.

Country	**Access to fibre local loop**
Monopoly of the incumbent	
Andorra	There is no regulatory decision yet. Andorra Telecom is the only operator.
Austria	Obligation to provide virtual unbundling (VULA).
Croatia	T-Com is required to provide an offer of access to fibre.
Lithuania	There is no regulatory decision yet.
Spain	CMT has decided not to impose on Telefonica the obligation to provide a wholesale offer. Telefonica has to provide an access solution in the case there is no more free space in trenches. In Spain, the first operator who deploys in a building has to put in place appropriate measures that will enable shared access on the vertical part of the network (deploying fibre in the rise pipe of a multi-dewelling building).
UK	Obligation to provide virtual unbundling (VULA).
Monopoly municipalities	
Germany	Obligation to provide virtual unbundling (VULA). DT has to provide black fibre access if there is no more free space in trenches.
Netherlands	The consortium Reggefiber is required to provide an offer of access to fibre. Two fibre cables are deployed to each appartment: the first one is used to provide television, the second one — to provide Internet services.
Norway	There is no regulatory decision yet.
Portugal	A market analysis is to be made to open access to fibre of PT in the area where PT is alone. In the vertical part of the network the first operator is under the obligation to install at least two fibres per appartment. Remaining operators compensate for this cost depending on the order of entry: 50% the second mover and 33% the third mover.
Switzerland	Not regulated. Services Industriels and Swisscom propose unbundling (Open Access model) on the two unused fibres (the quadfibre model). Multifibre deployment is a recommended architecture.

Multiple deployments	
Italy	There is no regulatory decision yet.
Slovakia	There is no regulatory decision yet.
Slovenia	APEK was going to impose on Telekom Slovenije an obligation to provide fibre unbundling.
Sweden	94% of municipalities propose fibre unbundling. Since May 2012: requirement for the incumbent to probide unbundling (black fibre on the access network).

The numerical model of the next section allows to simulate different methods of fibre deployment regulation, monopoly or multiple deployments, and to compare their impact on the final deployment cost.

2 Model

In order to compare the effect of different policy approaches, we construct a cost model of the fibre local loop in France: it allows to estimate the cost of each element of the local loop network as well as the total cost, and to check how the result changes in particular with the number of operators, technology and WACC. It also allows to numerically simulate geographically averaged price of the wholesale access in France, and to estimate the retail price increase associated with the transfer from copper to fibre.

The data and assumptions that we use include:

- cost of different network elements,
- network configuration parameters, in particular equipment capacity and cable length,
- for each of 36,000 municipalities, geographic and demographic data such as number of buildings and households, road length, etc.

Details can be found in Appendix A. Data.

The cost of network includes the following categories:

- capital costs of a passive fibre network,
- operating costs including maintenance cost and access payment for civil engineering of France Telecom,
- a part of common costs allocated to unbundled access service.

Ducts are included not in capital costs but in operating costs, since the existing civil engineering is used.

A detailed description of the model structure can be found in Appendix B.

2.1 Cost a function of operators number

We will show that the cost function is characterized by a significant scale effect, as the number of operators varies.

The following graph shows the access cost per line and per month as a number of operators. When calculating annual depreciation, we take a WACC of 8.5%. In the case of several operators, we add a risk premium of 5% to compensate for competition risk. The lifetime of cables is taken equal to 40 years.

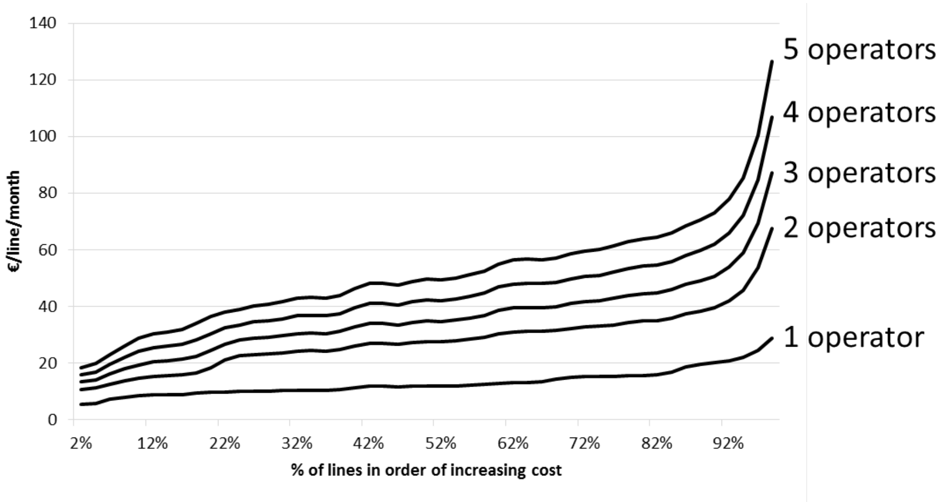

Figure 2.1: Cost as a function of density in unregulated competition, €/line/month

The geographically averaged cost is €12.94 per line per month in the monopoly and €28.10 per line per month in duopoly, or 217% higher. The increase is due to infrastructure duplication and a risk premium.

The numbers show that scale effects are significant. Hence, fibre local loop represents a natural monopoly.

2.2 Comparison of regulatory scenarios

We use the model to estimate parameters of market equilibrium for two main scenarios:

1. regulated monopoly with wholesale access (the regulator chooses only one operator who constructs the network and the wholesale access is imposed at the cost-based price);

2. regulation currently observed in France (the regulator does not limit the number of operators).

We compare these scenarios with respect to the average access cost level as a main comparison criterion, together with cost allocation per zone, access price and retail price.

2.2.1 Regulated monopoly with wholesale access

In this section, we estimate fibre local loop costs and corresponding prices that would be established if the regulator have imposed the monopoly on the fibre deployment. Using the model described above, we calculate monthly cost per line as a function of density.

To ensure service-based competition, the regulator needs to choose the network configuration that would simplify the wholesale access. There exist two general types of fibre network structure: the PON technology which consists in deploying in certain parts of the horizontal network the only fibre that groups multiple subscribers and the point-to-point technology which consists in deploying at least one fibre per subscriber within the local loop. The point-to-point technology is the more costly one, but it is more advantageous in prospect. First, it is better able to accommodate future demand for a higher speed access since there is no capacity sharing on the local loop level. Second, and very important in our context, it makes it simpler to unbundle. PON technology allows for virtual unbundling, but this type of unbundling leaves less freedom to service providers and leads to less innovation. The point-to-point technology is more suitable in the current scenario.

To simplify the wholesale access, a big size of ODF (Optical fibre Distribution Frame) has been set. The ODF capacity is equal to 20,000 lines in Paris and 10,000 lines outside Paris.[1] This high ODF capacity allows for a viable competition on the core network level: it becomes profitable for operators to connect to an ODF where there is a sufficient number of potential customers.

[1] The number of 10,000 was used in a study by ARCEP (French telecommunications regulator). Etude portant sur la mutualisation de la partie terminale des reseaux en fibre optique. Octobre 2008

First, let us study the cost structure yielded by the described regulation approach. The fixed costs constitute about 71% of the total costs. The figure below shows the share of each component of these fixed costs. Horizontal cost (cost of the network between an ODF and a building entry) has the greatest weight which is especially significant in non-dense areas. These costs are not subject to technical progress and mainly consist of labour force and cable price.

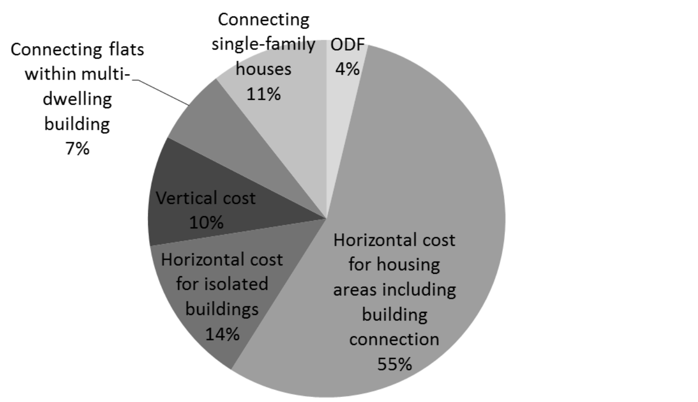

Figure 2.2: Fixed cost structure in regulated monopoly, %

The total cost was divided by 32 million of lines to obtain the national average. Then, all the lines were classified according to the density of the area they belong to. Each community of 36,000 municipalities was rated among one of 50 density categories. For each density interval, the absolute value of monthly cost is given, including CAPEX and OPEX. In Figure 2.3 communities are ordered according to their density, from more dense to less dense.

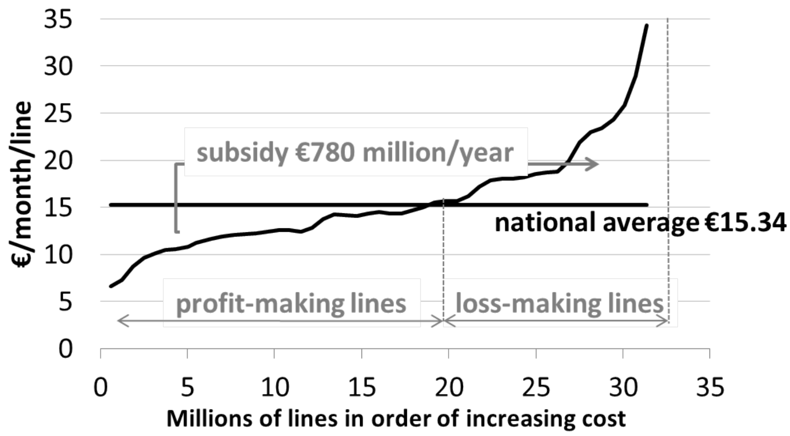

Figure 2.3: Cost as a function of density, €/line/month

The average cost is €15.34 per month per line. If the regulator fixes this single level of access price to fibre on the whole national territory, then the over-profit in dense areas can be redistributed to less dense areas through a funding mechanism so that to exactly compensate operator deploying the network in a particular area for the costs incurred.

This scheme of subsidizing uneconomic areas is already used in the French copper network. In fibre network, the subsidy will be equal to €782 million per year. 60% of economic lines will subsidise 40% of uneconomic lines.

To estimate the average retail price, we assume that the absolute value of difference between access price and retail price is the same for fibre and copper technologies. This difference includes essentially commercial cost, as well as cost of active equipment and profit margin, and there is no reason to assume that this difference will be higher in fibre than in copper. The value added tax is of 19.6%. Today in France, the access price to copper local loop is at €9 per line per month. The currently observed average subscription price in France is €32 per line per month including tax.

When passing from copper to fibre, the retail monthly connection price will rise from €32 to €39 or approximately 20%. Even though this calculation was made only for France, the retail price increase will not be excessive in other European countries as well. The internet connection price in France is already rather low compared to average European level, so the gap between copper and fibre does not tend to be greater.

2.2.2 Market configuration currently observed in France

In this section we consider the case where the number of operators is not regulated. As observed in France, it leads to well-developed infrastructure competition in dense areas and no competition in non-dense areas:

- Indeed, in highly profitable *dense areas* several competing operators will develop their fibre networks in parallel.[2] In these areas the competition is infrastructure-based and not service-based; that is why when calculating the corresponding network cost we choose the PON technology instead of the more costly point-to-point technology; this technology would be used by a rational operator.
- In *non-dense areas*, on the contrary, only one network will be deployed since duplication would be unprofitable and a rational operator would not constuct a network in the areas where it already exists. But given that the monopoly is not protected by regulation, the investor will need to be compensated for the risk by a higher WACC, that is why in non-dense areas the cost of competition will be higher than in regulated monopoly. The technology used in non-dense areas is point-to-point: the obligation of unbundling makes it rational to use point-to-point architecture to economize on expensive active equipment.

First, let us consider more in details how the cost is calculated in dense areas. Since several networks are constructed, a part of infrastructure needs to be duplicated: ODF buildings, ODF and horizontal cost (study, supply and laying) including connecting buildings. These three categories of costs constituted 42% of fixed cost and 30% of total cost in monopoly in dense areas (see figure below). The remaining infrastructure elements are mutualised among operators. The vertical cost and cost of connecting flats within building increase by 15-30% because of the need to deploy several fibre lines.

[2] In France, dense areas as defined by ARCEP (the French telecommunications regulator) include 148 of 36,000 municipalities and slightly more than 20% of fixed lines.

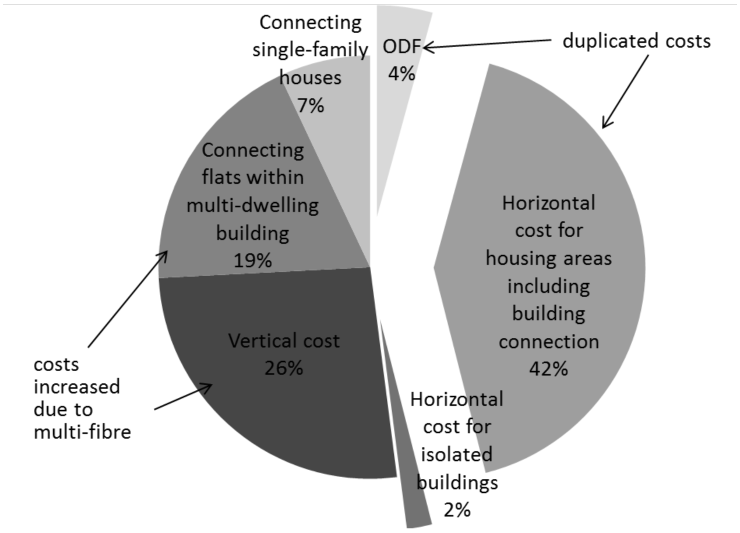

Figure 2.4: Fixed cost structure in dense areas in monopoly

The technology factor partially compensates for the cost increase following the duplication: PON technology is less expensive than the point-to-point one. Horizontal cost (study, supply and laying) excluding connecting buildings is higher by 20% in point-to-point.

When several parallel networks are active, the variable costs increase as well: a larger infrastructure requires more operating costs, and the cable maintenance cost is multiplied by the number of operators in dense areas. The common cost increases together with the other cost categories.

The cost that remains stable is the duct access payment. We suppose that the total price paid by all the operators for the access to France Telecom's civil works is such that it strictly compensates its cost. For example, each of two competing operators has to pay twice less than a monopoly operator. That is why the total price paid by all the operators does not change with their number.

Now, let us consider cost calculation in non-dense areas, where only one fibre network is built. Most likely this network will be built by the incumbent who already owns copper infrastructure, and so will be in a better position to construct a next generation network. In France ARCEP has obliged operators to construct a network of point-to-point type in non-dense areas.

Since costs are not duplicated and the point-to-point technology is used, the investment to be made is the same as in the regulated monopoly. However, since there is no obligation to remove copper, the investor faces a higher risk than in the case of regulation. In more expensive non-dense areas, if the investor does not arrive to attract sufficient demand for fibre, the capital expenses are not compensated. Where justified, the European Commission recommends including a risk premium when setting access prices to the unbundled fibre loop. That is why in the base model we suppose that in non-dense areas WACC in the non-regulated scenario is higher than WACC in the regulated scenario. Hence, we take WACC=10.40% for the first case and WACC=15.40% for the second case to calculate the capital cost.

The total investment needed to build a nationwide network significantly increases with the number of operators: by 13% for 3 operators, which is equivalent to a social welfare loss of €4.8 milliard.

	Monopoly	**Competition**			
Number of operators	1	2	3	4	5
Total investment	36,666	39,268	41,479	43,690	45,901
Increase compared to monopoly	100%	107%	113%	119%	125%

Table 2.1: Total investment as a function of number of operators, €million

The cost in competition is higher than the cost in monopoly because of two effects: infrastructure duplication in dense areas and a higher WACC in non-dense areas. If we suppose that the access price is cost-oriented, this price in competition is strictly higher than the price in monopoly. Moreover, access price grows higher as the number of alternative infrastructures increases.

The figure below traces the average cost as the number of competitors increases. The increase in cost in dense areas is explained by duplication. The average cost of a line situated in non-dense areas is 77% higher than the cost of a line in a dense area in monopoly, and 59% in duopoly. This gap is lower in duopoly since the total cost in dense areas is higher because of duplication.

The plain line summarizes the two dotted lines and demonstrates how the average national access price changes as the number of competitors increases. This cost increases by 31% for 2 competitors and by 37% for 3 competitors compared to monopoly.

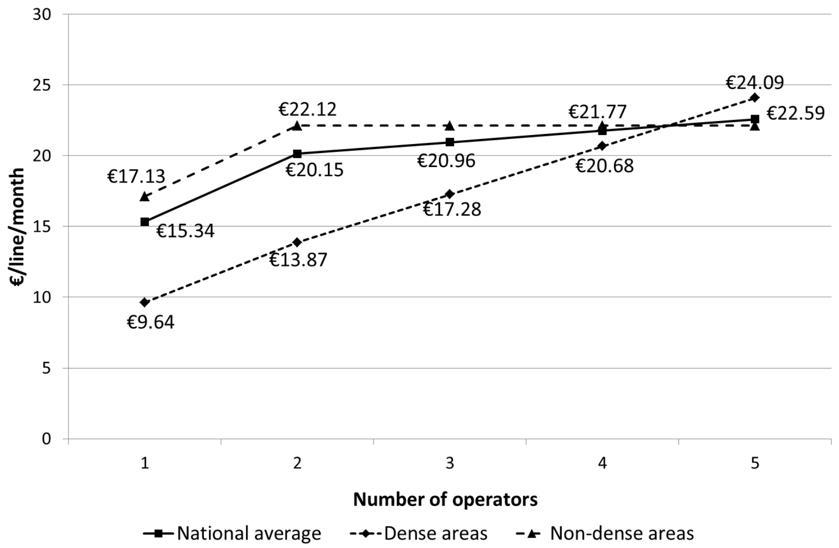

Figure 2.5: Average cost depending on number of operators, €/line/month

The effect of duplication on national price depends significantly on the size of high density areas. In countries with high average density the duplication will take place on a great surface, and its negative effect will be particularly significant.

Figure below demonstrates how the cost function changes with the number of competitors. Because of duplication, the cost of construction may become higher in dense areas than in non-dense areas. It will lead to absurd local disruptions in retail price. When 5 competitors are building their networks in parallel, the average cost of one line in dense areas is even higher than the average cost of one line in non-dense areas: €24.09 vs. €22.59.

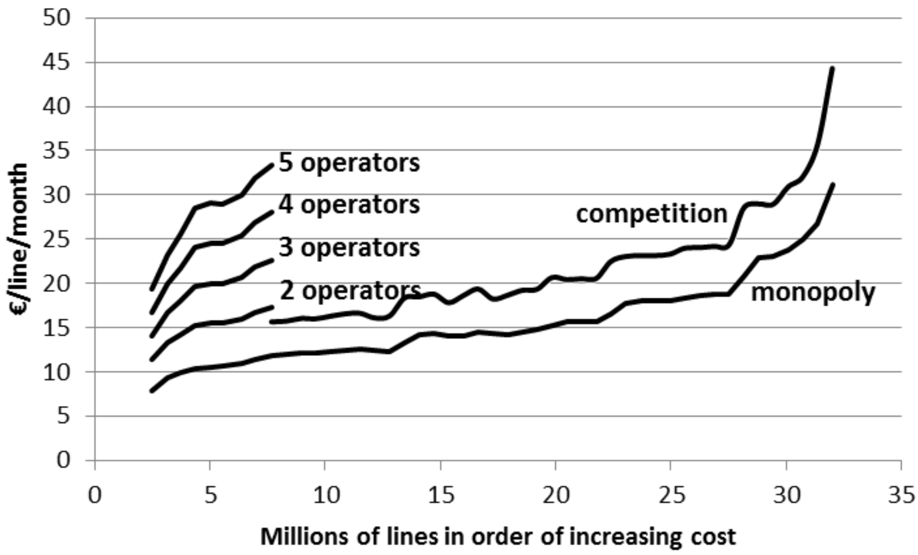

Figure 2.6: Cost as a function of density range, depending on the number of competing operators

2.3 Sensitivity analysis

In this section we check the robustness of our results by varying the most significant assumptions.

2.3.1 Extra cost of point-to-point horizontal network

There is no consensus on how more expensive a point-to-point network is compared to a PON network. Several studies suggest that the costs are almost the same, while others claim that point-to-point CAPEX is 40% higher than that of PON (see Appendix A. Data for more details). We study how this assumption changes our results.

In the base model we have assumed that one cost category increases in point-to-point: horizontal cost for apartment/office buildings excluding connecting buildings. It represents the greatest extra-cost when several fibre cables are installed instead of only one.

We have considered alternative scenarios, assuming that the horizontal cost excluding connecting buildings increases by 0%, 10%, 20% (as in the base case), 30% and 40%.

	Additional horizontal cost in point-to-point				
Nb operators	0%	10%	20%	30%	40%
1	14.32	14.83	**15.34**	15.85	16.36
2	18.82	19.49	**20.15**	20.82	21.48
3	19.63	20.30	**20.96**	21.63	22.29
4	20.44	21.11	**21.77**	22.44	23.10
5	21.26	21.92	**22.59**	23.25	23.92

Table 2.2: Sensitivity of average access cost with respect to extra cost of point-to-point horizontal network, €/line/month

The average access cost increases/decreases by less than €1.02 compared to the base case. The total welfare gain thanks to implementing the proposed policy compared to the current French market structure (3 operators) varies between €2,039 million and €2,277 million per year, or at maximum by 12%.

When there is no additional cost of point-to-point, the total investment in monopoly is equal to €33.4 milliard versus €36.6 milliard in the base model. The cost both in monopoly and in competition slightly decrease, the gap between monopoly and competition increases.

2.3.2 Risk premium parameter

A risk premium is added to WACC in non-dense areas with potential competition. In the base model it is 5%, as recommended by ARCEP. In this section we estimate costs with alternative risk premium values.

If no risk premium is granted to operators in non-dense areas, it significantly changes the access price in those areas. In fact, the price becomes the same irrespective of number of operators: see figure below. The plain line corresponds to the benchmark scenario where the gap is significant between monopoly cost and duopoly cost in non-dense areas. The dotted line corresponds to the alternative scenario where the same WACC is taken for both monopoly and oligopoly.

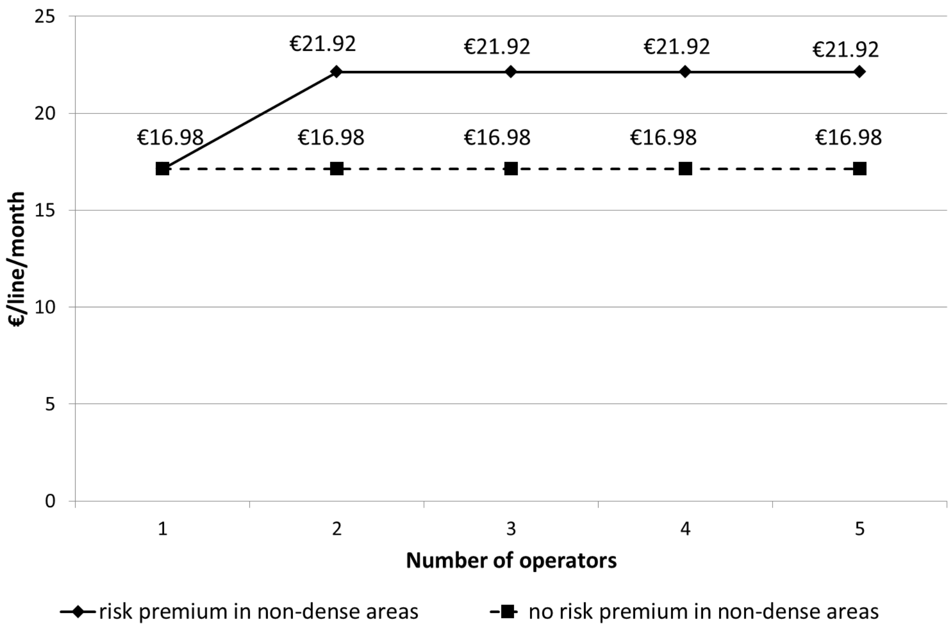

Figure 2.7: Average cost in non-dense areas depending on the number of operators, €/line/month

As a result, the national average price in competition is only insignificantly higher compared to monopoly as shown below.

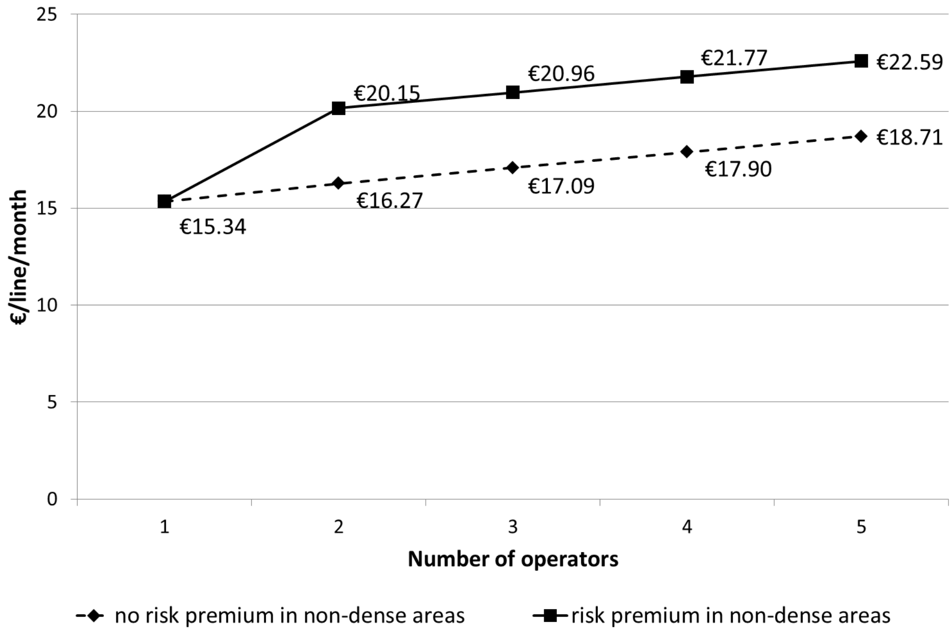

Figure 2.8: Average cost depending on the number of operators, €/line/month

Another alternative scenario that we consider lies between our base case scenario and the extreme case of no risk premium. It includes a risk premium of 2.6% which gives a WACC of 13%. The results for all three scenarios are presented in the table below.

	Risk premium		
Nb operators	0.0%	2.6%	**5.0%**
1	15.34	15.34	**15.34**
2	16.27	18.25	**20.15**
3	17.09	19.06	**20.96**
4	17.90	19.87	**21.77**
5	18.71	20.69	**22.59**

Table 2.3: Sensitivity of average access cost with respect to risk premium, €/line/month

A higher WACC increases the average access cost in competition.

3 Comparison of different approaches to regulating fibre network deployment

3.1 The impact of the different regulation approaches on the social welfare

Below we discuss different aspects of infrastructure-based and service-based competition. We compare them on the following criteria:

- benefit from the scale effect,
- competition at the deployment level,
- competition at the retail level,
- innovativeness of technology,
- minimization of digital divide,
- minimization of regulatory cost.

Benefit from the scale effect.

As has been already discussed in the first chapter, a unique monopolistic infrastructure allows to benefit from the scale effect. The cost is minimized by fully exploiting the scale effect and by avoiding the network duplication.

The strong scale effect is shown numerically in the previous chapter. The total investment needed to build a nationwide network increases significantly with the number of operators: by 13% for 3 operators compared to a monopoly. It is explained in particular by the increased horizontal cost and ODF cost.

In the case of infrastructure competition the majority of network elements should be duplicated and only civil engineering may be shared: regulated access to civil engineering allows alternative operators to build a fibre network using the existing ducts. However, in some countries even the shared usage of civil engineering may be difficult if there is a risk that the civil works' capacity would not be sufficient for two or three fibre infrastructures, which will create infrastructure bottlenecks. In the case when the existing civil works do not have sufficient capacity to containing all the fibre lines, additional investment in civil works will be needed.

Competition at the deployment level.

Since operators' performance depends on the network costs, market forces are needed to incite them to deploy efficiently.

In the case of infrastructure competition, it is ensured thanks to the rivalry between deploying operators. However, in less dense areas, it is possible that only one operator can afford to enter. Indeed, competitive positions of operators are not the same. A problem is faced by a potential investor who is not the incumbent: a new entrant has a lower expected demand than the incumbent which may be insufficient to justify the high deployment cost, in which case only the incumbent deploys. Hence, the competition is tilted.

Under infrastructure monopoly, there exists a mechanism which ensures that operators make efficient decisions during the deployment. If the constructing firm is chosen by tender, the winning company will build the network with the lowest cost and the best quality. Bidding for the exclusive right to supply a service allows to prevent monopoly from inefficient decisions since competition has asserted itself at the bidding stage, and consequently a monopoly structure does not lead to monopoly behavior. Bidding for the natural monopoly was introduced a long time ago in other industries, such as electric industry (see Rozek (1989)) or cable television (see Zupan (1989)).

Bids should be accepted from all the firms who guarantee the necessary level of quality. Each bid should include the price that the firm agree to charge to consumers, in the case of telecommunications it may be the wholesale access price and additionally the speed of rollout and the achieved connection speed. Such process will exclude inefficient bidders and incite the winner to lower the price.

The bidding mechanism should be such that information is transparent. Incumbent has to provide information on ducts and network structure and to grant access to other potential bidders. If the incumbent wins, infrastructure and service divisions must be structurally separated. The bidding mechanism should minimize the winner's curse, where the winner tends to overpay.

In order to promote efficiency, this operator should be chosen based on a call for tender. The criteria of choice should include technical characteristics, construction speed and the price operator is going to charge for the unbundled access. To be able to reply to the call for tender, alternative operators should be given access to the incumbent's civil engineering. Then, a cost-oriented access to ducts and trenches should be regulated. The winner will be obliged to grant access to retail operators on the announced price level. In the case the infrastructure operator is also a service provider the wholesale division should be structurally separated from the retail division.

The main shortcoming of the bidding procedure in the telecommunications industry is the *ex post* risk that the winner of a monopoly franchizing procedure will not fullfill the service contract as promised. This problem has been demontrated by Williamson (1976) in the cable television industry.

Competition at the retail level

In the case of the infrastructure-based competition, the competition at the retail level develops automatically.

In the case of a unique infrastructure, in order to guarantee the competition at the retail level, the regulator should impose access to this infrastructure. It may be also necessary to regulate the choice of technology: it should simplify infrastructure access. As was explained earlier, the point-to-point technology is more suitable in this context. A point-to-point technology is more beneficial to competition than a PON technology: even though it is more expensive, the loss in cost is compensated by an increased level of service-based competition and, correspondingly, consumer welfare. Such kind of competition will lead not only to lower prices but also to a diversity of offers. Offers may differ depending on the bundle of services included: phone, internet, a number of television posts. For example, a black fibre access is imposed on operators in the Netherlands, Sweden, New Zealand, etc. An obligation of virtual unbundling exists in the UK, Austria and Australia.

Innovativeness of technology.

Lebourges (2011) claims that infrastructure competition leads to strong innovation. However, the effect of innovation and new technology is insignificant in the industry in question. First, the scope for innovation is very low in fibre local loop. One needs to distinguish between active and passive network elements: if the former are indeed subject to strong technological progress, the latter mainly consist of fibre cable costs and labour costs that do not decrease over time. The latter constitute essential part of the total cost.

Minimization of digital divide.

Since telecommunications access plays important economic and social role, there is a need to ensure the overall access to this service.

As claimed by Lebourges (2011), infrastructure competition leads to high service penetration and coverage. It is true in dense areas where the cost is low and correspondingly the profit is high. However, in non-dense areas, infrastructure competition is not developed because of high connection costs, the market is monopolised, and consumers suffer from higher price and lower service level if wholesale access is not regulated.

Multiple infrastructures will be developed only in high density areas, so that city dwellers could benefit from low prices. The non-dense zone, on the contrary, represents a natural monopoly. Without regulation, the inhabitants of this zone will suffer from lack of competition and high price.

Regulated monopoly with access obligation allows to prevent this geographical and social digital divide and to ensure that the network is deployed and competition is developed even in low-density areas.

This policy should be supported by corresponding wholesale tariff regulation: a uniform national access price to the fibre and a mechanism of fund redistribution from uneconomic zones to economic ones. It will allow to avoid the digital divide and to develop service-based competition everywhere. Heterogeneous prices would lead to low access and correspondingly retail price in dense areas but high access and retail price and no service competition in non-dense areas.

For a small country with homogenous tele-density characteristics it seems optimal to give the national license to a sole operator. Since the new network must cover all consumers and the access price is averaged, the operator will automatically subsidize uneconomic areas. If, on the other hand, the national territory is large and contains zones with different density and geographical characteristics, it may be appropriate to divide the territory into administrative units and to appoint the infrastructure operator in each zone. These operators may be similar or different.

Low dense/ rural areas need additional funding for fixed telecommunications with the help of regulatory instruments. Governments find different funding sources, for example, in the UK it is a part of the TV licence fee. On an unregulated market, operators would propose lower wholesale prices in very dense areas. As one of the objectives of the regulators is to avoid digital divide, the regulated price should be uniformed, the national price calculated as an average of each zone's prices weighted by number of potential users. Then, the question arises on how to redistribute the higher margin obtained in densely populated areas to the less populated areas. The solution is to create a common fund. This fund will be filled with from the difference between the revenue and the cost from dense areas. This over-profit will be transferred to operators constructing infrastructure in less populated areas where the average national price does not cover the cost. A similar scheme is used in the road industry in France.

The policy will need to be supplemented with protection of low-income customers: those customers who use only telephone service should be subsidized, so that the price they pay does not increase with transmission to fibre.

Minimization of regulatory cost.

A regulatory intervention is subject to an error because of information asymmetry and uncertainty. For this reason price of access to infrastructure may not be exactly equal to the corresponding cost as a result of a measurement error. In theory it is related to the principle-agent problem, where the government (principle) cannot fully control a monopolist due to asymmetric information and uncertainty; this inefficiency entails regulatory cost. A risk of the infrastructure monopoly is the necessity for the regulator to impose the access obligation and to ensure that the price is not excessively high. It is especially difficult in the conditions where a monopoly has an interest to over-state its real costs of NGN deployment. Cost orientation of prices may be difficult to ensure in the case where information is asymmetric and regulator does not have enough details on the real cost of a product.

However, it is not an issue for the market of next generation fixed telecommunications. Today, information on the costs of different network elements is available to regulators, so that the fibre network cost level may be efficiently estimated. In fact, since the technology of the NGN and the costs of network elements are well known, the regulator possesses information necessary for regulation and is able to monitor costs. Uncertainty is as well low on the market. In the case the copper network is switched off, all consumers' demand migrates to fibre network and its volume is predictable and depends mainly on demographic factors that do not change drastically over time.

The monopoly is usually held either by the incumbent or by a consortium. If the network is deployed by the incumbent, there is no need to regulate access to civil engineering for alternative operators. There are also less coordination problems since all the information on the network structure and cable length is exchanged inside the company, which leads to more efficiency.

If multiple deployments are chosen, there is a need for alternative operators to get access to civil engineering, ducts and trenches. Such access is obligatory in most European countries: the UK, Norway, Croatia, Lithuania, Portugal, Spain, etc. For example, in Norway access to trenches is obligatory on the horizontal infrastructure and the price is cost-oriented. Similarly, in Croatia every operator has access to ducts. In Portugal, operators have to give access to trenches on the horizontal network. In both Spain and UK, incumbents are under obligation to provide access to its ducts and trenches on a cost-oriented basis. In Austria, it is possible to obtain access to infrastructure of any operator under condition to compensate the corresponding costs. In Germany, access to trenches is obligatory. Access to ducts is obligatory in Switzerland, prices should be cost oriented.

In Lithuania, the incumbent has published a commercial offer of access to ducts for both access and core network.

Recommended approach

It can be concluded that a unique infrastructure allows to benefit from scale effect. If the deploying firm is chosen by a call for tender, it garantees the efficiency of the network structure. To ensure competition, an access obligation should be imposed on the monopolist, and the access price should be regulated and cost-based. At the same time, service-based competition garantees service quality and diversity, while a uniform price helps to avoid digital divide.

As the numerical simulation has shown, the gain in the average price thanks to the proposed regulation is significant: the access tariff is 36% lower in a monopoly than in competition with 3 operators. This economy is likely to offset additional regulatory costs.

If for a unique operator the investment burden is too heavy, a consortium may be established to share it. A shared investment mechanism allows several operators to co-invest in one network.

3.2 Regulating price of wholesale access to infrastructure

After having imposed the access obligation, the authority can make a decision to limit the access price level to ensure that it is not excessively high. It is commonly recognized that the regulated access tariffs should be cost-oriented so that the network owner does not have a competitive advantage on the retail market. However, various methods of the cost level estimation lead to significantly different results. Below we discuss different pricing approaches and discuss the ability of each of them to incite investment in the NGN.

The costing methodology may be defined using the following axes:[1]

[1]Andersen Business Consulting, "Study on the implementation of cost accounting methodologies and accounting separation by telecommunication operators with significant market power", 2002 and BEREC

1. Modelisation approach

   - Top-Down model calculates the cost of an existing network;
   - Bottom-Up model calculated the cost of a hypothetical network;

2. Cost base

   - HCA (Historical Cost Accounting) consists in taking the costs as equal to the operators' accounting costs;
   - CCA (Current Cost Accounting) consist in taking the costs that reflect the value of assets for the current and future years;

3. Cost standards

   - FDC (or FAC - fully allocated/distributed cost) is an accounting approach based on the expenses incurred by the operator that allocates costs to each service in accordance with the cost causation principle. Under that methodology, a cost breakdown procedure is used that groups together costs by nature and function to calculate the cost of each service and allocates costs according to measures such as activity based costing, samples and surveys, revenues or price-proportional mark-ups.
   - LR(A)IC (long run (average) incremental cost) methodology is more grounded in economics. It considers that the cost of a service is equal to the change in total cost resulting from a discrete variation in output in the long run. In practice, LRIC often uses cost volume relationships.[2]

By combination of the above elements, Andersen Business Consulting obtains the following conclusions:

- a Bottom-Up is always CCA and LRAIC;
- an LRAIC is always CCA (Top-Down or Bottom-Up);
- an FDC is always Top-Down (CCA or HCA).

[2]BEREC "Consultation on a draft Opinion on the European Commission's Recommendation on Accounting separation and cost accounting " ERG (04) 15, annexe "Guidelines on implementing accounting separation and cost accounting", 22 March 2004

	Top-Down		Bottom-Up	
	HCA	CCA	HCA	CCA
Fully Distributed Costs	✓	✓	x	✓
Long-run average incremental costs	x	✓	x	✓

Table 3.1: Combination of different cost accounting concepts according to Andersen Business Consulting.
Source: Andersen Business Consulting (2002)

In our context it is appropriate to distinguish between three main asset types, each type is subject to different pricing principles since they play different roles in the NGN: copper cables, civil engineering and optical fibre cables.

In Europe, it is often obligatory to grant access to the civil engineeting and the corresponding price is regulated. Access price is generally regulated for copper cables and ducts but not for fibre cables.

Granting access to the copper local loop is obligatory in Europe, with access price being regulated. The price is most often calculated according to the CCA method (16 of 22 countries in the benchmark made by BEREC) in combination with the LRIC standard (14 of 22 countries).

The access to the fibre local loop is not systematically regulated as was shown in the previous section, because since the market is not well developed yet. However, the price regulation was initiated in some countries. For example, in Netherlands, the consortium that deploys the network has to keep prices on the level of CAPEX per line in each zone (between €12 and €17 per line per month and €100 per installation).

The system of access prices to different infrastructure elements will impact investment decisions and competition intensity on the optic fibre network. A low fibre access price tends to attract more service-based competition but risks to undermine investments in fibre. A low copper access price may hinder the migration to fibre, but may incite the incumbent to invest in next generation network. A high ducts access price may prevent fibre network construction by alternative operators.

Several authors study the question of optimal fibre and copper access pricing during transition to NGN: Bourreau, Cambini, and Doğan (2012), Nitsche and Wiethaus (2011), Cave, Fournier, and Shutova (2012), Gavosto, Ponte, and Scaglioni (2007), Brito, Pereira, and Vareda (2010).

Bourreau, Cambini, and Doğan (2012) model competition between two operators, an incumbent and a new entrant, where both of them may deploy next generation network. They find that if fibre access is not regulated, the optimal copper access price should be determined as a compromise between three contradicting effects: investment incentives of the new entrant increase with the copper access price, investment incentives of the incumbent decrease with the copper access price, and the consumers' incentives to migrate to fibre and correspondingly investement incentives increase with the copper access price. In the case when regulation is extended to the next generation network, the corresponding access prices to the incumbent's network and to the new entrant's network should account for relative market position of operators.

Cave, Fournier, and Shutova (2012) search for the efficient price of copper network in the transition to fibre. They consider three regulatory objectives: efficient cost recovery, efficient entry, and efficient migration to fibre. It examines a range of possible pricing principles including LRIC, HCA and CCA approaches and mixed HCA/CCA approaches observed in France and in the UK. These are simulated using a data set for the copper local loop in France, prepared by the regulator, ARCEP. Authors recommend to treat differently two types of assets: copper cables and ducts. In the case of ducts no accelerated depreciation is needed. Where full cost recovery allows it, the price of access to the physical works should be lowered to encourage the transition to fibre. The simulations show that the access prices associated with the proposed approach are lower than those derived from CCA and LRIC methods for pricing copper.

Nitsche and Wiethaus (2011) study the question of risk related to investment. They compare several policies of price regulation. They conclude that regulatory holiday with no access obligation is the worst solution: even though it provides the best investment incentives, the consumer surplus is extracted by the monopoly. The risk sharing, on the contrary, maximises the social surplus since the level of investment is higher.

They also consider an alternative regulation policy where the access to next generation network is regulated as well. In this case migration takes place at a wholesale level, that is why consumers' choice is irrelevant. They find that in equilibria where the NGN coverage of incumbent is greater, the entrant needs to make a choice between leasing access to OGN and NGN. To encourage him/her to switch to NGN, a low OGN access price should imply a low NGN access price. In equilibrium where the entrant's NGN coverage is larger, there is, on the contrary, a reverse relationship between two access prices: a low copper price combined with a high fibre price to give the new entrant more competitive advantage and to incentivise next generation network investment by both incumbent and new entrant.

Gavosto, Ponte, and Scaglioni (2007) apply a real option model to explain the investment decision in next generation networks to capture uncertainty. They find that, contrarily to widespread opinion, access price regulation negatively affects investments in NGN only in the initial period; in the long run, according to the real option model, investments are not affected.

Another question related to the issue of regulated access price is the commitment problem, the risk of dynamic inconsistency in the regulatory policy. Before the network is deployed, it is socially optimal to set high access tariffs to promote investment. However, once the network is deployed, it is socially optimal to set the access tariff to promote competition in the retail market. Because of the risk of policy change, the incumbent may decide to reduce investment.

Brito, Pereira, and Vareda (2010) study whether a two-part tariff access to a next generation network may solve the problem of lack of commitment. They model the industry as a duopoly, where a vertically integrated incumbent and a downstream entrant, that requires access to the incumbent's network, compete on Hotelling's line. The incumbent can invest in the rollout of a next generation network that improves the quality of the retail services. The access tariff is regulated.

Authors obtain three main results. First, they show that only if the investment cost is low, the regulator can induce investment when he cannot commit to a policy. Then the regulator can set the marginal price of the access tariffs at marginal cost, and use the fixed fee to give the incumbent incentives to invest. If the investment cost is high, the fixed fee is no longer enough to induce investment. Second, they show that in this case, two-part tariffs involve payments from the entrant to the incumbent that may be unacceptably high from political point of view. Third, they show that if the regulator can commit to a policy, a regulatory moratorium may emerge as socially optimal.

They conclude that it is possible only under certain circumstances and if fixed fee is not too high. However, this solution involves setting the fixed part of the access tariffs at a level that might be politically unacceptably high. Moreover, when the regulator cannot commit to a policy, this is only one of two types of equilibria, and in the other type of equilibria the incumbent does not invest, although investing would increase welfare. The regulator has to raise the marginal price of the access tariff above marginal cost to induce investment. Since, after investment occurs, it is socially optimal to set the marginal price of the access tariff at marginal cost, this policy is not dynamically consistent. Interestingly, a regulatory moratorium emerges as socially optimal, if the regulator can commit to a policy, and if the investment cost takes intermediate values.

The European Telecommunications Network Operators' Association (ETNO) and the European Competitive Telecommunications Associations (ECTA), two eminent trade associations in telecommunications, have proposed contradicting measures. While ETNO recommended the same pricing method for both the fibre and copper network, ECTA indicated that access price to copper should be cut substantially to create enough incentive for incumbents to invest in fibre.[3]

In September 2011, European Commission has launched a public consultation to revise the tariffs of access to the copper network for alternative operators, with the objective to accelerate the investments in the optical fibre and to favor migration of subscribers to fibre.[4]

In July 2012 Neelie KROES, Vice President of the European Commission, made a statement which gives the main points of consultation.[5] Concerning the access price to the copper network, European Commission concludes that there is no need to question the price signals sent by the current average copper unbundling price in Europe (about €9 per month). However, as NGN will get a greater value in the eyes of consumers, copper price should adapt accordingly, since NGN is the modern equivalent asset of copper. Concerning

[3] ETNO's position is based on a study by Plum Consulting available at `http://www.etno.eu/Default.aspx?tabid=2381`; ECTA's proposal is based on the WIK's study available at `http://www.ectaportal.com/en/REPORTS/WIK-Studies/WIK-Study-Apr-2011/`. See Cave, Fournier, and Shutova (2012) for a more detailed analysis

[4] European Commission. Public consultation on costing methodologies for key wholesale access prices in electronic communications. 3 October 2012

[5] European Commission. Enhancing the broadband investment environment - policy statement by Vice President Kroes. Brussels, 12 July 2012

access to the NGN, European Commission concludes that there is no need to apply cost orientation to wholesale access products where there is a significant competitive constraint from operators with cost-oriented access to the copper network or from other infrastructure-base competitors such as cable. If there is still need for regulation, regulated price level should address investment risks by aiming at full cost recovery in such infrastructure even if future costs decline. Certain asset classes like civil engineering are subject to distinct treatment in certain Member States. European Commission concluded that such distinct treatment does not lead to a significant divergence from the current European average unbundling price.

Recommended approach

In the proposed policy, the price fixed by the regulator for access to the monopolst's fibre network should incorporate a sufficient level of return on capital. It will incite investment by the monopolist. A compensation may need to be paid to the copper network owner to offset the remaining net book value of the copper network that has not been depreciated.

Switching off copper network may potentially create a problem of under-recovered investments and lost profits from the copper network since the copper is switched off before the end of its useful life. Today, the access price to the copper local loop in France is 9 €/line/month. A significant part of this price corresponds to ducts cost and not to copper cable cost. Since ducts will be still used even after the whole network passes to fibre, the problem concerns only the copper cable part of the network. The regulator may propose lump-sum compensation to the incumbent for the profit not to be received in future, as it was done in Australia where the regulator bought the old network of the incumbent. Additionally, as explained in Cave, Fournier, and Shutova (2012), the current pattern of copper access pricing already leads to investment over-recovery because of the change in valuation methodology. Consequently, the over-profit from civil works may compensate for lost profits from the copper network.

We have eliminated competition between copper and fibre since the old technology is switched off. But another potential source of competition is the coaxial cable technology which has a great market share and almost nationwide coverage in such countries as Belgium and Netherlands. Technical structure of cable network does not allow for unbundling, that is why there is no access regulation. Even if the copper is switched off, cable will continue to represent a competitive risk for fibre. The regulator may need to set a higher fibre

WACC to account for competitive risk and to maintain investment incentives in fibre. The competing cable network may also have positive effects by pushing fibre operators to raise efficiency of their active equipment.

Conclusion

We have shown that the access part of the NGN may be characterized as a natural monopoly which means that a single network is cost-minimizing. However, because of market inefficiencies, this optimal configuration is not always reached in the absence of regulation. It means that in order to fully benefit from the scale effect and to incite high level of fibre investment, a regulatory intervention is needed, when only one fibre local loop network is authorised in each zone of the national territory. If national territory may be divided in segments on socio-geographic basis which are relatively independent from the cost prospective, it can be justified to make several local monopolies. Additionally, in order to garantee monopoly, to avoid competition between two technologies and to ensure stable demand, the copper network needs to be switched off simultaneously with fibre activation.[6]

We have proposed a policy of fibre network regulation that should be adopted at the early stage of transition from old generation to new generation technology. It consists in appointing only one fibre network operator in each zone, and granting access to this network on a cost-based, nationally averaged price. The copper access needs to be deactivated once fibre is built. If necessary, a national fund needs to be created to redistribute over-profit from economic areas to uneconomic areas.

We have compared our proposed policy to the market structure that is being established in France. We find that the current policy adopted by ARCEP will lead to the access price of €17.26 per line per month in dense areas versus €9.63 per line per month for our proposed policy. The total gain in costs is for the national territory is equal to €179 million per month, or 27% saving.

[6]The copper switch-off is discussed in the consultation of European Commission: ‘Questionnaire for the public consultation on costing methodologies for key wholesale access prices in electronic communications’ 3 October 2011.

Our general recommendations can be implemented in practice in different ways. National-level studies need to be conducted with the objective of determining the best way to implement the policy in each national context.

Appendix

A. Data

We describe the data used in the model on fibre local loop parameters in France and its sources.

Network data

The following data on future network configuration is available:

- total number of lines — 32 million lines (Source: Notice explicative de l'outil de simulation de la tarification du génie civil de boucle locale en conduite de France Télécom - May 2010)
- number of meters of sewage used by the network

Geographic data

The geographic data was collected by Geocible, a firm specialised in geomarketing. For each municipality, the following data was available:

- Number of households in each municipality,
- Number of one-off houses,
- Number of apartment/office buildings,
- The surface of housing areas,
- Number of kilometres of routes inside housing areas,
- Number of kilometres of routes outside housing areas, leading to isolated buildings.

Cost data

Investment costs of different network elements were provided by Bouygues Telecom, a French telecommunications operator:

- Cost of ODF building and of different ODF components;
- Elements of horizontal cost for apartment/office buildings: subduct, cable, splicing, welding, reflectometry tests;
- Elements of horizontal cost for isolated buildings: poles and cables;
- Element of vertical cost;
- Cost of connecting flats/offices within building and of one-off houses.

Cable maintenance cost is estimated as 3% of CAPEX.

According to ARCEP's decision 05-0834, common costs are equal to 5.78% of other costs. This decision concerns the costs of a copper network, but parameters may serve to approximate the fibre network costs.

The data on WACC value and assets lifetime, which are necessary to calculate depreciation, are based on ARCEP's recommendations. ARCEP's decision 05-0834 fixes a lifetime of 25 years for local loop assets.

The base WACC is equal to 10.4% as recommended by ARCEP in its decision 2010-001 for the fixed telecommunications activities of France Telecom.

ARCEP in its decision n° 2009-1106 recommends to allow for a risk premium in non-dense areas where potential entry is possible. The WACC level recommended by ARCEP is 15%.[7] A German study published on the Bundesnetzagentur website (German telecommunications regulator) proposes to use a risk premium of 2.59%. [8] We take a 5% risk premium corresponding to WACC=15.4%.

Duplication. We consider that multifibre is 30% more expensive than monofibre. This assumption is based on the cost data of the existing operators published in Annex 2 of "l'Offre de référence SFR d'accès aux immeubles FTTH V 1.0 - 18/02/2010" and Annex 1 –

[7] ARCEP. Décision se prononçant sur une demande de règlement de différend opposant les sociétés Bouygues Telecom et France Télécom. Décision n° 2010-1232 en date du 16 novembre 2010

[8] Richard Stehle. Wissenschaftliches Gutachten zur Ermittlung des kalkulatorischen Zinssatzes, der den spezifischen Risiken des Breitbandausbaus Rechnung trägt. 24 Nov. 2010

Prix of "Offre d'accès à la partie terminale des lignes de communication électroniques à très haut débit en fibre optique de France Télécom".

Additional technology cost. There is no consensus on the cost of point-to-point technology compared to PON. Several studies mention that these costs are close. [9] Others claim that the additional investment is in in the range of 10-25%. For example, according to WIK [10], P2P FTTH architecture requires less than 10% additional investment than the PON architecture; the result is based on modelling for a hypothetical European country. Kulkarni et al. (2008) [11] find that in a dense urban area PON provides a CAPEX saving of about 20% compared to P2P (P2P was 25% more expensive than PON). A the same time, the OPEX modelling results show a saving of 55-60% for GPON compared to P2P, mainly due to civil works rental but also to additional expense on maintenance. According to a study by Analysis Maison, in the UK CAPEX in PON is 18% higher than in point-to-point. [12] Some authors claim that the cost gap is significant. From the data published by Axione (2010) [13], it can be deduced that additional CAPEX of deploying point-to-point network is of 40%.

In our base case, we take an average estimate of 20% of additional cost applied to the horizontal cost since it mostly this cost that increases in point-to-point architecture.

B. Detailed model description

First, we explain how the network cost is calculated for PON technology and without duplication. Then, how this cost is calculated for point-to-point technology. Finally, we explain how the same cost is calculated with duplication.

[9] See for example Allied Telesis. FTTx Solutions for Service Providers. 2009 and Metro Ethernet Forum "FTTH - Understanding which market scenarios are best served by active Ethernet point-to-point (EP2P) and which are best served by point-to-multipoint PON architectures" and IDATE Digiworld summit. FTTx economics: conditions for profitability.

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Calculating costs in monopoly for PON technology

The costs were calculated for each of 36,000 municipalities in France, and then the sum was taken to calculate the total cost.

The cost groups are considered in the following order:

- CAPEX: annualized costs of deployment;
- OPEX: operating costs;
- the part of common network costs allocated to local loop unbundling service.

CAPEX

Hereby we explain how each cost category of CAPEX was calculated.

The territory of each community is divided between housing area (highly populated area, for example, a town centre) and isolated houses that are detached from housing area.

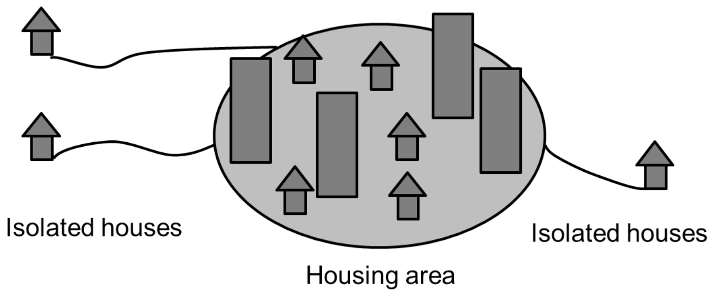

Figure 3.1: Buildings classification according to their location

According to their characteristics, two types of buildings are considered:

- apartment/office building (multi-dwelling units) with several floors which host multiple households or firms and are necessarily situated in housing areas,
- one-off buildings.

The following scheme shows where each cost driver is situated in the network

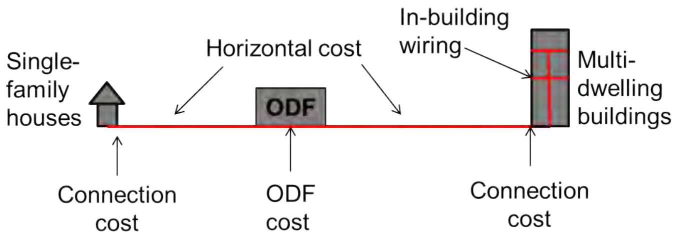

Figure 3.2: Cost drivers' position in the network

#	**Cost category**	**Calculation**
		ODF
1	ODF accommodation cost	To calculate the total surface of buildings that are needed for ODF, we multiply the total number of lines by surface needed per line (2 m^2 per 1,000 lines in PON).

2	ODF equipment cost line	ODF splitter: a splitter allows to join together 8 lines. So, the number of couplers that are needed is calculated as the total number of fibre lines divided by 8. The unit cost of a coupler including buying and installing is equal to €120. Optical rack: • Splicing: one drawer may contain 144 fibre lines (2 drawers per transport cable). The cost per drawer is €1,491. • Splitters: each splitter may contain 64 fibre lines. The cost per drawer is €1,748. • pigtails (a cable fitted with a connector at one end and bare fibre at the other. The non-connectorised end ('the pigtail') is intended to be permanently attached to a component or terminal.) Bays. For each municipality, the number of ODFs needed to connect subscribers is calculated taking 10,000 subscribers per ODF outside Paris and 20,000 subscribers in Paris. Fibre lines are grouped in cables containing 288 fibre lines in PON. Based on this number of fibre lines arriving to each ODF, it is possible to deduce the number of fibre cables arriving to each ODF. For each cable, a bay should be installed. The unit price of a bay is €1,723. Cost of connecting in ODF. For each transport cable identified above, a connection cost is added. This cost is €3,628/cable.
Horizontal cost		

3	Horizontal cost (study, supply and laying) for housing areas including cost of connecting buildings (civil engineering)	This cost includes multiple cost items : • For transport network (near ODF) – Cost of laying of subduct €6/m/line – Cost of cable and of their laying €8/m/line – Costs of big splicing box (used to connect cables between themselves): €2,600/box (The number of boxes is calculated as the product of number of ODFs and the number of transport cables in ODF) – Cost of small splicing box €29.7/box (There is one small splicing box per 12 fibre lines.) – Cost of welding €2,016 per 288 fibre lines – Cost of reflectometry tests on fibre, \euro16.7/fibre • For distribution network (near buildings) – Cost of laying of sub-duct €6/m/line – Cost of cables and their laying €3/m/line – Cost of splicing box: €399/box – Cost of welding €21 per 48 fibre lines. • For the network connecting buildings – Cost of laying distribution cables (12 fibre) at €3/m/line The cost of connecting is equal to €1,500 per multi-dwelling building and €520 per single-family house (labour force for building civil engineering).
4	Horizontal cost (study, supply and laying) for isolated buildings	Outside the housing areas, fibre is installed on poles. It is supposed that operators install their own poles which cost €9.08 per meter of cable including installation (decomposed in €3.50 for cables and €5.58 for poles).
	In-building wiring and connection	

5	Vertical cost	The vertical cost concerns only multi-dwelling units and includes two elements. 1. Cost of deploying at the building entry. For each municipality, the number of multi-dwelling buildings is multiplied by the average distance between the entry to the building and the in-building box estimated at 20 m per building. This distance is multiplied by unit cost of supplying and pulling the fibre cable (12 fibre) 2.8 €/m. 2. Vertical cost proper. The cost corresponds to the cost of deploying fibre in rise pipe of a building. It is supposed that all firms are situated in multi-dwelling buildings. For each French municipality, the total number of firms and households in multi-dwelling buildings is calculated. The cost function of rise pipe per subscriber is calculated based on data supplied by Bouygues Telecom on municipalities of Roubaix, Villeurbanne and Paris. The cost function allows to calculate the vertical cost for each municipality depending on the number of subscribers per building.
6	Cost of connecting flats/offices within building	The cost of connecting a flat in multi-dwelling building is €200 (half of this cost is already included in vertical cost).
7	Cost of connecting clients in single-family houses	The cost of connecting a single-family house is €200.

The depreciation method is such that payment is stable over the years. Capital cost is calculated with WACC=10.40%.

OPEX

Cost category		**Calculation**
Cable maintenance		3% of CAPEX. This proportion holds for copper and in practice may become even lower for fibre since the latter is less sensible to bad weather.
Civil engineering rental	Ducts rental	To deploy underground fibre lines and connect multi-flat buildings, the ducts of France Telecom are used. The corresponding rental price is calculated as the number of lines that are not served by sewage, multiplied by the rental price per line, which decreases with density.
	Sewage rental	In Paris, Neuilly and Levallois, sewage is used to pose fibre. The corresponding rental payment is calculated as the total number of meters of sewage used multiplied by price per meter.

Table 3.3: Calculating costs in monopoly for PON technology: OPEX

Common costs

The cost is equal to 5.78% of all the other costs (annuity, cable maintenance and civil engineering rental).

Calculating costs in monopoly for point-to-point technology

The total cost is divided by the total number of lines to get the average cost of premises connected. The technology used is point-to-point.

CAPEX

#	**Cost category**	**Calculation**
	ODF	
1	ODF accomodation cost	Same as in PON
2	ODF equipment cost	Same as in PON
	Horizontal cost	
3	Horizontal cost (study, supply and laying) for housing areas including cost of connecting buildings	Includes two subcategories: • connection cost is the same as in PON technology • remaining costs are constituted mainly of cable costs and need to be increased by 20% in point-to-point technology because of a greater cable capacity
	In-building wiring and connection	
4	Horizontal cost (study, supply and laying) for isolated buildings	Includes two subcategories: • pole price is the same as in PON • cable price is increased by 20% because of a greater cable capacity
5	Vertical cost	Same as in PON
6	Cost of connecting flats/offices within multi-dwelling building	Same as in PON
7	Cost of connecting clients in single-family houses	Same as in PON

Table 3.4: Calculating costs in monopoly for point-to-point technology: CAPEX

Capital cost is calculated with WACC=10.40%.

OPEX

Cost category		**Calculation**
Cable maintenance		Same as in PON
Civil engineering rental	Ducts rental	Same as in PON
	Sewage rental	Same as in PON

Table 3.5: Calculating costs in monopoly for point-to-point technology: OPEX

Common costs

The cost is the same as in PON.

Calculating costs in competition (PON technology in dense areas and point-to-point technology in non-dense areas)

We suppose that several providers are operating in dense areas. That is why certain infrastructure elements are duplicated and the corresponding costs must be multiplied by competitors' number. We suppose that the infrastructure is doubled in all the dense areas, so that there is competition for every customer. The technology used in non-dense areas is point-to-point, the same as in the monopoly model, in order to allow for a simpler unbundled access. The technology used in dense areas is GPON since there is no need for unbundled access.

To calculate the average, the total cost, CAPEX plus OPEX, is divided by the total number of lines.

CAPEX

Table 3.6: Calculating costs in competition: CAPEX

#	**Cost category**	**Calculation**
	ODF	
1	ODF accommodation cost	The cost is equal to • the monopoly cost multiplied by the number of operators in dense areas • the monopoly cost in non-dense areas

2	ODF equipment cost	The cost is equal to • the monopoly cost multiplied by the number of operators in dense areas; • the monopoly cost in non-dense areas
	Horizontal cost	
3	Horizontal cost (study, supply and laying) for housing area including cost of connecting buildings	This cost is divided into two subcategories – connection cost and the rest – which are treated differently. The cost is equal to • the monopoly cost multiplied by the number of operators and corrected for technology (PON 20% less expensive than point-to-point) in dense areas; • the monopoly cost in non-dense areas.
4	Horizontal cost (study, supply and laying) for isolated buildings	The cost is the same as in monopoly
	In-building wiring and connection	
5	Vertical cost	The monopoly cost is increased by 30% to account for multifibre
6	Cost of connecting flats/offices within multi-dwelling building	The monopoly cost is increased by 15% to account for multifibre
7	Cost of connecting clients in single-family houses	The cost is the same as in monopoly

In dense areas, the following costs increase proportionally to the number of operators:

- ODF accommodation cost,
- ODF equipment cost,
- horizontal cost.

Costs that increase compared to the sole network because of the need to deploy multi-fibre in dense areas:

- cost of vertical network,
- connecting flats within building.

Costs that become lower thanks to using PON instead of point-to-point technology in dense areas:

- horizontal cost (study, supply and laying) for housing area excluding cost of connecting buildings,
- horizontal cost (study, supply and laying) for isolated buildings - cable costs only.

The capital cost is calculated with WACC=10.40% in dense areas and WACC=15.40% in non-dense areas.

OPEX

Cost category		**Calculation**
Cable maintenance		The cost is equal to • the monopoly cost multiplied by the number of operators in dense areas; • the monopoly cost in non-dense areas
Civil engineering rental	Ducts rental	The cost is the same as in monopoly
	Sewage rental	The cost is multiplied by the number of operators

Table 3.7: Calculating costs in competition: OPEX

Common costs

These costs are the same as in monopoly.

C. Detailed results tables for the base case

		Cumulated number of lines, mln								
Nb operators	Average cost	**1.87**	**2.49**	**3.18**	**3.74**	**4.32**	**5.02**	**5.51**	**6.38**	**6.98**
1	**9.64**	6.61	9.26	9.57	10.24	10.54	10.51	10.79	11.16	11.80
2	**13.87**	9.60	13.11	13.66	14.83	15.71	15.30	15.78	16.25	17.32
3	**17.28**	11.78	16.25	17.07	18.92	20.41	19.62	20.41	20.96	22.66
4	**20.68**	13.95	19.40	20.47	23.01	25.11	23.94	25.05	25.66	28.01
5	**24.09**	16.13	22.54	23.88	27.10	29.81	28.25	29.68	30.36	33.35

Table 3.8: Cost variation in dense areas, €/line/month

		Competition (nb of operators)			
	Regulated monopoly	2	3	4	5
Annual depreciation+capital cost	4164	5867	6118	6369	6620
Cable maintenance	232	273	314	355	396
Civil engineering rental	1173	1176	1178	1181	1183
Common cost	322	423	440	457	474
Total cost	**5891**	**7738**	**8050**	**8361**	**8673**

Table 3.9: Annual cost of fibre network, €million/year

		Cumulated number of lines, mln												
Nb operators	Average cost	**7.67**	**8.32**	**8.96**	**9.59**	**10.20**	**10.87**	**11.51**	**12.16**	**12.80**	**13.44**	**14.07**	**14.72**	**15.36**
1	**17.13**	11.91	12.00	12.22	12.20	12.39	12.60	12.64	12.26	12.41	14.11	14.21	14.42	13.72
2-5	**22.12**	15.68	15.77	16.06	16.02	16.31	16.59	16.65	16.12	16.34	18.37	18.51	18.80	17.84
		16.00	**16.64**	**17.28**	**17.92**	**18.56**	**19.19**	**19.84**	**20.48**	**21.11**	**21.76**	**22.39**	**23.04**	**23.68**
		14.32	14.83	14.02	14.34	14.75	14.80	15.79	15.62	15.69	15.72	17.54	17.95	18.02
		18.65	19.38	18.26	18.69	19.25	19.36	20.69	20.45	20.54	20.59	22.50	23.06	23.16
		24.32	**24.96**	**25.59**	**26.24**	**26.88**	**27.52**	**28.16**	**28.80**	**29.44**	**30.08**	**30.72**	**31.36**	**32.00**
		18.02	18.14	18.64	18.69	18.78	18.91	22.75	23.08	23.08	24.49	25.34	28.01	34.30
		23.16	23.32	23.99	24.06	24.20	24.36	28.54	28.99	28.96	30.91	32.06	35.71	44.30

Table 3.10: Cost variation in non-dense areas, €/line/month

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Part II

Regulating two-sided markets of electronic communications

Introduction

On a two-sided market, an intermediary platform provides services allowing two sides of users to interact with each other.

The theory of two-sided markets (TSM) appeared at the beginning of 2000s. This theory refers to economic activities organised around a ‘platform’ which can address at least two distinct markets simultaneously. The markets are linked by indirect externalities which have a significant impact on competition strategy and equilibrium.

The standard instruments of antitrust regulation analysis can be misleading if the features of TSM are ignored. For example, the cross-subsidies between two markets may be suspected to be associated to a strategy of evicting competitors by a dominant firm even though in practice the subsidy is needed to optimise the number of users and consequently to maximize social welfare and consumer surplus.

Many markets related to telecommunications and to Internet may be characterized as two-sided: Internet service providers serve final customers on one side and content providers on the other side, different online intermediaries serve sellers on one side and buyers on the other one, etc.

Indeed, according to European Commission [14], electronic communications markets are often two-sided, where either two sides exchange communications or one side sends information and content to the other one. Accounting for ‘two-sidedness’ may impact the market definition and in some cases justify ex ante regulation:

[14] Commission Recommendation of 17 December 2007 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services. C(2007) 5406. 2007/879/EC

"Markets in the electronic communications sector are often of a two-sided nature, in that they comprise services provided over networks or platforms that bring together users on either side of the market; for example end-users that exchange communications, or senders and receivers of information or content. These aspects need to be taken into account when considering the identification and definition of markets, as they can affect both the way markets are defined and whether they have the characteristics which may justify the imposition of ex ante regulatory obligations."

For example, the mobile call termination was characterized as a two-sided service by the French telecommunications regulator. The regulator explains that this service that benefits both calling party and receiving party, and therefore the termination cost may be covered either by charging caller or by charging receiving party.[15]

Services provided through Internet are often two-sided, since they are usually financed through advertisement, thus linking advertisers on one side and users on the other side. For example, in 2008 the European Commission has used the notion of TSM in the case of merger between Google and DoubleClick on the market of online advertising, where intermediary platforms allow interactions between advertisers and web sites. [16]

Markets related to television and broadcastng are often multi-sided since a media should interact simultaneously with several groups of market participants: viewers, advertisers, content providers. In a decision of the French Competition Authority the TV media market is characterised as a TSM, since a TV channel provides advertisement support on one side and content for the viewers on the other side. Demand for commercials on a channel depends on the channel's audience, and the revenues from commercials are used to buy content rights. The Authority concludes that this interdependence should be taken into account.[17] In its 2010 consultation document ComReg used the notion of two-sided

[15] Enfin, l'Autorité rappelle que la prestation de terminaison d'appel, bénéficiant à la fois au client appelant, qui initie l'appel, et au client appelé, qui le reçoit, relève d'un marché biface, l'opérateur de l'appelé ayant la possibilité de recouvrer ses coûts soit par la facturation de l'opérateur de l'appelant, soit par la facturation de son client appelé.

[16] Case No COMP/M.4731 - Google/DoubleClick

[17] "Les marchés du secteur des médias sont souvent des marchés bifaces, dans la mesure où de nombreux médias proposent à la fois un support publicitaire à des annonceurs et un contenu à des lecteurs, auditeurs ou autres téléspectateurs.<...> Au cas d'espèce, la demande de publicité télévisuelle est fonction de l'audience des chaînes, elle-même fortement tributaire des contenus audiovisuels acquis par les éditeurs de

markets in order to define the market boundaries for broadcasting transmission services, although their interpretation of the two sides of the market is different:[18]

> "Defining the relevant market(s) for application of the three criteria test is determined, inherently, by the two-sided nature of the broadcasting market itself between consumers and providers of content."

Even though competition authorities in Europe and in the USA start to use the concept of two-sided markets, its usage is still limited. One of the reasons is the ambiguity of theoretical results depending on precise market characteristics and an insufficient empirical base allowing to deduce operational conclusions applicable to practical cases.

This work aims at analyzing the effects of accounting for TSM particularities in the antitrust analysis of abusing dominant market position in cases listed in the article 102 of the European Union Treaty (treaty of Lisbon), such as discrimination, bounding, predation, etc. Theoretical and empirical analysis has for objective to infer useful guidelines for competition authorities and consulting firms in the cases of litigation concerning TSM. We study a number of cases from telecommunications and internet industry in order to test the operational character of proposed methods.

The first chapter includes an overview of different aspects of antitrust regulation on TSM: merger, unilateral anti-competitive behaviour and collusion are discussed based on the existing literature, relevant examples from Internet and communications industry are given to illustrate theoretical discussion. The review of existing literature shows that the question of price structure is crucial on a TSM, that is why in our further study we choose to concentrate our attention on the pricing practices of platforms. The second chapter studies in details excessive pricing on TSM using the example of an online two-sided platform. The third chapter studies the impact of price discrimination on a TSM on the social welfare and consumer surplus. A model is proposed and the examples of online services and internet service provision are studied.

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chaînes de télévision. Inversement, la puissance d'achat des chaînes gratuites sur les marchés de droits est essentiellement fonction de leurs recettes sur le marché de la publicité télévisuelle. Afin d'évaluer de manière pertinente les effets de la présente opération sur la concurrence, il est donc indispensable de tenir compte du caractère interdépendant de ces marchés." French Competition Authority. Decision 10-DCC-11, 26 January 2010

[18]ComReg 10/98. Consultation Paper "Three Criteria Test on the Broadcasting Transmission Market" 03 - 12 - 2010

1 Competition policy on two-sided markets: literature review

On a TSM, an intermediary platform provides services allowing two sides of users to interact with each other. For example, an online market serves sellers on one side and buyers on the other side. An integral part of every TSM is externality between two sides: buyers benefit from a greater number of sellers and products proposed on the platform, sellers benefit from a greater number of potential buyers who use the platform. The utility obtained by each side depends on the number of users on the other side and vice versa.

According to Rochet and Tirole (2006),

> "a market is two-sided if the net utility on one side increases (decreases) with the number of members on the other side, everything else being given, in particular keeping prices charged by the platform to end-users constant."

Whereas end-users do not internalize the impact of their purchase on the other side of the market, the platform takes into account these externalities and tries to get the two sides on board by appropriately charging each side.

Non-neutrality of price allocation arises if, for example, a seller cannot pass an increase in its cost of interacting with a consumer, through to the consumer. So, two-sided markets are those in which the price structure affects the economic outcome – volumes, profits and/or welfare. These specificities of a two-sided market result in basic pricing principles that are different from traditional one-sided market. However, there exist many ways to define and to model TSM, that is why special attention should be paid when applying the concept.

The theory of two-sided markets was partially based on and is related to the theory of intermediation and of multi-product firms. A TSM model is close to the model of a multi-production: two products are represented by two services – to side 1 and to side 2 – with interconnected demands. The profit function of a two-sided platform could describe behavior of a multi-product monopoly, given that both models are characterized by non-zero cross elasticities. But the mechanisms of demand interdependence are different. In case of two linked products, demand on one good depends directly on the price of the other complement or substitute good, and this price interdependence is internalized by one consumer who wants to use both goods. On multisided markets, demand on one good doesn't depend directly on the price of another good, but on the level of its consumption. Positive externalities between two sides imply negative cross-elasticities. The well-known result is that multi-product monopolist's price in the case of negative price elasticities (product complementarity) is lower. By analogous reasoning, under two-sided positive externalities prices on both sides are lower, and the number of consumers on both sides is higher than without externalities. Price of each side positively depends on the externalities it creates on the one side and negatively on externalities it receives. Mathematically this result is close to pricing of complement products. TSMs theory is also related to the intermediary theory: a platform plays the role of an intermediary between two sides of the market.

There is a vast literature on two-sided markets. The first papers, Rochet and Tirole (2003), Caillaud and Jullien (2003), Armstrong (2006), study competition between two-sided platforms, paying special attention to pricing.

The most discussed particularity of TSM is their pricing principle: it accounts for externalities between two sides. Depending on the level of externalities and their unequal repartition between two sides, the social welfare maximization may be achieved by setting a zero price or a subsidy on one of two sides.

Two main factors determine the optimal level of relative prices on two sides:

1. Asymmetry in externalities: the price on one side is lower if it creates relatively more externalities for the other side.

2. Differences in price sensitivity: the price on one side is lower if price sensitivity on this side is higher than on the other side.

Examples of two-sided activities often present very asymmetric tariff structures with zero price on one side and positive price on the other side. Low or zero prices on one of market sides allow to increase the number of users on this side and to increase their surplus. This mechanism is also capable of increasing the surplus of agents on the other side if it allows to generate enough externalities to compensate for the price increase and thus create an additional surplus. For example, certain daily newspapers are free of charge for the readers (side 1), while commercial messages are paid by advertisers (side 2). Similarly, viewers do not pay for free television channels, while advertisers pay for diffusing TV commercials. In the software industry certain activities follow the same logic: a platform gives away the document or media reader and sells the encoding software or the professional version of the software; it is the case for Adobe, Realplayer, Mediaplayer, Divx, etc. Many other examples could be mentioned.

This economic model of very asymmetric pricing used by some platforms does not imply that all the platforms on the same market follow a similar pricing strategy. The free of charge press co-exists with paid newspapers, free television channels co-exist with paid channels, paid software co-exist with freeware, etc.

Some conclusions obtained for one-sided markets cannot be applied to TSMs: two-sided externalities modify equilibrium characteristics. Since they are not completely internalized by platforms, it leads to a market failure, that is why techniques of antitrust analysis on TSMs should be modified to take it into account.

In this section, we review the existing literature concerning different aspects of two-sided markets regulation as well as general theoretical literature in order to apply its results to antitrust analysis. Theoretic results are illustrated by real-life examples. We separately discuss each component of competition analysis in light of TSM: market definition, mergers, antitrust regulation and cartels.

1.1 Impact of the degree of competition on prices and social welfare

The equilibrium market structure depends significantly on the existence of two-sided externalities and the usual links between market structure, prices and welfare do not always hold.

First, let us consider the factors that determine the intensity of competition. The following list of those factors was suggested by Evans and Schmalensee (2005) to determine whether concentrated market structure on a TSM is more or less likely:

- positive network effect and scale economies make concentration more likely;
- congestion, platform differentiation and multihoming make concentration less likely.

A platform's cost structure is often characterized by economies of scale: creation and maintainance of a platform is usually related to fixed costs as in the case of a software platform. On the other hand, certain platforms may also show diseconomies of scale. For example, a software platform may become too complex and expensive to develop as the number of applications grows, in the case it was initially scaled for a smaller applications number. A big number of users may lead to congestion, in which case the platform may want to limit the number of users. It may also decide to accept only the agents with particular characteristics in order to optimize search between users, for example, to limit the platform to only one geographical area. It is interesting to note that (dis)economies of scale or congestion may be more present on one than on the other side.

Even if competition on a TSM is strong, it does not necessarily mean that consumers' benefits are high. Generally, an increase in competition on a TSM does not necessarily result in a more efficient price structure between two sides: it depends on degree of competition on each side, which in its turn depends on such characteristics as multihoming, consumer loyalty, etc.

According to J. Wright (2004), while competition lowers the overall level of prices charged to two sides, competition could result in a structure of prices that is closer to, or further away, from the efficient structure. The author compares choice of price structure by a two-sided monopolist to the choice of quality by a one-sided monopolist. As the chosen level of quality may be insufficient or excessive with respect to the efficient one depending on the effect on the marginal versus average consumer, similarly the structure of monopoly platform prices may be more or less efficient than the one chosen in competition.

Rochet and Tirole (2003) construct a model showing that for the case with linear demands and a charge per transaction as the only price instrument, the structure of prices in a generic two-sided market is the same under monopoly and competition.

Ordover (2007) mentions that in practice increased competition among platforms may have a rather surprising impact on price structure. For example, increased competition among credit card networks for issuers has led to an increase in interchange fees; a similar phenomenon was observed on the PIN debit card market. A reduction in price on the side where profits are being dissipated may be nothing more than a partial corrective for the reduction in quality on the other side caused by price elevation.

E. Damiano and H. Li (2008) construct an example of a model in which monopolized TSM may be more efficient than a competitive one. They study how matchmakers use prices to sort heterogeneous participants into competing matching markets, and how equilibrium outcomes compare with monopoly in terms of prices, matching market structure and sorting efficiency under the assumption of complementarity in the match value function. The role of prices to facilitate sorting is compromised by the need to survive price competition. They show that price competition leads to a high quality market that is insufficiently exclusive. As a result, in terms of the total match value, the duopolistic outcome may be less efficient in sorting than the monopolistic one. On the other hand, an advantage of the duopolistic structure is a greater number of participants.

In conclusion, theoretical studies do not give clear results on whether on a TSM a higher competition is socially beneficial or not: because of externalities, the impact of stronger competition on the welfare is ambiguous. Below we show that the same holds for empirical results.

Rysman (2004) and Rysman (2007) adopt an empirical approach to study the impact of competition degree on the social welfare on a TSM.[1]

[1] Rysman (2007) analyses the link between price and degree of competition. A methodological study was made, without test on real data. It is concentrated on regressions of price on the number of competitors controlling for other characteristics through observable variables. There are two challenges in estimating such regressions on a two-sided market. First, there is no single price variable but a different price variable

Rysman (2004) aims at assessing the impact of competition on welfare using real data from the USA. He estimates three simultaneous equations that characterize reader demand, advertiser demand and publisher's profit maximization. Data contains usage data, number of pages that proxies for the quantity of advertisement, advertisement prices, distribution areas, etc. The surplus of advertiser and publisher was found as a function of the number of competitors on yellow pages market. The downward or upward slope of the surplus function depends on the ratio between two factors:

- monopolisation is more beneficial for the society if the effect of positive externalities is strong;
- monopolisation is less beneficial for the society if the effect of the greater total number of users served on the market is strong.

Rysman concludes that, according to computation results, a more competitive market is preferable. He also claims that, if the consumer surplus is accounted for, this conclusion becomes even stronger. Since the personal gain from entry is significantly lower than the social one, entries should be encouraged.

Exclusion of an efficient rival is more likely to happen on a two-sided market with positive external effects than on a one-sided market. In fact, positive externalities lead to a chicken-and-egg problem for potential entrant: if the incumbent manages to attract many users on one of the sides, it may create a barrier to entry because a rival fails to gain the critical mass of users necessary for entry. That is why competition authorities should pay special attention both to prospective mergers between two-sided platforms and to their potentially anti-competitive practices.

1.2 Market definition

The process of defining market boundaries is an unavoidable process preliminary to any assessment of competition effects. It is more difficult to find the boundaries of a two-sided market than of a one-sided one because a regulator has to consider the link between different products and groups of customers, and to estimate which externalities are essential and

on each side of the market; that is why it can be useful to specify two regressions: each predicting price on each side. Second, the number of competitors may differ across two sides.

which are not.

1.2.1 Market definition analysis based on qualitative methods

First, a competition authority should properly determine all the market participants. A two-sided platform may take many forms: proprietary platform may compete with not-for-profit platforms. For example, Visa Europe remains a member-owned, not-for-profit association. Prior to its initial public offering in 2006, Mastercard Worldwide was a co-operative owned by financial institutions that issue its branded cards. Alternatively, a platform may vertically integrate into one of the sides: the case when an operation system developer also owns a part of the applications.

To delineate the market and to name potential competitors of a two-sided platform requires analysis of an often complicated market structure:

- First, in certain cases users on two sides may bypass platform's services and interact directly. For example, websites may sell their advertisement space directly without passing by intermediaries, thus competing with them.
- Second, two-sided platforms may compete with one-sided companies: a web site with banners is a two-sided business while a web site without banners but with subscription fee is only a one-sided business. In this case the one-sided business is particularly vulnerable to competition since the multi-sided platform uses advertisement side profits to subsidize the users' side.
- Third, a two-sided platform may compete with a vertically integrated business: video game console producers may either develop their own games or use the services of independent developers.

It is necessary to identify the groups of customers served by the subject of the inquiry, and then identify the various businesses that serve these customers.

Second, it should ne decided whether both sides should be included in the market scope.

Besides, a competition authority needs to distinguish between efforts to coordinate interdependent sides of the market and efforts to extend a monopoly from one product to another.

Usually, there are two distinct groups of users on a two-sided market: end customers and content providers, men and women, etc. More rarely, users on both sides are the same but they differ in the purpose of transaction: an eBay user may be a buyer or a seller at the same time, a mobile telephone user both sends and receives phone calls.

If multisided platforms in an industry all tend to serve the same two sides, and if and if these sides are highly complementary and closely linked, then it can be reasonable to consider that both sides belong to the same market and a 'transaction' between them is the product sold on this market. For example, men and women subscribed to a dating club can be considered as customers of a unique market.

But in most cases it is only one side of the theoretical two-sided market that can be included in the market definition because the products and users on different sides are significantly different. In spite of this, even if from the regulation point of view two sides are considered as two distinct markets, we will still refer to a 'two-sided market' as it is done in theoretical papers. For example, when considering the market of online advertisement, a regulator will not include advertisers and web sites in the same market. At the same time, even if the two types of users (web site owners and end customers) are not on the same regulatory market, it is necessary to take into account the link between them – the interdependence between the demand on advertisers' side and the demand on the side of websites. It is particularly tricky not to forget about one of the sides if it gets the product for free: for example, a a web site gets all its profit from advertisers, so there is a risk to forget about the reader side. As the product (content, e-mail, etc.) is free, there does not exist any market from the point of view of competition policy; at the same time, the audience plays an essential role in a web site's success and cannot be ignored.

J. Wright (2004) asks the question whether the ability to define separate markets on each side may depend on the price structure - the possibility to charge membership fees or only transaction fees. He explains that with pure transaction fees, platforms collect revenues from both sides simultaneously whenever there is a transaction, in which case it would seem to make little sense to define separate markets.

As there are no strict rules to detect a two-sided market in practice, regulatory definitions can vary even for markets of the same industry. Evans (2009) studies several regulatory decisions on market definition in the newspaper industry: some decisions have focused just on one side of the platform while others have taken into account the feedback effects between readers and advertisers.

1.2.2 Statistical analysis

The first task is to determine whether two markets are really linked by externalities and to check empirically whether a market is really two-sided. The problem is the lack of detailed data on both sides of the market. Even though the concept of TSMs could be applied to many cases, in every particular case it should be checked whether it is indeed justified for regulation purposes and whether accounting for two-sidedness will bring new useful elements in the analysis. For example, it is not clear whether network effects are still detectable in a mature market. As stated by Katz (2005), 'mature' payment networks such as Visa or American Express might reasonably be treated as one-sided platforms at the margin.

As Rysman (2007) mentions, it is difficult to establish causality: whether the correlation between consumer usage and merchant acceptance is caused by consumer usage affecting merchant acceptance, or merchant acceptance affecting consumer usage, or both. However, the market is two-sided in both of these cases that is why it is sufficient just to find correlation.

According to Evans (2012), market definition analysis is subject to a greater error on TSM. That is why cautions against placing great weight on mechanical approaches to market definition that 'cannot account for competitive nuances and complexities'.

Once the product and the group of consumers are broadly determined, one needs to implement statistical tests to precisely define product and geographical boundaries.

The most wide spread statistical instrument to define a market boundary is the SSNIP test (Small but Significant and Non-transitory Increase in Price). Critical Loss Analysis is a user-friendly implementation of this test. This analysis consists in comparison between Critical Loss and Actual Loss in quantity due to the change in price. Actual Loss is the predicted percentage loss in quality that the hypothetical monopolist would suffer if it did increase prices on all its products by X%. It is calculated from the data on own and cross price elasticities. Critical Loss is the percentage loss in quantity of a hypothetical monopolist's products that would be exactly enough to make an X% price increase in the price of all products unprofitable. It is calculated from the percentage markup data. If Actual Loss exceeds Critical Loss, the relevant market should be expanded.

Evans and Noel (2008) extend Critical Loss Analysis to the case of two competing two-sided platforms. First, they consider the symmetric case where values of price elasticities and indirect network externalities are the same across the two platforms. They describe two types of biases which appear when using one-sided market Critical Loss Analysis on a two-sided market. The estimation bias appears because one-sided estimate does not account for feedback between two sides. As a result, antitrust markets are defined too narrowly. The Lerner bias occurs when observed markups are used to calibrate the own elasticity of demand based on the one-sided Lerner Index, which overstates the true short-run own-price elasticity of demand and overstates Actual Loss. Indeed, indirect network externalities penalize price increases more, so the short-run own price elasticity must be especially low in order to support markups at a given level. The one-sided estimate is higher not only than the true short-run own-price elasticity but also than the true long-run own-price elasticity. It leads to a too broad market definition.

Second, Evans and Noel (2008) consider the case of competition between asymmetric platforms. The result is ambiguous: the signs of two biases described above depend on the analytical method and the extent of the price increase. In particular, when the extent of price increase on any side is the same across platforms, the biases move in the same directions as in the symmetric case. However, when the extent of price increase is allowed to differ across products, the direction of the bias depends on the degree of asymmetry and the particular mix of the values of price increase. Differentiated values of price increase result in a shift in the relative sizes of the platforms and generate feedback effects. For example, if price increases only on one of two platforms, a one-sided analysis will underestimate the number of users who will migrate to the other platform. If the other platform is more profitable, it will lead to underestimation of profit increase.

Another problem of the SSNIP test on a two-sided market is the assumption of equal price increase across all sides and platforms, while a hypothetical monopolist of several platforms could reoptimize prices across sides and across platforms. It may lead to underestimation of market power: in some cases even if equal price increase on all sides is unprofitable, a price increase after this re-optimization may become profitable.

A full-scale market simulation may be used as an alternative to the SSNIP test even though technically it is more complex. One-sided methods of simulation cannot be directly applied to TSMs. Evans and Noel (2008) explain that, for example, on a one-sided market one can use the Lerner Index to estimate the own price elasticity from the observed markup. But as was explained earlier when applied to a TSM the one-sided formula overestimates the true short-run own price elasticity of demand. Evans and Noel (2008) derive the first order conditions for profit maximization by a two-sided platform, but these conditions do not uniquely identify the values of the own price elasticities from the markups.

The question of modifying the SSNIP test and the traditional tests for a TSM is close to the question of modifying the test for a multi-product firm with substitute or complementary products. For example, Ordover and Willig (1981) propose a test for predatory pricing by a multi-product firm.

1.2.3 Examples

In several cases, the two-sided nature of telecommunications and internet markets has been taken into account by competition authorities and industry regulators.

According to European Commission, electronic communications markets are often two-sided, where two sides exchange communications or one side sends information or content to the other one.[2] Accounting for 'two-sidedness' may impact the market definition and in some cases justify ex ante regulation:

> "Markets in the electronic communications sector are often of a two-sided nature, in that they comprise services provided over networks or platforms that bring together users on either side of the market; for example end-users that exchange communications, or senders and receivers of information or content. These aspects need to be taken into account when considering the identification and definition of markets, as they can affect both the way markets are defined and whether they have the characteristics which may justify the imposition of ex ante regulatory obligations."

[2] Commission Recommendation of 17 December 2007 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services. C(2007) 5406. 2007/879/EC

In its 2010 consultation document ComReg used the notion of two-sided markets in order to define the market boundaries for transmission services.[3] On this market, broadcasters face two groups of users: advertisers and households. Reasoning of ComReg goes as following. In order to maximize advertising revenues, broadcasters need to maximize their audience. That is why they need to reach every group of customers, and so to sign agreements with every transmission platform. In conclusion, every transmission platform is regarded as a separate market: terrestrial, satellite, cable (and MMDS) and Internet TV. Let us consider this reasoning from the theoretical viewpoint. ComReg seems to suppose that TV viewers never change the transmission platform, always use only one of them, i.e. singlehome. Broadcasters, on the contrary, multihome. Economically, it is not clear that the benefit from additional customers always overweights the price paid to the transmission platform and so it is not clear why a TV channel always has to use all the transmission ways available.

In several cases the two-sided nature of some markets was taken into account by competition authorities long before the two-sided markets theory was elaborated. Evans (2012) gives the following examples of antitrust investigations in which authorities recognized the two-sided nature of the market. In National Bancard Corp. v. Visa U.S.A. (1986), Inc.,[4] regulators recognized the two-sided nature of Visa's business platform. In United States v. First Data Corp. (2004),[5] the U.S. Department of Justice defined the relevant market as the provision of PIN debit network services and recognized PIN debit networks as two-sided platforms. In spite of this, the Department asserted that the hypothetical monopolist test was appropriate in a two-sided market because the overwhelming majority of merchants would not reject or discourage customers from executing PIN debit transactions in response to a moderate increase in the price of the product.

In Times Picayune Publishing (1953),[6] the Supreme Court took note of the linkages between advertisers and readers. In GTE Media Services v. Ameritech Corp. (1998),[7] the district court recognized the two-sided nature of yellow pages businesses. In Newspaper Publishing (1994),[8] the European Commission (EC) clarified that different categories

[3]ComReg 10/98. Consultation Paper "Three Criteria Test on the Broadcasting Transmission Market" 03 - 12 - 2010

[4]779 F.2d 592 (11th Cir. 1986)

[5]2004 U.S. Dist. LEXIS 13590 (D.D.C. 2004).

[6]345 U.S. 594 (1953).

[7]21 F. Supp. 2d 27 (D.D.C. 1998).

[8] Case IV/M.423, Newspaper Publishing (1994).

of newspapers should not be considered substitutes from the point of view of buyers of advertising space because they "provide different 'channels' through which to reach different socio-economic groupings of readers." The Italian antitrust authority took a similar position in Class Editori/Sole 24 Ore (1995), holding that advertising in "daily papers specialized in business and financial information" was a separate product market from advertising in "newspapers of general information."[9]

1.3 Market power

Once the market is defined, regulator estimates platform's *market power*. The main criterion of the market power is the market share. It can be difficult to know how a high market share on one side impacts the market power on the other side.

Evans and Schmalensee (2005) claim that a two-sided platform has a decreased market power compared to a one-sided firm because it faces competition not only on one side, but on multiple sides. In particular, a price increase on one side negatively impacts the second side. Ordover (2007) disputes this conclusion and gives a counterexample: by charging a low price on one side, the platform operator reduces elasticity of demand on the other side. Moreover, if customers on one side participate on every platform, each platform has more market power.

As a consequence of decreased market power, Evans and Schmalensee (2005) claim that "competition on both sides of the platform limits profits"; moreover, they seem to suggest a complete dissipation of incremental profits from the less competitive side to the more competitive one. Ordover (2007) replies that such dissipation is more likely to be imperfect but could be sufficient to undermine incentives for anticompetitive unilateral or coordinated conduct. The operators of two-sided platforms may have enhanced incentives to engage in business strategies that lessen competition on that side of the platform from which the feedback effects (i.e., the inter-side network effects) are the most pronounced.

A regulator should determine whether aggressive pricing by an incumbent (e.g., a payment network signing bonuses to issuers) increases the difficulty of entry and constitutes

[9] Provv.n.3336, Clas Editori / II Sole 24 Ore (1995)

unlawful exclusionary conduct as it would have been considered on a one-sided market, or is simply an optimal price structure under competitive pressure. Additionally, it is possible to confuse competition for one set of customers for the exercise of market power against the other: payment networks have long argued that increases in interchange fees for merchants are largely due to intense competition for issuers.

Traditional indices used to estimate market power — market share, HHI (Herfindahl-Hirschman Index) and profit margin — need to be used with caution.

A high market share on one side does not necessarily implies a dominant market position if it is combined with a low market share on the other side.

Most two-sided platforms provide different products or services to different sides as in the case of shopping malls, computer manufacturers, etc. In this case it does not make economic sense to first allocate the various posts of platform costs to each side and then to compare margins between platforms on each side separately. The traditional instruments of market power analysis should be modified to account for the impact of one side's price change on the demand on both sides of the market.

However, there exist certain cases where standard instruments could be used to analyze multi-sided platforms. For example, as suggested by Evans (2012), if products or services on two sides are rather similar they can be combined into a simple metric. Such metric can be compared across firms and manipulated to calculate market shares and the Herfindahl-Hirschman Index. This is the case for online matchmaking businesses for men and women. In some other cases, transaction price may become a base of market power measurement. Percentage commissions charged by real estate brokers relative to the expected costs of making a successful match may be a reasonable basis from which to measure market power in real estate brokerage services.

1.4 Merger analysis

1.4.1 Horizontal mergers

In general terms, the economic analysis is likely to be more complicated on a two-sided market because there is a need to estimate the force of interaction between market sides in addition to the usual parameters.[10] In terms of merger control, three specific effects can be underlined:

1. Compared to a merger on a standard market, a merger on a two-sided market can generate more efficiency gains thanks to the externality effect. Whereas on a classical market efficiency gains from mergers are mostly related to cost reductions, mergers of platform operating on two-sided markets can generate another type of efficiency gains, related to the increase of the number of users on each side. For example, let us consider the merger between Google and DoubleClick, two-sided platforms that allow interactions between advertisers and web sites that propose advertisement space. The combination of their databases of online sites allows to improve and to refine the advertisement targeting capability of the post-merger firm. It leads to an increase in the value of the service for the advertisers who can target more accurately their advertising campaigns according to their needs. Another example is the merger of stock exchanges, platforms between traders, buyers of stocks (side 1) and corporations putting new stocks on the market (side 2). A merger will create an increase in the volume of traders (side 1), which will, in turn, increase the overall trading activity, reduce spreads between bid and ask prices, make markets more liquid, and finally allow stock and options to be sold more quickly, to the benefit of the corporations (side 2). (cf. Evans, 2003).

2. As explained earlier, pricing on a two-sided market depends on the external effects between the two sides. For that reason, certain statistical tools used for merger analysis should be modified to handle two-sided markets situations. In particular, the traditional SSNIP test (Small but Significant and Non-transitory Increase in Price) assumes an equal price increase across all sides and platforms, while a hypothetical

[10] Further information on the theory and practical cases of mergers on two-sided markets may be found in a report by the TILEC (2010).

monopolist on several platforms could re-optimize prices across sides and across platforms. This issue was mentioned by the French Competition Authority in the case n°10-A-29 on the online advertiement market.[11] Additionally, the price elasticity of demand on each side cannot be determined statistically as simply as for standard markets.

3. From a dynamic standpoint, two-sided markets are characterized by the snowball effect. In particular, this effect was mentioned in the analysis of the merger between Google and Double Click by the European Commission.[12] A company that has succeeded in attracting more advertisers on one side will attract more editors on the other side, which creates a virtuous circle allowing it to attract even more advertisers, etc. Within that framework, if a merger leads to a significant increase in the users base on one side of the market, more users on the other side may be attracted to the postmerger platform, creating or reinforcing a dominant position and possibly leading to foreclosing competing platforms from the market.

A merger or an unilateral practice may slightly reduce competition on one side of the market, but produce substantial pro-competitive gains from efficiencies for the customers on the other side.

Techniques

The SSNIP test allows estimating the potential market power of a merged firm in order to determine the likely impact on consumers. Implementation of this test on two-sided markets is discussed above in the section on the market definition. Below, we discuss a full market simulation analysis for assessing the anticompetitive impacts of mergers or horizontal collusions.

The first stage of simulations is to specify demand and the game interaction model. The next stage is to parameterize and predict market equilibrium with the after-merger market structure. Rysman (2007) describes three challenges related to implementing it on a multi-sided market. First, the demand function is characterized not only by price elasticities, but also by network externalities. They can be crucial in the model but are difficult to estimate because of lack of data and endogeneity problem. In some cases, their value

[11] Avis n° 10-A-29 du 14 décembre 2010 sur le fonctionnement concurrentiel de la publicité en ligne.
[12] Case No COMP/M.4731 - Google/DoubleClick

may be estimated from experts' opinions. Second, two-sided markets are often characterized by tipping and aggressive pricing, for which a dynamic model is more appropriate. Conceptually, it is feasible to introduce dynamics into simulation, but in practice doing so is a major computational undertaking and will often not be a reasonable option. *Third*, the link between prices and quantities is often ambiguous in two-sided markets. Indeed, if there are few customers subscribed on the second side, users on the first side do not subscribe even if the price is low.

Taking into account these challenges, Rysman (2004) models the two-sided market of yellow pages with two simultaneous equations: one representing consumer demand and the other representing advertiser demand. He finds that the results are fragile in the face of small parameter changes, in particular, of changes in the feedback (externality) value. That is why assumptions should be subject to sensitivity analysis and confidence intervals play an important role.

Examples

There are multiple examples of antitrust cases of mergers on the market that can be considered as two-sided: advertisement, stock exchange, etc. Some of them have been already analyzed in the scientific literature.[13]

The case of merger between Google and Doubleclick is analysed by Evans and Noel (2008). In April 2007, Google came to a definitive agreement to acquire DoubleClick, a developer of software for online advertisement. In its analysis, the European Commission and FTC recognize the two-sided character of the online advertisement market. The acquisition was authorized without conditions in November 2007 by the Federal Trade Commission in the USA and in March 2008 by the European Commission[14].

The European Commission and FTC have considered several scenarios of competitors' foreclosure by Google. An increase in the price of DoubleClick's products may attract more users to AdSense, the competing service by Google. The same effect may appear if DoubleClick's products are always bundled with the Google's matching services. Additionally, the merger of Google's and DoubleClick's database may allow to improve and to refine the

[13] See for example Evans and Noel (2008), Evans and Schmalensee (2005) and Chandra and Collard-Wexler (2008) for mergers in the newspaper industry.

[14] Case COMP/M.4731 Google/DoubleClick.

advertisement targeting and thus to gain market power. These practices are more likely to lead to monopolization because of indirect externalities. Monopolization on a two-sided market is more likely than on a standard market thanks to the snowball effect. Indeed, a company that has succeeded in attracting more advertisers on one side will attract more editors on the other side, which allows to attract even more advertisers, etc. If the merged network attracts more users by using one of anticompetitive strategies described above, it may achieve a critical size and deprive competing advertisement networks from achieving a necessary minimum size.

However, according to Google and DoubleClick, anti-competitive behavior of the merged platform is unlikely for the following two reasons.

First, the merger concerns vertical and not horizontal integration. While Google proposes an integrated solution that includes a service of exchange of advertisement space as well as technical solution, DoubleClick proposes only a technical solution. The market is characterized by a natural tendency towards vertical integration between firms proposing intermediary services and those that propose instruments for advertisement diffusion.

Second, Google and Double Click are on different market segments: Google is on the market of textual advertisement while DoubleClick is specialized on banners. Additionally, sites served by Google are small sites while sites served by DoubleClick are big sites.

The European Commission concludes that the risk of monopolization is small for the following reasons. First, each user is often subscribed to multiple intermediary networks. Even if this user decides to subscribe to the dominant network of Google, they have no obligation to quit the old network. Second, in practice we observe a strong competition between networks: multiple networks co-exist thanks to the differentiation on the level of services proposed and specialisation.

Stock exchanges may be considered as TSM between buyers and sellers of securities. Evans and Schmalensee (2005) give examples of stock exchanges mergers approved by authorities: between New York Stock Exchange and Archipelago in 2005, between NASDAQ stock exchange and Instinet in 2005, between New York Stock Exchange and Euronext in 2007. These mergers generate efficiency. Concentration of stock exchanges allows reducing transaction costs: more trading activity tends to reduce spreads between bid and ask prices and to make markets more liquid; stock and options may be sold rapidly which attracts more trading. Traditionally, stock exchanges tended to be local monopolies. As restrictions on cross-border trading have been relaxed and communications costs have fallen, competition has increased globally, and many exchanges changed their status to for-profit organizations. An interesting question is whether network effects will continue to limit the scope of competition or falling communications costs will make competition inevitable.

1.4.2 Vertical integration

The question of vertical integration on TSM was studied by Derdenger (2009) and Tregouet (2008). It is considered more in detailes below, in the context of exclusive dealing.

1.5 Unilateral anticompetitive practices

Below we study how, on a TSM, to treat pricing and non-pricing practices which potentially constitute unlawful conduct and impede competition. We discuss theoretical results from TSMs literature and give examples of antitrust cases where two-sided markets were involved and where presence of two-sided externalities had or could have had an impact on the authority's conclusion.

1.5.1 Predation and excessive pricing

Predation consists in setting prices too low compared to costs with the objective of evicting competitors who cannot maintain these low prices.

Predation analysis on a TSM is complicated by the following two factors. First, a platform's costs cannot be easily dispatched between two sides given a usually significant weight of the fixed costs.

Second, as have been discussed earlier, efficient price on each side of a two-sided market depends not only on costs of supplying this side but also on the value of externalities. That is why, as mentioned by many authors, the price which is estimated to be lower than marginal the cost does not mean predation and the price which is estimated to be higher than marginal cost does not mean excessive pricing.

J. Wright (2004) specifies that these not purely cost-oriented prices are set not only on new two-sided markets in order to solve the chicken-and-egg problem, but also on mature markets. As networks mature, the value of the costs and externalities and correspondingly the optimal price will likely change, but it will not follow a simple cost-oriented pattern.

A suspicion in predation arises when the sum of prices on both sides is lower than total cost. At the same time, predation may still take place even if this condition does not hold but the price only on one of the sides is lower than cost generated by this side.

For the reasons given above, predation test should be modified for the case of TSM. This modification may be close to the one proposed by Ordover and Willig (1981) for multi-product firms where price to one group of buyers may be below the direct marginal cost of serving this group. Ordover (2007) assumes that in the two-sided case it could be useful to check that the price structure delivers a per transaction price that exceeds the pertinent measure of marginal cost. Alternatively, the analysis might focus on a comparison of incremental revenues versus incremental costs defined over packages of goods or services that serve the interests of customers on both sides of the platform.

Fletcher (2007) argues that even if a platform covers its total costs, predation may still take place. The platform can set a price structure that does not maximize profit in the short term but instead aims at excluding competitors. Such pricing is unlikely to be a feasible exclusion strategy if platforms are symmetric because in this case it can be repeted by competitors. But if firms are asymmetric, especially if one of firms has a smaller user base or a different cost structure, then such strategy may be fruit-bearing. As a result two-sided markets can tip easily because of network effect.

In fact, the predation analysis on a TSM implies comparing the price not with the cost, but with the opportunity cost which takes into account the impact on the other side because of externalities. In applying such test, one needs to check that the incremental revenues generated on the other side of the market are related to the low price on the first side and not just a result of competitors' exclusion.

An example widely considered by policymakers is debit and credit card schemes. There are two types of card schemes: proprietary schemes and associations. Proprietary schemes such as American Express and Discover choose how much to charge cardholders and how much to charge merchants. For instance, American Express earned 82% of revenues from merchant fees.[15] Card associations such as MasterCard or Visa do not set fees to merchants and users directly, but it sets interchange fee – the fee paid from the merchant's bank (the acquirer) to the cardholder's bank (the issuer). Acquirers respond to an increase in the interchange fee by increasing their merchant fees, issuers respond by decreasing card fees. Policymakers have argued that the interchange fee is too high with respect to costs so that card charges are too low which stimulates overusing of cards. In this reasoning, they do not take into account the strong positive externality from users to merchants.

Behringer and Filistrucchi (2009) make an empirical study of the case of price wars in 1990s on the UK quality newspapers market. They conclude that the evidence brought forward at the time of investigation was not sufficient to prove predation since the two-sided characteristic was neglected. The change in the optimal financing mix of newspapers did not have as a goal competitors' eviction but was simply a result of increasing demand for advertisement. They construct a theoretical model of oligopolistic competition between platform to show that if the size of advertisement market increases, the optimal financing mix shifts towards more advertisement revenues. They analyze empirical data and show that the advertisement market and demand for advertisement is growing. They also conclude that if the revenue on both sides is taken into account, the pricing strategy of The Times did not lead to a negative price and so their predation was not proven.

Eichhorn and Sahm (2010) propose an interesting example of underpricing by the organizers of sports events: even though many visitors are ready to pay more than the proposed price and the demand volume is higher than supply volume, managers do not raise prices. It can be explained from TSM prospective: the two revenue sources include tickets sales and support from sponsors. The successful marketing depends on the atmosphere on the stadium and correspondingly on the intensity of emotional expression by spectators. At the same time, literature reports a negative relation between the intensity of emotional expression and income. Consequently, organizers are interested in attracting spectators with lower williness to pay in order to benefit from positive externality.

Presence of externalities can make predation feasible. Fumagalli and Motta (2009) pro-

[15] Evans (2003).

pose a predation theory based on incumbency advantages, scale economies and sequential buyers, where, in one of the extensions, scale effects appear because of two-sided externalities. Their predation mechanism is not based on information asymmetries. In the model the incumbent has a greater installed base of users but the rival is more efficient. There is only one new buyer on each side and users singlehome. Under the condition that the incumbent's advantage overweights the lower efficiency, incumbent may win the market by pricing the product lower than costs on one side and compensating it on the other side to get a positive profit. This model can be compared to Doganoglu and J. Wright (2010) where the incumbent has a time advantage. To illustrate their model, they give an example of the pharmaceutical industry. In 2001 the office of Faire Trading found that Napp has practised predatory pricing for morphine in the hospital segment and excessive pricing in the community segment (general practitioners). Authors interpret the market for morphine as a two-sided market between these two segments: buyers of the community segment tend to choose the same products as hospitals, consequently, there is a positive externality from the hospitals' side to the community side.

A regulator should also be careful when imposing tariff restricting measures. On a one-sided market price regulation is competitively neutral: a low price imposed by the regulator on a firm will give incentives to its competitors to lower the price as well. As observed by J. Wright (2004), a low price imposed by the regulator on a firm only on one of the sides will not necessarily give incentives to other firms to lower this side's prices as well. As a result, competitors will get a competitive advantage because they can freely fix both prices and so maintain the most efficient price structure. That is why regulator should account for market two-sidedness when imposing measures on dominant platforms.

The issue of predatory pricing seems to receive little attention in the TSM literature: most models take the number of competing platforms as given and so do not consider the question of potential foreclosure caused by predation.

1.5.2 Tying

There are two types of tying that were considered in the TSM literature: tying between products on one of the sides of two different two-sided markets (for example, of debit and credit cards) and tying of the principal product with a complementary product on one of the sides of a two-sided market (for example, an operation system with a pre-installed media player).

Tying between products on one of the sides of two different two-sided markets

An example of tying on a TSM is the 'honor-all-cards' rule on the market of payment cards. Some card associations require merchants to accept any card issued by the association, regardless of who presents it, which entity issued it and whether it is debit or credit card. It was attacked on the grounds that associations tie two different products — credit and debit cards — in order to use their market power on the credit cards market and to exclude rivals on the debit cards market. In 2003, Visa and Master card abandoned the 'honor-all-cards' rule in the U.S. but not in the rest of the world.

Evans and Schmalensee (2005) observe that such tying may have positive effects: even though it seems to be unbeneficial to merchants, in fact it increases the externality on the other side, attracting more potential clients at the benefit of merchants. This gives an efficiency explanation for tying.

Rochet and Tirole (2008) construct a model of tying by a not-for-profit payment card association. Tying is shown to be a mechanism to rebalance the interchange fee structure and raise social welfare in the situation when one side of the market faces different bypass opportunities for two goods - debit and credit cards. Otherwise the platform would have charged merchants a lower price since they have more bypass opportunities at the detriment of card holders. This effect is robust to introducing varying degree of substitutability between debit and credit cards, merchant heterogeneity and platform differentiation.

Tying of the principal product with a complementary "single-sided" product on one of the sides

Tying could be used in order to create additional value to attract more users on one of the sides. A complementary good given for free to every subscriber incites subscription. It allows to avoid the risk of adverse selection and opportunistic behavior of agents compared to direct monetary transfer.

A well-known example of tying in a two-sided market is the example of Microsoft who included its media player in the Windows operation system.[16] The more people have a particular media player, the more content providers will tend to encode content in a format readable by this player. Software companies distributing free media players gain profits from content providers. Microsoft has argued that the existence of such effects is not sufficient to tip the media players market to a single platform: first, producers of media players are horizontally differentiated and, second, most content providers as well as many users engage in multihoming.

Choi (2010) models competition between two intermediaries and studies the effects of tying arrangements. On the content providers' side, agents are heterogeneous in their fixed cost of creating content, which is incurred twice in multi-homing. On the consumer side, agents are lineary differentiated. Prior to participating in the two-sided market, consumers need to buy a complementary product. For example, operating system is necessary for consumers to participate in the market of streaming multi-media. One of two intermediaries is also a monopolist on the related market of complementary product.

Choi finds three channels through which tying between the intermediary service and the complementary product can affect social welfare. First, all consumers patronize the tying firm's platform which implies less variety and hence less welfare. Second, content is provided only on the tying firm's platform which implies savings in duplication costs. Third, tying varies the equilibrium number of entrants on the content side. The first effect is negative, the second one is positive, the sign of the third one is ambiguous. The coordination of consumers on the tying firm's platform enhances the incentive to enter the content side of the market. However, the tying firm's pricing decision in that side of the market can offset this positive effect.

Choi concludes that tying is unambiguously welfare-reducing if multi-homing is not allowed. When multihoming is allowed, the welfare implications of tying can be subtle and ambiguous even if competing products are foreclosed. Tying can be welfare-enhancing because it induces more consumers to multi-home and hence makes platform-specific exclusive content broadly available.

[16]See also Dolmans, M. and T. Graf (2004) "Analysis of tying under article 82 EC: the European Commission's decision in perspective." 27 World Competition 225; Evans, D. and A.J. Padilla (2004) "Tying under article 82 EC and Microsoft decision: a comment on Dolmans and Graf." 27 World Competition 503

The above results depend on the assumption that there is an exogenous amount of exclusive content available for each music format. It would change if exclusive contracts could be used by non-tying firms inthe response to tying, in order to create incentives for consumers to multi-home when the monopolist ties.

Amelio and Jullien (2007) study tying as a method to introduce implicit subsidies in the context of a market with non-negative price restriction. They consider both "tying" where the tied product may be also sold separately, and "pure bundling", where the tied product cannot be sold separately.

Amelio and Jullien study both a monopolistic and a duopolistic two-sided market. They assume that only the customers of side 1 value the tied good and they all have the same willingness to pay for it. In the monopolistic case, if production of the bundled good is efficient, it is optimal for the platform to use a mixed bundling strategy (tying) which leads to the same sales of services while generating a positive revenue from customers not joining the platform. In the duopoly case, platforms are horizontally differentiated on both sides, and agents single-home. The demand for the tied good is homogeneous among members of one side so that there is no price discrimination possibility within sides.

Amelio and Jullien find that in a monopolistic context all consumers benefit from tying. In a duopolistic context, the opportunity cost of selling on the profitable side accounts for the loss generated on the subsidized side and increases with tying. Thus tying on one side also affects the intensity of competition on the other side. In this case, the impact of such tying is ambiguous on both equilibrium profits and consumers. While consumers on the subsidized side always benefit from subsidy, consumers on the other side may benefit or not. Two particular cases are:

- when the two sides evaluate the participation of each other in a symmetric way, total consumer surplus and total welfare decrease with tying;
- when the subsidy is given to consumers who do not value the participation of the other side, then consumer surplus increases on both sides.

They conclude that the impact on the consumers' surplus and on the total welfare depends on the gap between values of externalities on two sides.

The tying can be more generally viewed as a method of second-degree price discrimination. Similar to discrimination, supplying a free complementary good to some categories of customers may help a network to coordinate the customers' participation and thereby be welfare improving.

1.5.3 Exclusive dealing

A platform may propose exclusive contracts to its customers on one of the sides, forbidding a customer to sign a contract with any other platform. Such behavior can potentially foreclose competing platforms. We review existing literature on exclusive dealing and vertical integration on TSM, discuss extensions and give examples of antitrust cases.

Theory

By signing up one side early with attractive offers, the incumbent increases demand for its product from the other side due to network effects, which it exploits later on. The other side prefers to 'herd' with the first side on the incumbent's platform. In this case the foreclosure may happen even without entry costs and switching costs.

To foreclose an entrant, the incumbent needs to use an exclusive contract: when either all the contracts are exclusive exogenously, or the firms have the right to decide whether to propose an exclusive or non-exclusive contract.[17]

Whether exclusive contracts are primarily pro- or anti-competitive on two-sided markets is still a source of active theoretical debate and an open empirical question. There are multiple factors which determine their welfare effect.

As is well known, the classical argument of the Chicago school says that an exclusive deal is never closed until it creates efficiency and increases the total welfare. This argument holds on a perfect market but is not valid in certain circumstances, in particular, when the scale effect (Rasmusen, Ramseyer and Wiley, 1991; Segal and Whinston, 2000) or network

[17] In the most works on two-sided markets all contracts are exogenously assumed to be either exclusive or not. Platforms cannot modify this characteristic. One of reasons is that a complete characterization of equilibria when both exclusive and non-exclusive deals are allowed proves to be difficult. Depending on model parameters and selection criteria, there can be many equilibria: with several active platforms or only one; with or without exclusive contracts offered in equilibrium. Besides, within-side competition between sellers and side payments from buyers to sellers also affect sustainable equilibrium configurations.

effects (Shapiro, 1999) are present, or when buyers are rivals themselves (Simpson and Wickelgren, 2007; Abito and Wright, 2008). In two-sided markets network effects may become a source of such inefficiency.

Through network externalities, exclusive contracts on two-sided markets may deter entry or foreclose rivals. This effect is described for networked industries (see, for example, Shapiro (1998)). Incumbent attracts exclusively a part of users with low prices in order to exclude a rival and to make up for the low profit on the remaining users. Similarly, on two-sided markets, incumbent platform may attract one of the sides in order to extract surplus on the other side.

Exclusive contracts aiming at foreclosure were used, in particular, in game industry. For example, in 1985 Nintendo required game developers to make their games exclusively available on its system for two years following their release. As a result, consumers had no reason to switch to one of the rival systems. Shapiro (1998) notes that Nintendo dominated the video game business from 1985-1992 and that its position on the market was weakened only after it abandoned these practices in the face of antitrust challenge.

Doganoglu and J. Wright (2010) study how introductory offers, which may contain exclusivity provisions, can be used by an incumbent to exclude a more efficient entry. According to their result, when users multihome and exclusive contracts are available on the sellers' side, the incumbent is always able to exclude a rival even though the rival proposes a higher level of service quality and users are optimal coordinators. Both consumer welfare and overall efficiency are reduced by the use of such exclusive deals.

On the other hand, it is also argued that exclusivity may be an integral tool used by entrant platforms to break into established markets: by preventing contracting partners from supporting the incumbent, an entrant can gain a competitive advantage, spur adoption of its own platform, and thereby spark greater platform competition. Otherwise competition would have been absent or limited. Lee (2008) claims that such positive effect took place in the sixth generation of video-game industries and in competition between cable and satellite television for exclusive content. This question needs further theoretical investigation in two-sided market literature.

Armstrong and J. Wright (2007) analyze how exclusive contracts make it easier for a platform to undermine a market-sharing 'competitive bottleneck' equilibrium where the sellers' side multihomes while the buyers' side single-homes. Such contracts provide an easy way to persuade multihoming sellers to abandon the rival platform by setting an exclusive price that is slightly more attractive than the rivals' price. Even if the platforms are otherwise symmetric, this allows one of them to attract all sellers, and therefore to be able to charge a premium to buyers. As a result, a dominant-firm equilibrium is established and the entire buyers' surplus is extracted.

However, it is important to remind that because of network effects the welfare-maximizing configuration on a TSM may be different from those on one-sided markets, and higher competition does not always lead to higher efficiency. A market-sharing equilibrium with several competing platforms may be less efficient than a dominant-firm equilibrium. Armstrong and J. Wright (2007) study exclusive contracts and find that foreclosure is efficient if there is no product differentiation, when the only efficient outcome is for all sellers to subscribe to a single platform. At the same time, a dominant-firm equilibrium may lead to higher prices and correspondingly to the extraction of the whole additional network benefit by the platform. It does not happen in a two-sided game with exclusive contracts if the platform commits to licenses and royalty rates at the first stage. For example the domination of a unique DVD format is likely to benefit users because both platforms (Sony and Toshiba) had committed to the payment rates from hardware manufacturers and movie studios in advance.

Exclusive contracts are more likely to have a negative impact on consumers when thay have differentiated preferences towards contents or products sold. In this case, exclusivity on the sellers' side may limit consumers' choice as it prevents them from accessing some content, products or services.

Exclusive arrangements may have such pro-competitive benefits as encouraging investment and effort provision by contracting partners. For example, platform has more interest to invest in training developers on particular programming tool if it is sure that a rival platform cannot benefit from it. That is why it may want to make its system incompatible with systems of other platforms. In fact, if a developer is too small to work on several platforms, such incompatibility means exclusivity. Platforms may have interest to make software incompatible with each other. To our knowledge, this question is yet to be considered in the two-sided market literature.

To conclude, the overall impact of exclusive dealing on two-sided markets on the total welfare in the general case remains an open question. Empirical studies may help to estimate this impact in particular cases. For example, Lee (2008) conducts empirical research to answer this question for the market of the sixth generation video-game industry. He finds that exclusive arrangements between hardware platforms and software publishers benefited the smaller entrant platforms at the expense of the incumbent.

The distribution of welfare between the platform and two sides of users also depends on contracts' exclusivity. It is shown that platforms' pricing strategies may privilege one side to the detriment of the other side. For example, Armstrong (2006) shows that the side joining exclusively is treated more favourably because users on this side are unique to each platform, and therefore platforms are especially motivated to attract them in order to increase externalities on their platform and at the same time to decrease externalities on the rival platform.

In order to investigate relationship between content quality and exclusivity, Hagiu and Lee (2007) consider a model of negotiation between one content provider and two platforms. They show that whether or not a piece of content ends up exclusive to one platform depends crucially on whether or not the content provider maintains control over the pricing of its own good. If the content provider sells its content outright and relinquishes control over its price, the content will tend to be exclusive. When the content provider maintains control of its pricing and cash flow rights, the likelihood of exclusivity is no longer monotonic in quality. High quality content will multihome since foreclosing a portion of the market by being exclusive will be too costly; mid-quality content will be exclusive since it can soften price competition at the platform level enough to offset the losses from excluding a portion of the market; and finally, low quality content will multihome since it does not yield any comparative advantage even if it was exclusive.

Analysis of Hagiu and Lee (2007) implies that exclusive arrangements in platform industries with affiliated content may harm consumer welfare: not only are certain consumers on the excluded platform foreclosed from accessing the content, but platforms can sustain higher prices to consumers. It is another type of vertical restraints which appears in two-sided markets in addition to exclusive contracts. For example, Nintendo designed, produced and sold games itself and made it compatible only with its own console. If an independent software developer opts to sell the game or even entire studio outright, in fact it becomes vertically integrated with the platform.

In networked industries, integration and exclusivity may be efficient in solving the ‘chicken-and-egg’ coordination problem, one of the fundamental barriers to entry discussed in the two-sided market literature: with pessimistic beliefs, buyers expect no sellers to join, and sellers expect no buyers to join, as a result no users join. If a platform has an integrated seller on it, buyers are sure to meet at least this seller on the platform and the problem is solved. Tregouet (2008) shows that even if a monopoly platform can integrate with a seller, it does not help to solve the ‘chicken-and-egg’ problem unless it can commit to the price this vertically integrated division will charge in the second period. Indeed, otherwise this division charges a monopoly price leaving no surplus to buyers. The crucial assumption of the model is the dynamic component, allowing sellers to subscribe to the platform before buyers.

Derdenger (2009) investigates the effect of vertical integration on prices and consumer surplus. He finds it has two opposite effects on the level of competition: demand effect differentiates consoles and forces prices higher; market structural effect drives prices lower. Without vertical integration console prices are discounted by the profit console manufacturers receive from their interactions with developers when an additional consumer purchases a console. With vertical integration a third profit stream is created. Price is further discounted by the profit the console receives from producing and selling its own games.

Derdenger (2009) constructs an empirical model where demand for consoles captures the complementary nature between hardware and software (network effect in the two-sided market terminology) while accounting for software heterogeneity and competition (negative within-side externalities on sellers’ side). Basing on data from video game industry, he concludes that the market structure effect dominates, so that console competition increases thanks to vertical integration.

To conclude, the relation between two-sided characteristic, vertical restraints and foreclosure opens many questions to be investigated.

First, what is the exact mechanism and conditions for exclusivity and integration to help to break into a market and what is the corresponding equilibrium. It is an open question because exclusivity may benefit both incumbent and entrant. For example, producers of new electronic devices include in their product many free applications from its integrated division. Then the entry happens even if third-party developers are already tied with the incumbent.

Second, how platforms' motivation to use vertical constraints changes when there are within-side negative externalities: sellers are competing between themselves and prefer to decrease the number of other sellers on the same platform. This decision has an impact not only on competition between platforms but also on competition between downstream sellers. There can be two opposite effects. With no exclusivity and no integration there can be lack of investments, fewer developers and correspondingly smaller application diversity. On the contrary, if the profit from first-party developers is high, platforms prefer to restrict the number of sellers in order to maintain high application prices and to get high profit from its integrated division. With the number of sellers being limited, there is an imperfect competition between them. Then they can negotiate with platforms not only on price of contract but also on their exclusivity/ non-exclusivity/integration. Such bilateral oligopoly bargaining model is the subject of future work. But it is already far from standard two-sided models where users have no market power.

Finally, strategic variables of platforms may include not only prices, but also quality choice. The platform is likely to propose a higher quality of services if contracts are exclusive because the competition is tougher. A platform may propose a higher quality to more loyal buyers — those who are exclusive to this platform. Then, users who value quality will choose an exclusive contract. If the exclusivity is forbidden it may result in change (decrease) in quality.

Another question is whether there are new efficiency justifications that arise from exclusive contracts or tying arrangements that platforms may use on one side of the market.

Examples

Bardey and Rochet (2009) study the health industry. In this industry the adverse selection occurs because health plans cannot perfectly discriminate between policyholders. Each policyholder has an interest to choose a health plan with the lowest premium, where other policyholders are characterized by lower risks. It can lead to a 'spiral of death' phenomenon, where less restrictive plans attract high risks. Les restrictive plans have a higher premium. Utility of policyholders includes a direct externality: the higher the risk of other policyholders of the same plan, the higher is the premium. According to this one-sided interpretation, more restrictive health plans are more profitable. However, Bardey and Rochet (2009) show that if a two-sided dimension is added, less restrictive plans may become more profitable in spite of high-risk policyholders. Indeed, these policyholders generate more activity for physicians and therefore the insurer may negotiate with physicians a lower fee-for-service rate. Authors explain that the two-sided characteristic changes the perception of vertical integration: on a one-sided market, it can be perceived anticompetitive since restrictive plans are more profitable, while on a TSM it is not necessarily true.

Ordover (2007) gives an example of exclusive dealing on the market of payment systems. Visa and MasterCard issuing banks were restricted to participate in competing credit card networks.[18] The relevant market was defined as general purpose charge market in the U.S., and competition between Visa members was viewed as intrabrand. It is interbrand, not intrabrand competition that is the primary concern of antitrust enforcement. On the one hand, it may have a crucial impact on the market equilibrium because, according to theoretical results, the ability to multihome impacts the extent of competition and its outcome. On the other hand, the ability of the platform to choose its design, in particular such aspects as multi/singlehoming, may be necessary for its success.

1.5.4 Price discrimination

Basing on the analysis of case studies and theoretical literature, we distinguish between three general types of anticompetitive practices on two-sided markets which can be termed 'discrimination':

- *'pure' discrimination,* when platform charges different prices for the same service of access to the platform;
- *discriminatory selection of users,* when platform excludes a part of users based on their observed characteristics or sorts them out using price instruments;
- *second degree discrimination*:
  - package pricing when platform charges different prices for different qualities or quantities of access service:
    * access tiering, when platform charges different prices for different levels of service quality,
    * price-quantity packages,

[18]SCFC ILC, Inc. v. Visa, Inc., 36 F.3d 958 (10th Cir. 1994)

– two-part tariffs, when platform charges both subscription and usage fees in order to discriminate between users.

We analyse possible implications of each of these types of discrimination on the social welfare, prices, and number of users. A part of these effects is studied in the existing literature, the rest still needs to be investigated.

'Pure' discrimination

Under 'pure' discrimination, users at least on one of the sides pay different prices for the same service. It can be either perfect (first degree) discrimination when each user's type is observed, or third degree discrimination when users are divided into separate markets. Users' types need to be observed.

Examples of 'pure' discrimination are:

- advertising networks such as Google that charge differentiated advertising fees on one side and pay differentiated remunerations to websites that supply advertising space,
- websites that charge differentiated advertising fees on one side of the market and differentiated subscription fees to internet-users on the other side.

A platform has two main motivations to introduce price discrimination based on users' characteristics and observable data:

- First, the platform may charge a higher price to those users whose willingness to pay is high, in order to extract from them more surplus. The same motivation holds on a one-sided market. The low willingness to pay may be related either to high price elasticity, or to high level of reservation utility, or to low level of externality the user perceives from the other side. For example, Liu and Serfes (2007) consider the case of different reservation utility in the form of linear differentiation.
- Second, the platform may charge a lower price to those users who generate higher externalities for the other side; this strategy attracts more users on the other side and to extract their surplus. For example, on the Google website bidders with higher advertisement quality pay less because their advertisements are supposed to be useful to consumers. This motivation for discrimination was not studied explicitly to our

knowledge. We study this question in details in Chapter 2.

The two motivations may interact.

Depending on market characteristics, 'pure' discrimination may have both negative and positive impact on the social welfare.

- On the one hand, if discrimination does not lead to an increase in the equilibrium number of users, it is more likely to lead to a decrease in the social welfare.
- On the other hand, discrimination may be advantageous to the society in the following cases:
  - Some low-demand groups of consumers who are not served under homogeneous pricing are served under discrimination and so are better off. This is a standard argument applied also to one-sided markets. But there is an additional effect on a TSM: new low-demand customers attract more users on the other side thanks to externality effect. Hence, if discrimination on one of the sides attracts more users on this side, then, thanks to external effects, it is more beneficial (or less harmful) for the social welfare on a two-sided market than on a standard market. Indeed, Liu and Serfes (2007) show that more agents multihome under discrimination than under no discrimination, which leads to a higher total number of users (given that the number of singlehoming users is fixed). In their model, perfect price discrimination is efficient, while uniform price leads to less output than the first-best.
  - Discrimination may also allow the platform to capture a profit necessary to cover investments in innovation and infrastructure, which has positive effect on social welfare. Two-sided platforms often belong to industries where a high investment is needed for entry.
  - Discrimination on one side may lead to a lower price on the other side. In the context of the Internet, Weisman and Kulick (2010) argue that discrimination increases efficiency because additional surplus extracted on one side will be passed to the other side through lower prices. As a result, more users on the other side will be attracted, which will increase the total number of transactions and hence the total welfare. Our counter-argument is that platforms do not pass the whole additional surplus on to the other side. The effect of discrimination on the other side's price is not well studied yet. This question needs further

investigation.

Not only the impact of discrimination on the total surplus is undefined, but also its effect on this surplus distribution between intermediaries and users is ambiguous. In the case of monopoly, the possibility to discriminate unambiguously gives to intermediaries more instruments of extracting surplus from consumers. In the case of oligopoly, discrimination may strengthen the competition and hence may result in a higher consumer surplus as it was shown on one-sided markets.[19]

At the same time, discrimination may also soften competition. Such effect was shown by Liu and Serfes (2007). They consider a model of perfect discrimination in the case of two linearly differentiated competing platforms. They conclude that when the indirect externality is strong and marginal cost is low, discrimination may soften competition on a two-sided market both under singlehoming and under multihoming on two sides. It happens because in competition platforms have a motivation to charge negative prices. As negative prices are not allowed, equilibrium prices are set to zero and do not depend on network externalities. Prices and profits are constraint from below.

Note that the equilibrium prices and discrimination strategies depend on whether agents on each side singlehome or multihome (see, for example, Liu and Serfes (2007)). One can also imagine a strategy where platform announces two prices: one price to those users who decide to multihome and another price to those who decide to singlehome. In practice, price may depend on whether a contract is exclusive (user restricts himself to singlehoming) or not. Such strategy may be feasible even if users' types are not observed.

<u>Discriminatory selection of users depending on their quality</u>

Another strategy that falls under discriminative behavior is to filter users depending on their characteristics even if their willingness to pay is the same. It may be a profitable strategy in the environment where users on one of the sides (or on both sides) value the average 'quality' of the other side's users. Under these circumstances, the platform will control the 'quality' of users: either directly by prohibiting access for some non-desired types of users, or, if their types are not observed, indirectly by adopting a screening price

[19] As was shown by Thisse and Vives (1988) for uniformly distributed preferences and symmetric prices. Armstrong (2006) gives several examples on how price discrimination may relax competition, but this effect appears only in such particular cases as bundling by a multiproduct firm, price-matching contracts or negative network effects.

strategy. Examples of such practices with observed users' types are numerous:

- mobile operation system managers do not accept certain applications on their application stores;
- as stated by net neutrality proponents, an Internet service provider may exclude content providers based on the latters' content or those content providers that directly compete with the Internet service provider's own services;
- some online advertising intermediaries accept only a limited number of high-quality websites;
- videogame console manufacturers accept only a selected set of game developers;
- online dating services reject a number of applications;
- Ebay will probably introduce a sellers certification system;
- on the dating website Meetic, a higher subscription fee even for women ensures serious intents of the candidates in comparison with other websites.

Hagiu (2009a) model the situation where one of market sides values not only the quantity of the other side's users but also their average quality and platform may observe quality of each user. The conclusion is intuitive: a platform is more likely to engage in low quality users exclusion when the other side places more value on the high quality and low value on quantity. [20]

Second degree price discrimination

Even if a platform does not observe each user's type, it can still adopt a pricing policy of imperfect discrimination. Two-part tariffs, price-quantity and price-quality packages enable platforms to get a higher profit.

One type of second degree price discrimination is **access tiering**, when users pay different prices for different qualities of service.[21], as in the following examples:

- different subscription options on matchmaking websites: 'standard', 'premium', etc.

[20]Our guess is that if platform could price discriminate among users, it should have interest to attract a greater number of users.

[21]Even though Weisman and Kulick (2010) argue that this practice should be called differentiated pricing rather than discrimination, in the theory of industrial organisation and according to Tirole (1994) it is a particular case of discrimination.

- potentially, Internet service providers can grant different connection speed to content providers. It is discussed in more details in the next section.

Where two platforms are present on the market, price structure may be used to sort out users between two platforms even if their types are unobserved.

E. Damiano and H. Li (2008) model a market where prices serve as an instrument to sort out users between two platforms in the environment where users value the average quality of the other side's users and not their quantity. The quality of a platform may be exogenous: it can be measured by the quality of users on it. The separation between low and high quality platforms allows to increase the total efficiency. Authors compare two situations: when both platforms are managed by one monopoly and when they are independent competitors. They find that the duopoly may be less efficient because the sorting role of prices is compromised by the need to survive competition.

Ambrus and Argenziano (2009) find that a monopolist may be motivated to operate two networks. It charges high price on one side and low price on the other side on the first platform and does vice versa on the second platform. Low type consumers choose cheap networks while high type consumers choose expensive networks but they profit from high number of users on the other side. Each platform's quality is determined by the number of users. A similar equilibrium holds if platforms are competing.

Among others, Ambrus and Argenziano (2009) give the following real-life examples that correspond to their findings. Careerbuilder.com and Monster.com are two main platforms in the market for online job search in the US. The former has a lower subscription price for the firms and correspondingly a greater number of job postings but a smaller database of resumes. Another example concerns the industry of videogames where game consoles and PCs are competing. PC is more expensive than a console for players while publishing is virtually free compared to royalties to the console producers. As a result, the choice of games on a PC is larger but there are less players than on a console.

Viecens (2006) study the question of screening between two competing platforms. The quality of a platform for each side is determined by the characteristics of users on the other side of the same platform. Users on both sides are heterogeneous, and prices on one of two sides are always zero. The main objective of the author is to study existence conditions of different equilibrium configurations. The main conclusion is the existence of equilibria with two active platforms. In some of these equilibria the platforms are asymmetric in prices, in types of customers they house and in the quality of service. These results depend on two crucial assumptions:

- buyers are heterogeneous in the value assigned to quality;
- high type sellers care about the type of members on its own side.

There is another example of second degree price discrimination. The packages may differ not only in quality but also in quantity of the platform's product. For example, a professional network website LinkedIn proposes several subscription options, which are different in particular in the number of messages that a user can send (a number of contacts). Similarly, a dating website Lavalife.com, an industry pioneer founded in Canada in 1987, offered a fee schedule based on the number of initial contact messages that a participant wishes to purchase.[22] On a market of images Shutterstock.com fee schedule is based on the number of images a user wants to buy.

Two-part tariffs as an instrument of discrimination among heterogenous users were considered in several articles on TSMs. The tariff includes a fixed access charge plus a per transaction price. For example, Reisinger (2010) investigates the effects of such price instruments on competition between platforms. He concludes that there are two effects. The first one is a traditional effect of stronger competition leading to lower profits. The second one is the countervailing effect of more efficient cost distribution between two sides leading to higher profits. He finds that in the case of competitive bottlenecks if the per-transaction costs are large, the countervailing effect dominates. Utility of an agent of the multihoming side is often the same under two-part tariffs and under pure subscription or per-transaction fees, while the welfare of the single-homing side falls exactly in case platforms' profit increase.

1.6 Coordinated anticompetitive practices

There are two types of coordination practices that could be considered on a two-sided market. First, platforms may coordinate among them. Second, platform itself is sometimes

[22]Ettore Damiano and Hao Li (2007)

viewed by regulatory authorities as a method to coordinate between users on one of the sides.

1.6.1 Coordination between platforms

Two-sided platforms, similarly to one-sided firms, may be involved in anti-competitive practice of coordination with the objective to exercise their market power, extract consumer surplus and exclude competitors. This practice may be more difficult to reveal on a TSM: if a regulator has found an evidence of price fixing on one side, they should check whether there is price fixing on the other one. In some cases, cooperation among platforms may be socially beneficial if it allows to maximize positive network externalities.

Authors observe that it is potentially harder to form a cartel on a two-sided market. Evans and Schmalensee (2005) mention that it requires coordination, agreements and monitoring on both sides. J. Wright (2004) observes that it is often easier to fix prices on one side of the market than on the other: game console price is publicly observable while developer charges are not. That is why the punishment for deviation from agreed price on the developer side is more difficult to implement. Price collusion on the first side may be just a greater competition on the other side, and potentially eliminating the incentives of the platforms to engage in collusion.

1.6.2 Coordination between members of the same platform

The platform itself can be seen as a coordination practice. In this case the platform may be represented by a not-for-profit cooperative or a joint venture that establishes rules and fixes prices for all of its members. Then, it can be considered as collusion among the members. On the other hand, such form of service compilation allows internalizing network externalities and minimizing transaction costs. On a TSM, even price fixing can be welfare-enhancing.

To ensure a more accurate competitive-effects assessment one needs to identify the competitive objective of the suppliers and the consumer demand to which the suppliers are responding.

Rooney and Park (2007) give the example of the music market where songwrighter members of ASCAP and BMI were collectively pricing their blanket licenses. US Supreme Court has examined whether it constituted per se price-fixing by competing songwrighters.[23] However, the Court recognized that the license responded to the demand of radio stations for a bundle of related services and that the collaborating songwrighters could not have provided the same product themselves. Here, associations of songwriters can be viewed as two-sided platforms that deal with songwrighters on the one side and with radio stations on the other.

Evans and Schmalensee (2005) give the example of Nabaco v. Visa, where the payment system Visa was blamed for imposing the same interchange fee from acquirer to issuer banks for all of its members. It was considered as a price set collectively by competitors. Visa replied that centralized setting of interchange fee was necessary for payment system's organization, allowing avoiding transaction costs of bilateral negotiations and limiting members' opportunistic behavior. Here, Visa payment system is a two-sided platform with cardholders on the one side and merchants on the other.

A regulator should also consider what would be the market structure if a two-sided platform did not exist. One of alternatives would be a complete integration of platform into one of the sides, which would create a vertically integrated structure. Another alternative is a direct tacit coordination directly between agents on two sides. For further research, it could be useful to analyse whether platform is a more socially efficient method to solve the externality problem compared to tacit coordination or integration.

Today, discrimination becomes more feasible with the development of Internet technologies: automatic treatment of information allows for individual price setting. For example, price of advertising announcements on the Google search results page are determined through auctions. This mechanism allows discriminating between participants in order to extract a high surplus from each of them.

[23]Broadcast music, Inc. v. Columbia Broadcasting system, Inc., 441 U.S.1, 1979

1.7 Conclusion: specifics of competition policy on two-sided markets

The most discussed particularity of TSM is their pricing principle which accounts for externalities between two sides. Depending on the level of externalities and their unequal repartition between two sides, the social welfare maximization may be achieved by setting asymmetric prices, for example a zero price on one of two sides.

Positive externalities lead to a chicken-and-egg problem for a potential entrant: if the incumbent manages to attract many users on one of the sides, this creates a barrier to entry because a rival fails to gain the critical mass of users necessary for entry. That is why competition authorities should pay special attention both to prospective mergers between two-sided platforms and to their potentially anti-competitive practices.

A regulator should find a balance between maximizing positive externalities and avoiding the extraction of the consumer surplus by the platform.

To estimate the risk of monopolisation, the authority should take into account that the intensity of potential competition increases with the strength of network effects and of scale economics but decreases with the network congestion, platforms differentiation and the number of multihoming customers.

For the purposes of competition law, each side of a theoretical two-sided market is in most cases defined as a separate market since the nature of the services on each side are significantly different. However, the link between sides may be considered in the economic analysis.

When estimating market power, it is useful to calculate market share, Herfindahl-Hirschman Index and profit margin not only on one but on both sides of the market.

Compared to a merger on a standard market, a merger on a two-sided market often generates more efficiency gains thanks to the externality effect but creates a higher risk of monopolisation. If a merger leads to a significant increase in the user base on one side of the market, more users on the other side may be attracted to the postmerger platform, creating or reinforcing a dominant position and possibly leading to foreclosing competing platforms from the market.

Predation analysis on a TSM is complicated by the following two factors. First, a platform's costs cannot be easily dispatched between two sides given a usually significant weight of the fixed costs. Second, efficient price on each side of a two-sided market depends not only on costs of supplying this side but also on the value of externalities. That is why, as mentioned by many authors, the price which is estimated to be lower than the marginal cost does not necessarily implies predation and the price which is estimated to be higher than the marginal cost does not necessarily implies excessive pricing. Presence of externalities makes predation feasible in the presence of incumbency advantages and sequential buyers.

The impact of platforms' practices is ambiguous. On the one hand, tying, exclusive contracts or pricing lower than costs may give the incumbent instruments to exclude the rival. On the other hand, they also may be an instrument of entry or may have as a consequence the raise of social welfare through rebalancing price structure.

When conducting empirical analysis, a statistician needs to account for the externality effects on both sides and hence for the impact of one side's price on the other side's demand. It requirs additional data and potentially leads to a larger estimation bias.

The literature review has revealed that the question of price structure is the question the most widely discussed in the TSM literature. However, further research is necessary in this area. That is why we choose to concentrate our attention on the tariff practices: Section 2 deals with excessive pricing and Section 3 deals with price discrimination.

2 The effects of asymmetric prices on two-sided markets: a case study of online declaration services

2.1 Context

This section studies the question the potential effects of asymmetric pricing on TSM using the example of market of the online tax declaration services destined to two categories of users: chartered accountants and charted management bodies.

The function of chartered accountants is to maintain profit and loss accounts and balance sheets of enterprises. Chartered bodies are organisms that make a fiscal pre-control for small enterprises and allow them to benefit from tax advantage. If a company is subscribed to a chartered body, accountants have to transfer tax declarations to this body before sending it to the tax administration. These declarations can be sent either in the paper format or in electronic format, through an online declaration service.

Online tax portals allow chartered accountants to transmit online tax declarations to a management body using a standardized format. This service is paid both by sending party (accountants) and by receiving party (management bodies).

The French Competition Authority received a complaint from chartered management bodies judging that the new price list adopted by an online declaration portal in 2010 constituted asymmetric pricing, where the accountants' price is subsidised by the management bodies' side, at the expense of management bodies. In this case we study this case from the TSM prospective.

The section includes three parts. In the first part, we show that the nature of services and their economic characteristics motivate the use of the theory of two-sided markets. In the second part, we analyze the portal's pricing based on the TSM literature. In the last part, we propose a simple model in order to compare the effects of the price lists adopted by the portal before 2009 and starting from 2010; we estimate its impact on the users' surplus: profit of chartered accountants and of management bodies.

2.2 Two-sidedness of the online declaration services

The online tax filing activity may be considered as a two-sided according to the following two characteristics:

1. The portal constitutes a two-sided platform. This platform allows to serve two distinct types of users: chartered management bodies on the one side and chartered accountants on the other side. The platform is common to two types of users, each of them representing one side of two-sided activity.

2. Each type of portal users (accountants and management bodies) constitute one side of the activity and are interested in a more intensive use of the platform by the other type of users. This phenomenon is referred to as positive cross group externalities. More precisely, since management bodies achieve cost savings by receiving tax declaration in the digital form, the greater is the number of chartered accountants who use paper-free declaration, the greater are economies for management bodies. Symmetrically, the accountants also benefit from cost economies if management bodies accept to receive their declarations in the paper-free form. Consequently, there exists a mutual interest for a greater number of customers to use a common platform in order to benefit from these gains. These gains have an externality nature since the possibility to benefit from it for a customer depends not only on the action of this customer but also on the actions of other players.

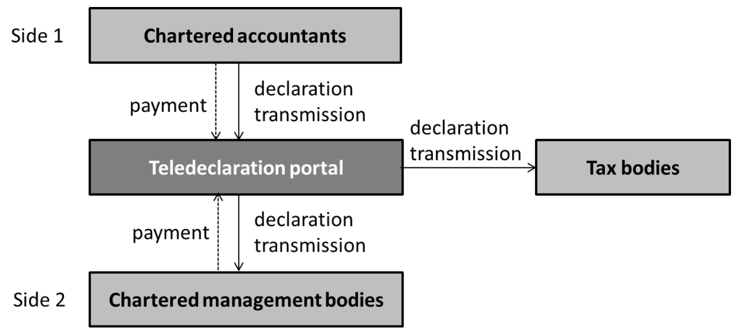

Figure 2.1: Tax declaration flux

2.3 Pricing on the two-sided market of online tax filing services

As was explained in the literature revue, the pricing process on each side of a two-sided market is different from the process observed on one-sided market because of interdependence between two sides that generates a positive externality. Consequently, the level of externalities and their unequal repartition between two sides may be such that the objective of maximization of the social welfare leads to zero or negative price (subsidy) on one of two sides.[1] There are multiple examples of two-sided markets with positive prices on one side and zero prices on the other: newspapers free for readers and paid for advertisers, TV channels free for audience and paid for advertisers, etc.[2] Low or zero prices on one of the sides allows to increase the number of users on this side and increase their surplus. This mechanism is capable of increasing also the surplus of agents on the other side if it allows to generate enough externalities to compensate the price increase. Theoretic reasoning allows to understand why, in the case in question, it is rational to reduce the tariffs on the side of accountants and why it increases the social welfare. According to economic literature, two main factors determine the optimal level of relative access prices to the platform for

[1] "A price ⟨...⟩ can be negative if that side of the market involves a low cost, is competitive, or causes a large external benefit to the other side" Armstrong (2006)

[2] "...the subsidy might be so large that the price is negative (or zero, if negative prices are not feasible). This analysis applies, in a stylized way, to a market with a monopoly yellow pages directory. Such directories typically are distributed for free, and profits are made solely from charges to advertisers. The analysis might also apply to software markets in which one type of software is required to create files in a certain format and another type is required to read such files. Often, the reading software is supplied for free, while the writing software needs to be paid for." Armstrong (2006)

the two sides:

- **Asymmetry in the externality benefit:** the price on one side is lower if this side creates relatively more externalities for the other side[3];
- **Differences in the price sensitivity:** the price on one side is lower if the price sensitivity of agents on this side is relatively higher than on the other side.[4]

These two factors may be either cumulative or on the contrary compensate each other. The market of online tax declaration is characterized as follows:

- Economies made from the dematerialization of a tax declaration are higher for management bodies: between €6 and €10 per online tax filing, against approximately €2 per online tax filing for accountants. A subscription of an additional accountant creates more benefit for management bodies than subscription of an additional management body for accountants.
- Accountants are, on the average, smaller than management bodies and are likely to be more sensible to a price change, consequently their demand presents a higher price elasticity.

We have shown two factors that justify the price differentiation between prices on two sides in the social optimum are indeed observed on the market of online tax filing. They are cumulative and tend to systematically push to allocate platform's costs more on the side of management bodies and to incite accountants by a low price level. Such strategy maximizes the number of users of paper-free tax filing and fairly distribute the gains from positive externalities.

2.4 A simple model

We propose a simple model of the tax declaration market. Let us suppose that the cost economy achieved on average by an accountant per one declaration is equal to €2 and the one achieved on average by a management body — to €6. These average efficiency gains of

[3]"a platform will target one group more aggressively than the other if that group ⟨. . . ⟩ causes larger benefits to the other group than vice versa." Armstrong (2006)

[4]Rochet and Tirole (2006)

two types of users related to online tax filing constitute a measure for positive externality associated to the usage of online tax filing.

A simple model of online tax filing activity allows to illustrate that regarding the real data presented below, a zero price for accountants allows to increase the surplus on both sides. To simplify the presentation, the following hypotheses were made concerning functioning of the activity:

1. Potential users of the service are N accountants and M management bodies;
2. M^* management bodies and N^* accountants are subscribed to the platform, $N \geq N^*$ and $M \geq M^*$;
3. Each accountant should transmit a number S of tax files each year;
4. On average each accountant sends a number S/M of declarations to each management body;
5. Using online tax filing results in an average gross gain per online tax filing evaluated at E_{expert} equal to €2 for accountants, and gross gain for management bodies evaluated at $E_{man.body}$ equal to €6.
6. The gain from online tax filings are not uniform. In fact, some agents are better equiped than others, are more efficient and/or have a greater activity volume, which allows them to better benefit from the digital form than others (amortisation of equipment and education costs, etc.) [5] The average gain per online tax filing for an accountant is between €0 and €4 and the average gain for a management body is between €2 and €10.

The gain achieved on average by an accountant from using the online tax filing is equal to the gain per online tax filing multiplied by the number of declarations they send to management bodies subscribed to the same platform:

$$S_{expert} = E_{expert}\, S\, \frac{M^*}{M}.$$

[5] We will suppose to simplify the demonstration that the declarations volume does not impact unit cost.

Similarly, economy achieved by a management body subscribed to the platform is equal to

$$S_{man.body} = E_{man.body}\, S\, \frac{N^*}{M}.$$

The surplus (or net gain) of a user is defined as the difference between the gain achieved by the user of online tax filing minus the price paid to the platform for the declaration transmission. The total surplus of a user from using the platform is consequently equal to the surplus per online tax filing multiplied by the number of online tax filings made on the platform.

The portal has changed its price list in 2010. It is possible to evaluate the effect of changing the pricing made in 2010 by the portal on the gains and surpluses of the two market sides, accountants and management bodies.

1. Price list in 2009: both accountants and management bodies are charged €2.5 per tax declaration.
2. Price list in 2010: accountants are not charged any more for using the platform, management bodies are charged €5 per online tax filing.

Calculation of the gain or total surplus of accountants and of management bodies for each of price lists may be described in the following manner:

Price list of 2009

Since the price of one online tax declaration is €2.5, accountants and management bodies who economize more than €2.5 per declaration subscribe to the service. We need to determine the number of management bodies and accountants who satisfy this condition: as explained above in the hypothesis 6, for the price of €2.5 certain users will obtain the gain inferior to this price and will not subscribe to this platform. We obtain that $N^*/N = 38\%$ of accountants are subscribed and $M^*/M = 94\%$ of management bodies are subscribed to the platform in 2009 prices (see the figure below). Each accountant derives a gross gain from using online tax filings ranging between €0 and €4 per declaration. The proportion of accountants who subscribe to the service is therefore decreasing as a function of price of service. The scheme below presents a demand function as a proportion of subscribed accountants to their total number: if the price is equal to €2.5, 38% of accountants subscribe.

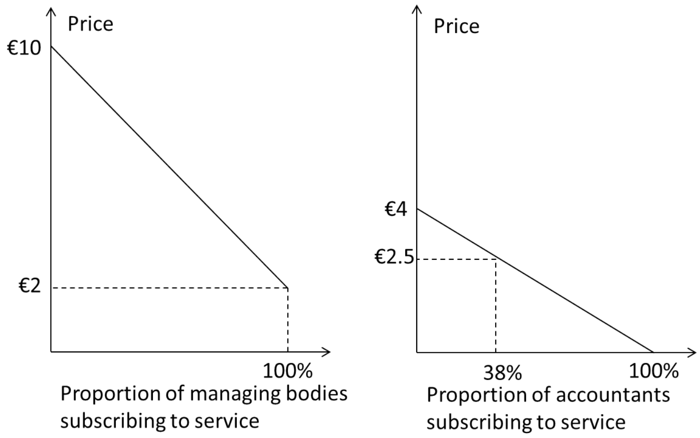

Figure 2.2: Demand function on the accountants side

The asymmetry of achieved gains indicates that:

1. Externality created by an accountant on the side of management bodies is more important than the externality created by a management body on the side of accountants;

2. Accountants are more sensible to the price level of online tax filing service than management bodies. Indeed, in the rational calculation, if the cost of an online declaration is higher than €2 for an average accountant, they have no interest to adopt this procedure, while a rational management body will have an interest to use the procedure of online tax filing if its unit cost stays on average lower than €6.

It is therefore apparent from these simple factual data that the principle of asymmetric price treatment of two sides may generate gains for each of them and so for the whole economy. Accountants should be priced at a level inferior to that of management bodies so that each of two sides may best take advantage from externalities.

Absolute value of elasticity writes $\frac{p}{4-p}$ for accountants and $\frac{p}{10-p}$ for management bodies.

For the same value of prices, accountants' absolute value of elasticity is higher, which indicates that they are more sensible to a price increase.

The gain per declaration made by an average accountant is €3.25 (average between €2.5 and €4), and the surplus of an average accountant subscribed (gain minus service cost) is

$$(€3.25 - €2.5) \cdot S \cdot 0.94 = 0.71S.$$

The total surplus of all the accountants is obtained by multiplying the average surplus ($0.71S$) by the quantity of subscribed accountants:

$$0.38N \cdot 0.71S = 0.27NS.$$

Reasoning in the same manner, the average surplus of management bodies, economy minus service price, is $1.43SN/M$. In total, the surplus of all the management bodies is $1.34NS$. This pricing policy does not maximize the social welfare.

Price list of 2010

All the accountants subscribe since they do not have to pay and always obtain a positive gain from online tax filing. Only those management bodies subscribe whose gain per one online tax filing is higher than €5, which constitute 63% of all management bodies. The average surplus of accountants, gain minus service price, is $1.26S$. In total, the surplus of all the accountants is $1.26NS$. The average surplus of management bodies, economy minus service price, is $2.5SN/M$. In total, the surplus of all the management bodies is $1.58NS$.

Comparing pricing in 2009 and 2010

The total surplus of accountants rised from $0.27NS$ to $1.26NS$, or by 367%, thanks to price decrease. The total surplus of management bodies rised from $1.34NS$ to $1.57NS$, or by 18%, thanks to the increase in the number of accountants.

2.5 Conclusion: asymmetric prices on two-sided markets

We have studied the pricing system of an online tax declaration service. Using the TSM concept, we have explained that a relatively higher price level on the management bodies side of the market is not necessarily a sign of an anti-competitive strategy but may be simply a result of maximizing the positive external effects. We have constructed a simple model to illustrate this point, which allows to estimate consumer surplus of different groups of users. The model shows that adoption of an asymmetric price structure in 2010 by the online tax filing portal was able not only to significantly increase accountants' surplusbut also to increase by 18% the total surplus on the side of management bodies in spite of a higher price. In total, the new price list of 2010 has led to an increase in the surplus of all the users compared to the price list of 2009. This result is explained by the new price list that better internalizes the positive externalities.

3 Price discrimination on two-sided markets

3.1 Case studies

When users on one of the sides of a TSM are heterogenous, different discrimination strategies may be available to platforms: setting different prices for the same service basing on users' observable characteristics, excluding users with particular characteristics from the platform, setting different prices for different quality or service levels.[1]

Below we provide several real life examples of discrimination on two-sided markets related to electronic communications industry: different online and electronic network services are often characterised by asymmetric externalities.

[1]From an anticompetitive authority's point of view, different prices between two sides may also be considered as discrimination. In fact, price charged to one side is generally not the same as price charged to the other side even if costs are the same. For example, marginal costs born by a dating website are the same whether a man or a woman joins, but the prices are generally low or even zero for women and high for men. Such differentiated price is in most cases not only profitable for a platform but also beneficial to social welfare: as utility functions on different sides are generally different, the uniform price is not optimal. Indeed, Rochet and Tirole (2003) conclude: "The price structure does not correspond to a fair cost allocation. Rather, like private business models, it aims at getting both sides on board." This question is discussed in the previous section.

3.1.1 Internet industry and the question of neutrality

The market of Internet service provision consists of final consumers who are served by downstream ISPs (Internet service providers), who in their turn interact with upstream ISPs. Content editors pay to the upstream ISPs to get access to the network. This ecosystem may be viewed as a TSM. Indeed, ISPs form a platform that ensures interactions between two sides of the market: content providers and final users. There exists a positive externality between two sides: users value content diversity while content providers obtain a greater financial gain from a greater number of Internet users.

The debate on net neutrality concerns the pricing policy with respect to content providers. Today, content providers (CP) pay only to upstream ISPs in order to put content online and this price depends neither on content characteristics nor on content providers' identity. Such absence of discrimination is called net neutrality. However, certain ISPs propose to abandon these pricing principles in order to be able to charge CPs a higher and differentiated price.

Let us discuss the main arguments given by proponents and opponents of net neutrality.

The first argument concerns fair distribution of charges between final consumers and content providers. Net neutrality opponents argue that since content providers get the benefit from access to the network, they should pay for it. However, it should be mentioned that content providers do not pay to downstream Internet service providers but they pay to upstream providers to access the network. Additionally, they provide content that makes the services of Internet providers valuable and for which Internet service providers do not pay. If content providers had to pay for access to final ISPs, there would be a risk that ISPs sign exclusive contracts with content providers, and certain content becomes of limited access.

The second argument concerns funding investment in the next generation network. Opponents of net neutrality argue that such network with better quality and higher capacity is necessary for content providers and hence they should participate in the investment by paying to ISPs. At the same time, it is difficult to check that these payments will be indeed used to construct the new network.

The third issue concerns the problem of congestion. As demand for traffic increases, the risk of congestion arises, which is especially serious in mobile network. If content providers had to pay more for access, the traffic would be reduced. Another solution would be to introduce quality tiering, where the standard access is for free, but the high-speed access is paid. If such quality discrimination is introduced, it should be checked that the standard service is still of reasonable quality.

Potentially, Internet service providers can grant different connection speed to content providers. This practice is forbidden in a project for rulemaking by FCC: "...a broadband Internet access service provider may not charge a content, application, or service provider for enhanced or prioritized access to the subscribers of the broadband Internet access service provider".[2]

Weisman and Kulick (2010) argue that in the long term access tiering implies development of improved network. In the short term, since access tiering is mutually beneficial to both platform and content providers (otherwise they would not have agreed to pay more for a better service), it should be beneficial to the total welfare. In their opinion, the exclusion of those content providers who are not ready to pay for a better quality is a result of a normal competition process. They conclude that the introduction of net neutrality regulation may have a negative effect by protecting less efficient content providers. In fact, in this reasoning Weisman and Kulick (2010) fail to account for externalities which is an integral part of all TSMs; this market imperfection can lead to inefficiencies that contradict their reasoning. Content providers when making subscription decision do not completely account for the impact of their decision on consumers, because the platform does not pass all the externality perceived by consumers to the content providers' side in the form of lower prices. Furthermore, the platform itself does not fully account for the externality, as would have accounted a social planner.

Even though it was recognised that the TSM concept is a proper instrument to analyse net neutrality[3], only a few works have applied a two-sided model to analyse it. Economides and Tag (2007) find that in monopoly, for reasonable parameter ranges, net neutrality regulation increases the total surplus. In duopoly with multi-homing CPs, net neutrality

[2]FCC "Notice of Proposed Rulemaking. In the Matter of Preserving the Open Internet Broadband Industry Practices" October 22, 2009

[3]European Commission states: "Some concerns over net neutrality arise from the nature of the Internet as a two-sided (or multi-sided) market." European Commission "Questionnaire for the Public Consultation on the Open Internet and Net Neutrality in Europe" 30 June 2010

always increases the total surplus. Musacchio and Kim (2009) find that net neutrality regulation is not needed in the transition to the next generation access because a monopolist chooses himself to pass to the new efficient network. Curien and Maxwell (2011) discuss asymmetric pricing between content providers and consumers by applying TSM theory.

Still, one should be cautious when applying the standard TSM assumptions to net neutrality. In a traditional two-sided model Internet-users would have access to the content only of those CPs who are subscribed to the same platform. Obviously, it does not correspond to the real life, where Internet-users have access to all the Internet content irrespective of ISP they are subscribed to. There are several ways to solve this modelling problem. The first one is to suppose that all the CPs multihome in order to gain access to all users. This approach was adopted in Economides and Tag (2007). Nevertheless, the question arises whether it is appropriate to model the Internet network as the competition between two platforms. In real life, CPs usually do not have a choice between subscribing to only one or all platforms, their choice does not impact the number of Internet-users they can reach, and they generally do not pay access charges to two platforms but only to one, which ensures connection with the rest of the Internet network. Musacchio and Kim (2009) use access assumptions that are less standard for a TSM modelling. They study competition between current generation and next generation networks. They suppose that users of the next generation network have access to the contents of the current generation network but not vice versa. In the analysis we conduct in the chapter 3, which is applicable, in particular, to the issue of net neutrality, we suppose that the ISP is a monopolist, so that CPs do not make choice among different suppliers, but only whether to join the whole network or not. This assumption makes CPs automatically access all the users and pay to only one ISP.

Curien and Maxwell (2011) explain that from the TSM prospective a higher price for final users than for content providers may be explained by asymmetric externalities. More exactly, such pricing is efficient under two conditions:

1. If a final Internet service provider decides to charge content providers, the decrease in the content offer will be more significant than the increase in the number of users thanks to price decrease on their side, in other words, price elasticity on the content providers' side is higher.

2. A decrease in the content volume would decrease the utility obtained by surfers to a

greater extent than an equivalent decrease in the number of surfers would decrease gains obtained by content providers, in other words, externalities obtained by final users are higher.

Concerning the first condition, authors conclude that it is difficult to know whether this condition holds. As for the second condition, authors find that it is easier to justify thanks to the three following effects. According to the long tail effect, a multiplicity of niche contents of a moderate value if considered separately constitute a 'long tail' of the global information with a high value for an Internet user. A non-neutral treatment of content providers would lead to the exclusion of the smallest of them and consequently to a damage to Internet users through the negative impact on the 'long tail'. According to the effect of selection, small CPs that may disappear if net neutrality obligation is suppressed seem to be unimportant to consumers, however, they may in future develop in market leaders as a result of competitive selection. Additionally, net neutrality allows to keep low entry costs for CPs. Net neutrality may be seen as a support to creation and provision of online content, which often may be characterized as a public good. Moreover, net neutrality allows to avoid Internet fragmentation, where certain contents are unavailable only on networks of certain ISPs.

Another question is which modelling interpretation to give to the net neutrality obligation. In both mentioned articles, net neutrality is modeled not as the absence of discrimination, but as the total prohibition to charge CPs. This hypothesis is too strong and does not completely correspond to policy makers' interpretation: net neutrality proponents generally propose not to forbid positive charges on the CPs side, but to forbid differentiated price. Our net neutrality interpretation in the chapter 3 is different: we suppose that neutrality forbids price discrimination among CPs but still allows for positive prices on both sides. This assumption seems to be closer to policy makers' interpretation.

Not only assumptions and interpretation are different but also conclusions. There is no consensus neither among industry planners nor among industrial organisation theorists on how the platform will behave: either it will charge a lower price to more successful CPs such as Google because they attract more customers, or it will charge a higher price to more successful CPs because they get more profit.

According to Faratin and Wilkening+ (2006),

> "...the majority of ISPs charge positive prices for both content requestors and servers ... However, ... there is considerable heterogeneity in pricing in the Internet where ISPs also charge considerably less (even below cost) to content providers whose content is much in demand."

An alternative opinion exists:

> "Verizon senior vice president and general counsel John Thorne has described service providers such as Google as "enjoying a free lunch that should, by any rational account, be the lunch of the facilities providers." [4]

The first scenario enables attracting more successful CPs, which potentially increases the total value of externalities and social welfare. At the same time, such policy risks to exclude less successful CPs who will suffer from higher price. Their exclusion will decrease externalities. Moreover, it also risks to exclude start-ups that could develop in successful CPs in future. The second scenario leaves to small CPs more space for development but there is a risk of scaring away successful CPs. Also, the welfare implications will depend on the strategic effect that the price paid by CPs has on the price paid to the platform by consumers, as well as on the price paid by consumers to CPs in case it takes place. When assessing welfare implications, it is also necessary to answer the question whether it is socially beneficial to limit the number of low type CPs because they are less efficient.

The impact of net neutrality is even less straightforward if we introduce quality: more successful CPs will prefer paying more for a higher quality speed level. Higher quality for successful CPs may compensate for higher price. Note that willingness to pay for a higher speed depends not only on profitability of CPs, but also on the importance of high speed for particular on-line services.

The quality discrimination may negatively impact small CPs who pay less and get a lower level of service. A standard result on a one-sided market is inefficiently low quality proposed to the low type in order to avoid high type switching to low package.

Moreover, Internet users may abandon websites with too low speed, which will block the opportunities of development for the new services.

[4] Arshad Mohammed, 'Verizon Executive Calls For End to Google's 'Free Lunch" Washington Post (7 February 2006).

3.1.2 Software markets

Hardware platforms need to attract software developers on one side and users on the other side. This business model is used on mobile application stores, computers, video-game consoles, etc.

The most well known example is Apple that plays the role of intermediary between owners of iPhones and application developers who can sell applications through AppStore. The indirect externalities are positive: application developers choose iPhone in particular thanks to its great number of users; similarly, one of the reasons for users to buy iPhone is a great number of applications available. On the one side, users pay for the iPhone device, on the other side, developers pay for iPhone development kit and a proportion of revenues obtained from selling applications.

Each iPhone application is checked by Apple in order to choose only those without technical problems, without inappropriate content, not violating copyright, and not competing with Apple's own applications. Apple is able to do it because characteristics of future applications can be observed. The aim of such selection is to choose only applications of good quality so that their higher average quality create a higher value of positive externalities obtained by consumers.

Other similar platforms are Google's Android, Blackberry's AppWorld, Nokia's OVI Store, Palm's App Catalog and Windows 7 Phone Marketplace.

The economic models adopted by application providers differ. One economic model consists in giving up applications and getting revenue from incorporated advertisements. Other developers do not expect to gain profit from their applications: these applications are intended for popularizing and improving the principal non-mobile service. For example, banks make applications allowing users to consult the account balance, etc.

A particular characteristic of such markets is that applications need to be created or ported to the specific device, so there are bariers of migrating from one platform to another.

3.1.3 Advertisement markets

Many websites are financed by advertising, being an example of a TSM with advertisers on one side and potential consumers on the other side. Advertisers need to communicate with the greatest possible number of potential consumers and so the externality they receive is positive. Consumers receive either positive or negative externality depending on their perception of ads and whether it is useful or not (see, for example, Evans and Noel (2008)).

Even though the fixed cost of production of such services as search engine and email may be high, consumers do not pay for them, because the advertisers cover those costs. A well-known example of such economic model is Google. Such subsidy is profitable thanks to asymmetric externality: consumers are attracted by free services and, in its turn, the great number of consumers attracts advertisers.

In order to minimise unuseful adds, websites sorts out consumers and ads according to their geographical location and language. So, this practice creates multiple sub-platforms.

The price setting is discriminative: advertisers do not pay the same price even though costs incurred by Google per ad are equal. For the advertisements shown on the page of search results, their prices are determined on auctions. It allows discriminating among advertisers because everybody reveals price they are ready to pay. The one who bids more gets the first place in the advertcisement list, the next one gets second place, etc. More exactly, to determine the winner, not only the bid but also the relevance and the quality of the ad is taken into account. An advertiser with better quality pays less for the same position — the ad quality is determined by click-through rates, relevance, accounting history of advertiser, etc.

Users on both sides usually subscribe to services of multiple intermediaries simultaneously (they 'multihome'). In fact, advertisers buy advertising space on multiple websites and Internet users look through multiple pages. Potentially, it allows for discrimination among advertisers depending on whether they use a service exclusively or not.

But in practice, it is rare that advertisers and small websites interact directly. Often they use services of a matching intermediary. It allows for another interpretation of advertising market two-sidedness. Such interpretation was recognised by European Commission in its analysis of the case Google/DoubleClick(§304).[5]

Google is the biggest player on the market of such intermediation. For the banners on different websites, for each group of ads, an auction is organised based on cost per click or per thousand impressions allowing for discrimination.[6]

The details of Google's pricing policy are not publicly available. For example, publishers are not informed of the price their space was sold for and advertisers do not know which part of the price they paid goes to Google. In the case where prices on two sides are not observed, intermediaries have a possibility to discriminate between its users depending on their size, geographical zone, etc.

Heterogeneity of users may incite platforms to select users with particular characteristics. One of parameters of differentiation between advertisement networks is the quality of advertisers and websites participating in the network. Smaller networks may propose to their clients access to approved websites because they are able to thoroughly check the content policy on each website. This market niche is not accessible to big networks.

Another parameter of differentiation between advertisement platforms is geographical location: with many products being destined to a particular country or geographical area, companies are interested in reaching potential buyers only in these areas. Finally, users are heterogeneous in their size: networks may specialize on bigger or smaller clients. For example, before the merger between Google and DoubleClick, the former specialized on smaller websites while the latter specialized on greater websites. DoubleClick had a market share of 30% on average sites (0.1 to 1 million visits per month) and of 48% on big sites (more than 1 million visits per month). Google had respectively 41.5% and 15.85%.[7]

In conclusion, prices are often not uniform on advertising market, and each user's characteristics play a role in the determining of price or the right to publish.

[5] European Commission 'Merger Procedure Google/DoubleClick : Case COMP/M.4731', 2008

[6] The cost per thousand impressions corresponds to the cost an advertiser is ready to pay every time the banner is shown on one of Google's partner websites.

[7] http://attributor.com/blog/get-your-fair-share-of-the-ad-network-pie/

3.1.4 Online markets

There exist multiple services that fall into this category: on-line markets destined for various goods such as Ebay, online music markets such as iTunes Store by Apple or Zune market by Microsoft, intermediary websites between photographers and buyers of pictures such as Shutterstock, etc. Pricing systems on these markets are very different and complicated, include both access fee and a percentage of sales revenue.

On Ebay, the insertion fee depends on the category of product to sell and is equal to zero if less than 50 items per month are listed. For auctions, it depends on the reservation price:

Insertion fees for auction-style format listings

Auction-style format listings		
Starting or reserve price	**Insertion fee**	
$0.01–$0.99	**Free for 50 listings per month**	**$0.10**
$1.00–$9.99		**$0.25**
$10.00–$24.99		**$0.50**
$25.00–$49.99		**$0.75**
$50.00–$199.99		**$1.00**
$200.00 or more		**$2.00**

Figure 3.1: Ebay insertion fees

Source: ebay.com

Additionally, a transaction fee is charged in the case of successful deal, as shown on Fig. 3.2.

Auction-style format listings	
Total cost to buyer (less any sales tax)	**Final value fee** (Based on the total amount of the sale, including the cost of the item, shipping, and any other fees a seller may charge, excluding any sales tax)
Item not sold	No fee
\$0.01–\$50.00	9.0% of the item's total cost to buyer with a maximum charge of \$100.00.
\$50.01–\$1,000.00	
\$1,000.01 or more	

Figure 3.2: Ebay transaction fees

Source: ebay.com

On Shutterstock, buyers pay a subscription fee depending on the number of pictures they want to download.

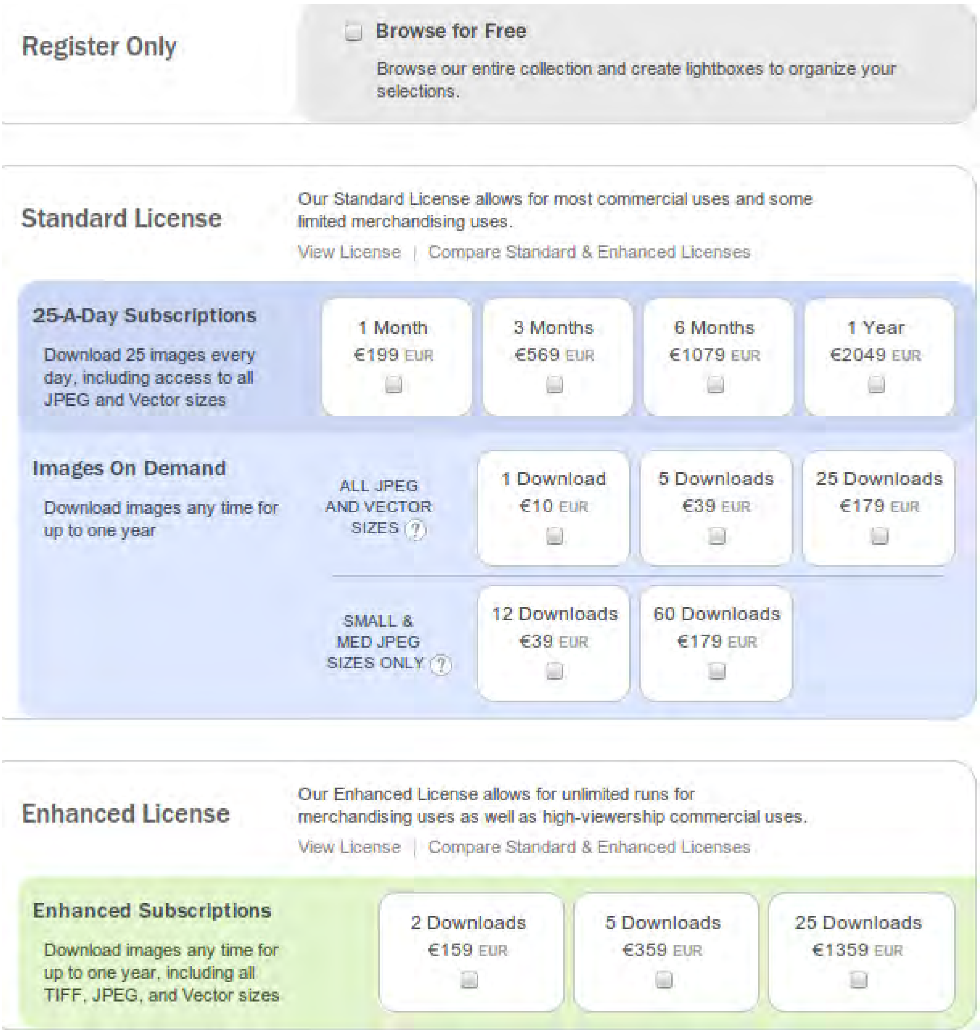

Figure 3.3: Shutterstock fees

Source: shutterstock.com

3.1.5 Internet social networks

The professional networks such as LinkedIn and Viadeo connect potential employers on one side with potential employees on the other side. On the one side, professionals can create their free accounts, on the other side, companies may create their free companies pages. At the same time, there exist paid accounts that allow for more functionality, advertisement and additional services.

Features	Business Annual: $19.95/month* Monthly: $24.95/month Upgrade	Recommended Business Plus Annual: $39.95/month* Monthly: $49.95/month Upgrade	Executive Annual: $74.95/month* Monthly: $99.95/month Upgrade
Contact anyone directly with InMail – Response Guaranteed!	3 ($30 value)	10 ($100 value)	25 ($250 value)
See more profiles when you search	300	500	700
Zero in on profiles with Premium Search Filters	Premium Filters	Premium Filters	Premium + Talent Filters
See expanded profiles of everyone on LinkedIn	Yes	Yes	Yes
Who's Viewed My Profile: Get the full list	Yes	Yes	Yes
Save important profiles and notes using Profile Organizer	5 folders	25 folders	50 folders
Automate your search with Saved Search Alerts	5 per week	7 per week	10 per day
Get introduced to the companies you're targeting	15 outstanding	25 outstanding	35 outstanding
See names of your 3rd degree and Group connections	First Name	First Name	Full Name Visibility
Get the real story on anyone with Reference Search	Yes	Yes	Yes
Let anyone message you for free with OpenLink	Yes	Yes	Yes
Get Priority Customer Service	Yes	Yes	Yes

Figure 3.4: LinkedIn fees

Source: linkedin.com

The free account allows to attract the greatest number of users on both sides in order to increase network externalities. The paid account allows to gain profit. A similar principal was used by French government to set fixed phone tariffs before 1990s: low subscription price attracted more users while high interaction price created profits.

3.2 A model of perfect discrimination: general assumptions

We model price discrimination on a TSM, when platforms discriminate between different types of users on one side; this pricing behavior is practiced by two-sided platforms on the markets related to electronic communications, as discribed above.

Several articles study different types of discrimination on TSM as described more in details in the first section. However, different questions remain open, in particular on how the impact of discrimination depends on the different market characteristics: degree of competition, market maturity, sign of externality, possibility to give users free bonuses, and presence of fixed costs. We study these factors and their interaction.

We propose a model of TSM where platforms practice discrimination of the first degree, or perfect discrimination. Intermediaries observe the type of each user which allows them to propose individual prices depending on users' preferences. We consider the case both of monopoly and of duopoly. We analyse the implications of authorisation or prohibition of such pricing by the regulator in terms of the market structures, the total social welfare, platforms' profits and users' surplus. We look for criteria which would allow to judge whether discrimination is likely to be beneficial or harmful for society in each particular case.

We study how the behavior of a platform changes if a threat of entry arises. We also compare pricing strategy depending on the degree of maturity of the market and on the platform's competitive position. We check which standard effects of discrimination on one-sided markets apply on TSMs and which effects are specific to TSMs.

Suppose that on the market there are two types of users who need an intermediary to interact: we will refer to them as to 'buyers' B and 'sellers' S.[8] For example, they may be game developers and players, or software developers and computer users. The number of users on each side is infinite and normalized to 1.

We will consider two market configurations: either with only one platform on the market (Platform 1), or with two platforms (Platform 1 and Platform 2).

Both platforms bear costs $c^S \geq 0$ on each seller subscribed and costs $c^B \geq 0$ on each buyer subscribed. We denote total costs $c^S + c^B = c$. In some of the following sections we will suppose that these costs are zero, in order to concentrate our attention solely on externality effects.

Suppose that S-users are not homogenenous in their characteristics and may be divided into two groups: 'high' type Sh and 'low' type Sl. These two groups are different in their performance, which may be reflected in the benefit they obtain from interactions and in the externality value they create for the other side. The proportion of Sh-users in the sellers'

[8] In practice, the two sides of users may correspond to any two different categories of users, not only buyers and sellers. In particular, in the net neutrality context, sellers correspond to content providers and buyers correspond to internet-users. In the context of the online advertisement, sellers correspond to advertisement and buyers correspond to internet-users or websites.

population is equal to $0 \leq \alpha \leq 1$. Sellers' utility from subscribing to a platform $i = 1, 2$ depends on their type and on the number of potential buyers on the same platform:

$$U^{Sh}(n_i^B) = a^{Sh} n_i^B, \text{ and}$$

$$U^{Sl}(n_i^B) = a^{Sl} n_i^B,$$

where $0 \leq n_i^B \leq 1$ is the number of buyers on Platform i, while a^{Sh} and a^{Sl} reflect the externalities received by sellers.

Buyers' utility function is a linear function of the number of each type of sellers:

$$U^B(n_i^{Sh}, n_i^{Sl}) = a_h^B n_i^{Sh} + a_l^B n_i^{Sl},$$

where $0 \leq n_i^{Sh} \leq \alpha$ and $0 \leq n_i^{Sh} \leq 1 - \alpha$ is the number of each type of sellers on Platform i and parameters a_h^B, a_l^B reflect the externality received by buyers. We also denote $a^B = \alpha a_h^B + (1 - \alpha) a_l^B$, reflecting the average externality received by buyers in the case where all the sellers are subscribed to the same platform.

Buyers' utility can also be rewritten as

$$U^B(n_i^{Sh}, n_i^{Sl}) = (n_i^{Sh} + n_i^{Sl}) \left(a_h^B \frac{n_i^{Sh}}{n_i^{Sh} + n_i^{Sl}} + a_l^B \frac{n_i^{Sl}}{n_i^{Sh} + n_i^{Sl}} \right),$$

where the first factor reflects the buyers' preference for sellers' quantity, while the second factor reflects the buyers' preference for the sellers' quality, that depends on the proportions of sellers types.

We will consider several cases:

1. Sh-users bring more utility to the buyers than Sl-users: $a_h^B > a_l^B$ and $a^{Sh} = a^{Sl}$. Popular Internet resources such as Google's services or Facebook bring more utility to an average Internet user than other less popular resources.

2. Sh-users create the same externality as Sl-users but obtain a higher externality than Sl-users: $a^{Sh} > a^{Sl}$ and $a_h^B = a_l^B$. It means that Sh-users are ready to pay more to be connected to a platform. Popular Internet resources are more visited, that is why their profits, mainly generated by advertisement, are higher.

3. Sh-users both create a higher externality and obtain a higher externality than Sl-users: $a^{Sh} > a^{Sl}$ and $a_h^B > a_l^B$. It can be interpreted as a higher transaction surplus between a buyer and a high type seller; this surplus is divided between them. Indeed, seller's margin from a high quality good is higher and consumer's satisfaction is higher as well.

We suppose that intermediation is efficient and the costs are covered by the total surplus that can be obtained on the market:

$$c < \alpha a^{Sh} + (1-\alpha)a^{Sl} + \alpha a_h^B + (1-\alpha)a_l^B.$$

Platform(s) charge subscription fees p^{Sh}, p^{Sl}, and p^B that are not restricted to be non-negative. A negative price means that not only subscription is free, but also users get a compensation in the form of bonuses, free services such as email, pictures hosting, etc.

A common problem in TSMs modelling is the possibility of multiple equilibria. This problem arises in our model as well. Each equilibrium depends on the expectation of users on one side of what is the number of users on the other side. It means that, given prices on both sides, there may be multiple equilibrium number of users, each of them satisfying users' preferences and allowing for common and fulfilled equilibrium expectations. For example, if users on each side expect that no other side's users will join the platform, there will be very few or even no users joining in equilibrium under the condition that no free bonuses are given to subscribers. This equilibrium is similar to the prisoners' dilemma: even if it is profitable for all users to join the platform, they do not join because of the risk to find themselves alone on the platform.

Some authors consider and characterise all the equilibria (Caillaud and Jullien (2003)). However, using additional criteria to select equilibria allows to significantly simplify analysis and to choose only those equilibria that seem to be the most reasonable. The examples of criteria below allow to choose only one equilibrium for each price set or to narrow their number:

- to consider only stable set of equilibria, a strengthening of trembling hand perfection (E. Damiano and H. Li (2008));
- to assume that users minimize the scope for coordination failures, meaning that users

'choose' the equilibrium with the highest consumer surplus (Doganoglu and J. Wright (2010));

Definition 1. Users are optimal coordinators if among Nash equilibria they choose the equilibrium which gives them the maximum utility for given prices.

- to allow users coordinating their actions whenever it is in their joint interest and does not require communication (Ambrus and Argenziano (2009)). Formally, under such coalitional rationalizability, groups of players consider self-enforcing implicit agreements to restrict their play to a certain subset of the strategy space. Such restriction should be supported by all the possible coalitions;
- to suppose that users' expectations are stubborn:
  - bad expectation of users against one of the platforms (Caillaud and Jullien (2003)),

    Definition 2. Users' expectations are against a platform if among Nash equilibria they choose the equilibrium that gives it the lowest profit for given prices.
  - good expectation of users in favour of one of the platforms;

    Definition 3. Users' expectations are in favour of a platform if among Nash equilibria they choose the equilibrium that gives it the highest profit for given prices.

Let us consider a simple example. If there is only one platform on the market, users have the choice between joining it and not joining any platform. Suppose that users from the same side always make the same decision. Below is the table of gains:

buyers \ sellers	join	not to join
join	$a^B - p^B$ $a^S - p^S$	$-p^B$ 0
not to join	0 $-p^S$	0 0

Table 3.1: Affiliation game between buyers and sellers

There are two potential Nash equilibria in this game. In the first one, no users join. In the second one, all users join; prices must be such that both sides get a positive gain:

$$a^B - p^B \geq 0$$
$$a^S - p^S \geq 0.$$

These constraints are known as *participation constraints*.

Configurations where only one side joins are not equilibria: in fact, corresponding prices should be non-negative in order to allow for non-negative profit. Consequently, a user who joins and pays would better choose not to join.

The described above criteria may help to choose among multiple equilibria. For example, the optimal coordination criterion makes users choosing the affiliation equilibrium because it gives to both types of users a higher surplus. In this case, the criterion allows for choosing only one equilibrium. At the same time, such criterion does not always lead to a unique equilibrium: one can imagine a situation where one side prefers one equilibrium, while the other side prefers another equilibrium. If users' preferences are such that they choose the equilibrium which gives the maximal profit to the platform, they will coordinate on the affiliation equilibrium as well. If, on the contrary, they choose the equilibrium which gives the minimal profit to the platform, they will coordinate on the non-affiliation equilibrium. The number of such equilibria depends on the number of configurations that give minimal/maximal profit value.

Below we first study the case of the market monopolised by one platform and then competition between two platforms. The monopoly section considers three options of different users' expectations: optimal coordination, newly created market, well established market. Several model extensions are considered: negative externalities, fixed costs incurred by the platform and a possibility for sellers to improve their quality. In the duopoly section, two options of users' expectations are considered: optimal coordination and competition between the incumbent and the entrant. An extension is proposed where buyers become differentiated.

3.3 A monopoly model

Let us suppose that the whole market is served by only one platform. Indeed, in practice because of network effects, a two-sided platform's position is often close to monopoly, as in the case of Google in textual advertisement or Facebook in online social network services.

If all potential users are subscribing to this platform, utilities obtained by each group are:

$$U_i^{Sh}(1) = a^{Sh},$$

$$U_i^{Sl}(1) = a^{Sl},$$

$$U_i^B(\alpha, 1-\alpha) = a_h^B \alpha + a_l^B (1-\alpha).$$

If all the externalities are positive, this configuration is socially optimal since the externality is maximized. At the same time, distribution of the social surplus between the platform and the users may be not in favor of consumers.

3.3.1 Users' optimal coordination

Let us suppose that users are optimal coordinators: a group of users can always coordinate on an equilibrium that is Pareto superior for them.

Discrimination

When all the externalities are positive, it is optimal for the platform to attract all the users. If each user's type is observed, the platform can extract the whole surplus from every type of users. Monopolist prices are equal to respective utilities:

$$p^{Sh} = a^{Sh},$$

$$p^{Sl} = a^{Sl},$$

$$p^B = a_h^B \alpha + a_l^B (1-\alpha).$$

Note that the price paid by sellers does not depend on the externality they create.

Even if Sh-users generate a higher than Sl-users externality for the other side, it is not taken into account when forming prices.

If all the externalities are positive, the social welfare W is maximal, but the users' surplus is zero. All the welfare is absorbed by the platform:

$$W = \pi^D = \alpha a^{Sh} + (1-\alpha)a^{Sl} + a_h^B \alpha + a_l^B(1-\alpha) - c,$$

where W is the total social welfare and π^D is the platform's profit under discrimination.

The monopolist's equilibrium and the decision to enter or not the market is socially optimal because the monopolist's profit function coincides with the social welfare function.

Let us consider the case where $c = 0$ in order to concentrate attention solely on the externality effects. With externalities being positive, the monopolist's profit under perfect discrimination π^D is always positive. Then the platform never excludes low-type sellers. It is a consequence of the model specification: low type users bring utility, even though this utility is smaller than that brought by high-type users, there is no reason to exclude them. It would be different if buyers' utility depended only on the average quality of sellers and not on their quantity.

If one of externalities is negative, the profit may be negative, in which case the platform does not enter the market. Since the welfare function coincides with the profit function, a platform always makes an efficient decision to enter or not the market.

Serving only high-type users yields a profit of

$$\alpha(a^{Sh} + a_h^B) - \alpha c^S - c^B,$$

serving only low-type users yields a profit of

$$(1-\alpha)(a^{Sl} + a_l^B) - (1-\alpha)c^S - c^B.$$

Suppose again that $c = 0$. A user type is served if the corresponding profit per user is positive: $a^{Sh} + a_h^B \geq 0$ for the high type and $a^{Sl} + a_l^B \geq 0$ for the low type. The result does not depend on α because profitability of serving one of groups of users does not depend on their number, which is a consequence of the linearity.

No discrimination

If each user's type is not observed or it is forbidden to discriminate, the platform cannot discriminate, and so $p^{Sh} = p^{Sl}$. Suppose $a^{Sh} > a^{Sl}$. It can either charge the higher price $p^{Sh} = p^{Sl} = a^{Sh}$ in order to attract only high-type sellers, or the lower price $p^{Sh} = p^{Sl} = a^{Sl}$ in order to attract both types of sellers.[9] In the first case the profit will be:

$$\alpha a^{Sh} + a_h^B \alpha - \alpha c^S - c^B.$$

In the second case the profit will be:

$$\alpha a^{Sl} + (1-\alpha)a^{Sl} + a_h^B \alpha + a_l^B(1-\alpha) - c.$$

To make its choice between the two strategies, the platform compares these two profit values, so that its resulting profit is their maximum. If all the externalities are positive, the profit obtained by the monopoly under no discrimination is strictly lower than the social welfare:

$$\begin{aligned}\pi^{ND} = \max\{\alpha(a^{Sh} + a_h^B) - \alpha c^S - c^B;\ \alpha a^{Sl} + (1-\alpha)a^{Sl} + a_h^B\alpha + a_l^B(1-\alpha) - c\} \\ < W = \alpha a^{Sh} + (1-\alpha)a^{Sl} + a_h^B\alpha + a_l^B(1-\alpha) - c.\end{aligned}$$

The platform serves all the types ofw users in the case where:

$$\alpha a^{Sh} + a_h^B\alpha - \alpha c^S - c^B \leq \alpha a^{Sl} + (1-\alpha)a^{Sl} + a_h^B\alpha + a_l^B(1-\alpha) - c^S - c^B,$$

which is equivalent to

$$\begin{cases}\alpha \leq \frac{a^{Sl}+a_l^B}{a^{Sh}+a_l^B-c^S} = 1 - \frac{a^{Sh}-a^{Sl}-c^S}{a^{Sh}+a_l^B-c^S}, & \text{if } a^{Sh} + a_l^B - c^S \geq 0, \\ \alpha \geq \frac{a^{Sl}+a_l^B}{a^{Sh}+a_l^B-c^S}, & \text{otherwise.}\end{cases}$$

[9] Platform may exclude Sl-users only if $a^{Sl} < a^{Sh}$. Indeed, if $a^{Sl} = a^{Sh}$ then both sellers' types get the same utility and are ready to pay the same price. Discrimination is impossible.

If all externalities are positive, for serving only high type sellers to be profitable, their proportion α and the externality obtained by them a^{Sh} must be sufficiently high. The externality obtained by buyers from low sellers a_l^B and externality perceived by them a^{Sl} must be sufficiently low. The value of externality generated and perceived by Sl-users is sacrified only if it is compensated by the high externality perceived by Sh-users. Hagiu (2009a) finds a similar result: the exclusion of low type becomes more probable as a^{Sh} increases.

We extend this result to the case of negative externalities where the same logic holds: probability to exclude users increases with a^{Sh} and decreases with a_l^B and a^{Sl}. For example, suppose that buyers obtain a negative utility from advertisement so that

$$a^B = a_l^B = a_h^B < 0.$$

Let us suppose that $c = 0$. Then, given that $\alpha a^{Sh} + (1-\alpha)a^{Sl} + \alpha a_h^B + (1-\alpha)a_l^B > 0$, the condition that all potential subscribers are served rewrites

$$\alpha \leq \frac{a^{Sl} + a^B}{a^{Sh} + a^B}.$$

This condition holds when the number of high-type users is low and the positive externality they create is low as well.

Analysis of anti-discrimination policy effects

The result shows that if the perfect discrimination is feasible, all users are always served but otherwise low types may be excluded from the market. The social welfare is the highest when all potential users participate. Hence, the authorisation of perfect discrimination guarantees maximal social welfare. However, perfect discrimination implies extraction of the whole user surplus; additional surplus extracted on the sellers' side thanks to discrimination is not passed to the buyers' side in the form of lower prices.

When the users' types are not observed and the platform chooses not to discriminate, it leaves a positive surplus to a high-type sellers (information rent) equal to $(a^{Sh} - a^{Sl})$ per user, which gives a total consumer surplus of $\alpha(a^{Sh} - a^{Sl})$ for all users, hence the social welfare is maximised. If the platform chooses to exclude low-type sellers, it extracts all the surplus from participating groups and the social welfare is not maximised. It is the worst case from the consumers' prospective. Consequently, a social planner should pay attention: if discrimination is forbidden, this may imply a price so high that the low type sellers will be excluded.

Proposition 1. In a monopoly setting and if users are optimal coordinators, the social welfare is higher if perfect discrimination is feasible compared to the absence of discrimination, but consumers' surplus is zero. Anti-discrimination policy is more likely to have a positive effect when the gap between externality values generated or received by two groups of sellers is small.

A similar result was obtained by Ambrus and Argenziano (2009). They find that in equilibrium under discrimination all consumers join the network and the monopolist charges prices equal to the reservation values. However, in their model consumers are only different in their willingness to pay. In our model, they can also be different in the value of externality they create; we study how it can impact the price.

Information costs

Let us suppose that there exists a cost of gathering information on users so that discrimination becomes feasible. It may be the cost of sales force necessary to create an extensive clients database in order to be capable of sending personalized offers and discriminating. Then personalised offers can be sent.

The cost of identifying all sellers by their type is θ. Suppose that other costs are zero: $c = 0$. Then, the discrimination profit under optimal coordination is

$$\pi^D = \alpha a^{Sh} + (1-\alpha)a^{Sl} + a_h^B \alpha + a_l^B(1-\alpha) - \theta.$$

The profit in the case of non-identified seller types is

$$\pi^{ND} = \max\{\alpha a^{Sh} + a_h^B \alpha; a^{Sl} + a_h^B \alpha + a_l^B(1-\alpha) - \theta\}.$$

The platform is ready to spend θ under the condition

$$\theta \leq \min\{(1-\alpha)(a^{Sl} + a_l^B); \alpha(a^{Sh} - a^{Sl})\}.$$

Introduction of information costs makes discrimination less likely. It may have both positive and negative effects.

Introduction of the outside option when users are optimal coordinators

In this section we change our assumption on reservation utilities. Before, all reservation utilities were equal to zero. Now we suppose that Sl reservation utility is zero as before and Sh reservation utility becomes positive and is noted V, such that $a^{Sh} > V$. The interpretation is the following: successful sellers have a greater negotiation power and more outside options.

We suppose that users are optimal coordinators.

Discrimination

As externalities are positive, it is profitable for the platform to attract all the users to participate. When all user types are observed, the following charges are applied by the monopoly:

$$\begin{aligned} p^{Sh} &= a^{Sh} - V, \\ p^{Sl} &= a^{Sl}, \\ p^{B} &= a_h^B \alpha + a_l^B (1-\alpha). \end{aligned}$$

The corresponding profit is

$$\pi = \alpha(a^{Sh} - V) + (1-\alpha)a^{Sl} + a_h^B \alpha + a_l^B (1-\alpha).$$

The price charged to seller of high type is now lower than that paid by sellers of low type since the former have a greater negotiation power thanks to the alternative option.

No discrimination

The platform has the choice between two options – serving all sellers or only one group of sellers. These options are discussed below in more details.

a) All the users are served. The corresponding prices are

$$p^S = \min\{a^{Sh} - V; a^{Sl}\},$$

$$p^B = a_h^B\alpha + a_l^B(1-\alpha).$$

Platform is ready to set low price in order to attract more sellers. The corresponding profit is

$$\pi_a^{ND} = \min\{a^{Sh} - V; a^{Sl}\} + a_h^B\alpha + a_l^B(1-\alpha).$$

b) Only one type of sellers is served. The seller price is higher and the buyer price is lower:

$$p^S = \max\{a^{Sh} - V; a^{Sl}\},$$

$$p^B = a_l^B(1-\alpha).$$

The corresponding profit is

$$\pi_b^{ND} = \max\{a^{Sh} - V; a^{Sl}\} + a_l^B(1-\alpha).$$

Serving all the potential users is more profitable if the gain in externality from Sh-users compensates for the loose in seller price:

$$\min\{a^{Sh} - V; a^{Sl}\} + a_h^B\alpha > \max\{a^{Sh} - V; a^{Sl}\}.$$

If $a^{Sh} = a^{Sl}$, the condition rewrites as

$$\alpha a_h^B > V.$$

The final profit is equal to

$$\pi^{ND} = \max\{\pi_a^{ND}; \pi_b^{ND}\}$$
$$= \max\{\min\{a^{Sh} - V; a^{Sl} + a_h^B\alpha + \alpha_l^B(1-\alpha); \max\{a^{Sh} - V; a^{Sl} + a_l^B(1-\alpha)\}\}\}$$
$$= a_l^B(1-\alpha) + \max\{\min\{a^{Sh} - V; a^{Sl} + a_h^B\alpha\}; \max\{a^{Sh} - V; a^{Sl}\}\}.$$

Analysis of anti-discrimination policy effects

Under discrimination, two types of users – Sl and B – obtain a zero surplus. Sh-users obtain a positive surplus equal to V thanks to their negotiation power. If discrimination is not possible, buyers still obtain no surplus. The surplus of sellers depends on the chosen configuration. Sl-users obtain a positive surplus only under the condition $a^{Sl} > a^{Sh} - V$.

Compared to the basic model configuration, introducing a side option for Sh-users allows them to obtain a positive profit under discrimination, and the equilibrium market configuration does not change.

Therefore, in a monopoly setting and if users are optimal coordinators, when Sh-users have an outside option with positive utility, discrimination allows to always reach the optimum and Sh-users obtain positive surplus.

Below, we test different hypotheses on users' expectations; they impact the equilibrium selection process.

3.3.2 Users' expectations on a newly created market

In this section let us consider the case of a new market: the platform promotes a new service which nobody is aware of. Then, users on one side would expect no users on the other side to join as long as it is rational to do so. Consequently, they expect to get a zero utility and decide not to join themselves (untill a free bonus is offered to subscribers). We will show that discrimination may allow the platform to solve this problem of unfavourable users' beliefs.

As a result, the market is not established, which is inefficient. Suppose for simplicity that all the externalities are positive ($a_l^B \geq 0$, $a_h^B \geq 0$, $a^{Sh} \geq 0$, and $a^{Sl} \geq 0$) and the cost born by the platform is zero ($c = 0$).

Discrimination

Under discrimination, platform has a wide set of strategies of attracting users to the newly created market than under no discrimination thanks to its ability to set different prices to different seller types:

- Non-discriminatory strategies
  - to propose free subscription to buyers, so that sellers follow them, the prices will be $p^B = 0$, $p^{Sh} = a^{Sh}$, $p^{Sl} = a^{Sl}$ and the corresponding profit $\alpha a^{Sh} + (1-\alpha)a^{Sl}$ (similar to no discrimination strategy, but the surplus that can be extracted is higher under discrimination);
  - to propose free subscription to sellers, so that buyers follow them: $p^B = a^B, \quad p^{Sh} = 0, \quad p^{Sl} = 0$, the corresponding profit is $\alpha a_h^B + (1-\alpha)a_l^B$ (similar to no discrimination strategy);
- Discriminatory strategies
  - to propose free subscription to Sh, so that the remaining users follow them;
  - to propose free subscription to Sh, so that only buyers follow them;
  - to propose free subscription to Sl, so that the remaining users follow them.

The last three strategies based on the distinction between two types of sellers are more complicated and are possible only if discrimination is feasible.

On a newly created market, monopolist's profit is equal to

$$\pi^D = \max\left\{\alpha a^{Sh} + (1-\alpha)a^{Sl}; \alpha a_h^B + (1-\alpha)a_l^B; \alpha a_h^B + (1-\alpha)a^{Sl}; \alpha a^{Sh} + (1-\alpha)a_l^B\right\}.$$

Proof. See Appendix. □

The platform is more likely to charge zero price to those customers who obtain a lower externality. Such customers are used as a 'bait' for other users. The higher the externality created by high-type sellers, the higher the probability that they will not have to pay for the service. They do not pay whenever $a^{Sh} < a_h^B$. Note that the externality they create is compared not to the externality created by the low-type sellers, but to the externality they obtain from buyers. Indeed, the platform makes the choice not between attracting one or another type of sellers, but between extracting surplus from a group of sellers or from buyers.

No discrimination

Earlier we have considered the affiliation game between sellers and buyers:

sellers / buyers	join	not to join
join	$a^B - p^B$ $a^{Sq} - p^S, \quad q = h, l$	$-p^B$ 0
not to join	0 $-p^S$	0 0

Table 3.2: Affiliation game between buyers and sellers in the benchmark monopoly model

As expectations are unfavourable for the platform, users will always prefer the non-affiliation configuration whenever it is a Nash equilibrium. The aim of the platform is to charge such prices that not subscribing will not be an equilibrium: to make at least one of user groups to subscribe to the platform even though there are no other type's users on it. It requires a non-positive price at least on one of two sides: either $-p^B \geq 0$ or $-p^S \geq 0$. This side does not bring the platform any direct revenue.

So, the platform has two strategies of attracting users to the newly created market:

- to propose free subscription to buyers, so that sellers follow them; the prices will be

$$p^B = 0,$$

$$p^S = \begin{cases} a^{Sh}, & \text{if } \alpha a^{Sh} \geq a^{Sl}, \\ a^{Sl}, & \text{otherwise} \end{cases}$$

  (platform may choose between charging a higher price and attracting only high-type sellers and charging a lower price and attracting all the sellers) and the corresponding profit is $\max\{\alpha a^{Sh}; a^{Sl}\}$;
- to propose free subscription to sellers, so that buyers follow them: $p^B = a^B$, $p^{Sh} = 0$, $p^{Sl} = 0$ and the corresponding profit is $\alpha a_h^B + (1-\alpha)a_l^B$.

The platform chooses between these two strategies by comparing corresponding profits. It decides to attract buyers before sellers whenever

$$\max\{\alpha a^{Sh}; a^{Sl}\} \geq \alpha a_h^B + (1-\alpha)a_l^B,$$

the externality obtained by buyers (and consequently the surplus that could be extracted from them) is low and externality that they create for sellers (and consequently the surplus that can be extracted from sellers) is, on the contrary, high.

In conclusion, when discrimination is not available, the resulting profit of a monopolist intermediary on a newly created market equals

$$\pi^{ND} = \max\left\{\alpha a^{Sh}; a^{Sl}; \alpha a_h^B + (1-\alpha)a_l^B\right\}.$$

This profit is strictly lower than the profit that can be obtained by a platform on a well established market:

$$\max\{\alpha a^{Sh}; a^{Sl}; \alpha a_h^B + (1-\alpha)a_l^B\} < \max\{\alpha a^{Sh}; a^{Sl}\} + a^B.$$

The whole market is served and the optimum is achieved under the condition either $\alpha a_h^B + (1-\alpha)a_l^B \geq \max \alpha a^{Sh}; a^{Sl}$ or $a^{Sl} \geq \max\{\alpha a^{Sh}; \alpha a_h^B + (1-\alpha)a_l^B\}$, which can be rewritten as

$$\max\{a^{Sl}; \alpha a_h^B + (1-\alpha)a_l^B\} \geq \alpha a^{Sh}$$

.

Analysis of anti-discrimination policy effects

Let us compare profits under discrimination and under no discrimination:

$$\pi^{ND} = \max\{\alpha a^S; a^S; \alpha a_h^B + (1-\alpha)a_l^B\}$$
$$\leq \pi^D = \max\{\alpha a^S + (1-\alpha)a^S; \alpha a_h^B + (1-\alpha)a_l^B; \alpha a_h^B + (1-\alpha)a^S; (1-\alpha)a_l^B + \alpha a^S\}$$

Not surprisingly, the non-discrimination profit is always lower or equal. The two profits are equal only in the case where $\pi^{ND} = \pi^D = \alpha a_h^B + (1-\alpha)a_l^B$, i.e. when exernality obtained by buyers is so high that platform prefers to extract the whole surplus from them irrespectively of availability of discrimination. The profit value is the same under discrimination and no discrimination because buyers are homogeneous and so there is no need for discrimination even if authorised.

Since all externalities are positive, the socially optimal configuration includes all users subscribing, which yeilds the following proposition.

Proposition 2. In a monopoly setting and if users' expectations are unfavourable, when costs are zero, the optimal configuration is achieved both under discrimination and no discrimination, but consumers' surplus is lower under discrimination.

Negative externalities

Let us relax the assumption on positive externalities. In the presence of negative externalities, platform cannot use some of its divide-and-conquer strategies anymore.

If buyers get a negative utility, $a_h^B < 0$, $a_l^B < 0$, both under discrimination and no discrimination, the only possible strategy is to attract buyers first and get the surplus from sellers. Under no discrimination, it gives a profit of $\max\{\alpha a^{Sh}; a^{Sl}\}$, under discrimination – of $\alpha a^{Sh} + (1-\alpha)a^{Sl}$. The profit under discrimination is strictly higher and the investment is more likely as in the case of positive externalities. For example, first a website becomes well-established, and then it attracts advertisers to commercialize the project.

Another possibility is the following: bad quality advertisement is an annoying factor for users ($a_l^B \leq 0$), while good quality advertisement is useful and informative ($a_h^B \geq 0$). In this case the non-discriminating platform has the only strategy of attracting buyers first. The discriminating platform has an additional strategy: it may attract only low-type sellers (low-quality advertising) first, and than extract the surplus from buyers and remaining sellers. It gives a profit of $\max\{(1-\alpha)a_l^B + \alpha a^S; (1-\alpha)a_l^B + \alpha a_h^B\}$.

Now suppose that, on the contrary, S-users get a negative utility from B-users ($a^S < 0$): two groups of S-users create the same positive externality, but they have different sensibility with respect to the number of B-users. Then, the only feasible strategy both under discrimination and no discrimination is to attract S-users first, giving the profit of $\alpha a^{Sh} + (1-\alpha)a^{Sl}$. It does not make sense for a discriminating platform to attract only one group of sellers, because in any case there is nothing to extract from any group of sellers.

Fixed costs

Suppose that on the market the platform bears a fixed cost of entry F: it may be a cost of investment in equipment, of development of a new product, etc. Let us study the efficiency of a monopolistthe platform's entry decision.

The social planner would make the investment F whenever it is compensated by the surplus obtained by all users:

$$F \leq \alpha a^{Sh} + (1-\alpha)a^{Sl} + \alpha a_h^B + (1-\alpha)a_l^B.$$

A monopolist will make the investment and enter the market whenever $\pi > F$.

Neither discrimination nor non-discrimination equilibria guarantee the the socially optimal investment decision. The reason is the following: because of unfavourable expectations of users the platform cannot extract the whole surplus from them, so its profit function does not coincide with the social welfare function, as it was in the case under favourable users' expectations. Both discrimination and no-discrimination profits are lower than the social welfare. In the meantime more surplus is extracted under discrimination than under no discrimination, so that a discriminating platform has more incentives to invest, and these incentives are closer to socially optimal. In this case a ban on discrimination does not increase social welfare but does increase users' surplus. The optimal policy depends on the value of the fixed cost:

- $F \leq \pi^{ND} \leq \pi^D \leq W$, the platform enters the market both under discrimination and no discrimination, so that ban on discrimination does not lead to inefficiency and allows for a more fair redistribution of surplus;
- $\pi^{ND} \leq F \leq \pi^D \leq W$, the platform enters the market only under discrimination, so that ban on discrimination is inefficient;
- $\pi^{ND} \leq \pi^D \leq F \leq W$, the platform does not enter the market independently of discrimination policy, the outcome is inefficient;
- $\pi^{ND} \leq \pi^D \leq W \leq F$, the platform does not enter the market independently of discrimination policy, the outcome is efficient.

As the non-discrimination profit tends to be very low and probably lower than fixed costs, on an emerging TSM discrimination may often be an instrument of entry.

Proposition 3. In a monopoly setting and if users' expectations are unfavourable, when fixed costs are positive, discrimination may be an instrument of entry. However, if fixed cost is low, it serves solely as an instrument of rent extraction.

3.3.3 Users' expectations on a well established market

Let us consider another example of users' expectations. On a well established market users have expectations in favour of the incumbent platform: they coordinate on an equilibrium beneficial for the platform. In other words, unless it is irrational, they suppose that users on the other side subscribe.

Then, under discrimination, the incumbent can charge each user the maximum price equal to utility and get the profit of

$$\pi^D = \alpha a^{Sh} + (1-\alpha)a^{Sl} + \alpha a_h^B + (1-\alpha)a_l^B.$$

Under no discrimination, the incumbent can charge only uniform price to sellers and get the profit of

$$\pi^{ND} = \max\{a^{Sl} + \alpha a_h^B + (1-\alpha)a_l^B; \alpha a^{Sh} + \alpha a_h^B\}.$$

All the users are subscribing if discrimination is feasible. If discrimination is not feasible, all the users are subscribing only under the condition

$$a^{Sl} + \alpha a_h^B + (1-\alpha)a_l^B \geq \alpha a^{Sh} + \alpha a_h^B.$$

Proposition 4. In a monopoly setting and if users' expectations are favourable, discrimination allows to always reach the optimum, but the whole surplus is extracted by the monopoly. The result is similar to the case of users' optimal coordination.

These equilibrium configurations, prices and profits coincide with the case when users are optimal coordinators. In fact, when all users get a slightly positive utility from subscribing, it is optimal for them to coordinate on subscribing (optimal coordination), which also gives the platform the highest possible profit (expectations in favour of the platform).

Fixed costs

Suppose that on this market the platform bears a fixed cost F. The social planner would make the investment F whenever $F \leq \alpha a^{Sh} + (1-\alpha)a^{Sl} + \alpha a_h^B + (1-\alpha)a_l^B = \pi^D$.

Discriminating platform always takes this socially optimal entry decision. In the case where this cost is such that $\pi^{ND} \leq F \leq \pi^{D}$, the platform enters the market only under discrimination. For the same fixed costs value, the platform is functional even under no discrimination and discrimination serves only to extract consumer surplus and should be prohibited.

3.3.4 Sellers' incentives to invest in quality

Suppose that low-type sellers may improve their quality to upgrade to high-type sellers. Each of them needs to invest I to do so. Then, the proportion of each type of sellers becomes endogenous. Let us study sellers' investment incentives.

The initial distribution between low and high type sellers is the same as previously. After the platform announces its prices, low type sellers decide whether they want to upgrade their quality to the high level. Their choice depends on the platform's offers: by setting its prices, the platform may either incite low type sellers to make the investment or not.

The model result will allow to answer an important question: whether the abscence of net neutrality is likely to empede the development of small content providers.

In this subsection we suppose that externalities are positive and users are optimal coordinators.

Discrimination

The platform has the choice between two strategies:

a) the platform does not incite investment and gets a profit of

$$\pi^{D}(\text{‘no inv’}) = \alpha a^{Sh} + (1-\alpha)a^{Sl} + \alpha a_h^B + (1-\alpha)a_l^B$$

as in the benchmark model.

b) the platform incites investment. For Sh-users to participate it must hold that their net profit is positive

$$a^{Sh} - p^{Sh} \geq 0.$$

For Sl-users to invest it must hold that their net profit from investment is positive and is higher than the profit from non-investment:

$$a^{Sh} - p^{Sh} - I \geq \max\{0, a^{Sl} - p^{Sl}\}.$$

As the platform may charge arbitrarily high p^{Sl} price, the active constraint will be $a^{Sh} - p^{Sh} \geq I$. In the optimum it holds that $p^{Sh} = a^{Sh} - I$. It gives the platform a profit of

$$\pi^D(\text{'inv'}) = a^{Sh} - I + a_h^B.$$

Platform compares two profits, π^D('no inv') and π^D('inv'), and incites investment only if π^D('inv') is higher:

$$(1-\alpha)(a^{Sh} + a_h^B - a^{Sl} - a_l^B) \geq I.$$

The social planner incites investment if the total gain from it expressed in buyers' additional utility and sellers' additional utility is higher than investment cost:

$$(1-\alpha)(a^{Sh} + a_h^B - a^{Sl} - a_l^B) \geq I$$

which coincides with the criterion used by the monopolist.

Consequently, the discriminating monopolist always takes the efficient decision on whether to incite investment or not.

The corresponding profit is the maximum of π^D('no inv') and π^D('inv'):

$$\pi^D = \max\left\{\alpha a^{Sh} + (1-\alpha)a^{Sl} + \alpha a_h^B + (1-\alpha)a_l^B; a^{Sh} - I + a_h^B\right\}.$$

No discrimination

Similarly to the case of discrimination, the platform has the choice between two strategies:

a) the platform does not incite investment and gets a profit of

$$\pi^{ND}(\text{`no inv'}) = \max\{a^{Sl} + (1-\alpha)a_l^B + \alpha a_h^B; \alpha a^{Sh} + \alpha a_h^B\}$$

as in the benchmark model.

b) the platform incites investment in which case users' participation conditions write:

$$\begin{cases} a^{Sh} - p^S - I \geq \max\{0; a^{Sl} - p^S\} \\ a^{Sh} - p^S \geq 0 \end{cases}$$

There exists sellers price p^S that satisfies the above conditions only if $a^{Sl} \leq a^{Sh} - I$, or the additional externality created by a high-type seller compared to a low type seller is sufficiently high to compensate for the investment.

The seller price that maximizes profit is $p^S = a^{Sh} - I$, the corresponding profit value is

$$\pi^{ND}(\text{`inv'}) = a^{Sh} + a_h^B - I,$$

which is equal to the case of discrimination.

Platform compares two profits and incites investment only if $\pi^{ND}(\text{`inv'})$ is higher than $\pi^{ND}(\text{`no inv'})$

$$a^{Sh} - I + a_h^B \geq \max\{a^{Sl} + (1-\alpha)a_l^B + \alpha a_h^B; \alpha a^{Sh} + \alpha a_h^B\}.$$

This monopolist decision under no discrimination is inefficient: there is always too much investment. The reason is that the platform cannot extract the whole surplus when there are two types of sellers, but it can extract the whole surplus when investment is made and there is only one type of them.

The resulting profit value is the maximum of $\pi^{ND}(\text{`inv'})$ and $\pi^{ND}(\text{`no inv'})$:

$$\pi^{ND} = \max\{a^{Sl} + (1-\alpha)a_l^B + \alpha a_h^B; \alpha a^{Sh} + \alpha a_h^B; a^{Sh} + a_h^B - I\}.$$

Analysis of anti-discrimination policy effects

In our model, discrimination always leads to the optimal level of investment in quality. The discriminating monopolist always takes the efficient decision because of being capable to extract the whole surplus. The impossibility to discriminate may lead to overinvestment: the platform tends to set the prices so that to incite investment by low-type users even in the case it is not efficient from the social welfare prospective. Platform arrives to extract the whole surplus even in no-discrimination in the case the low-type sellers are upgraded and aligned with the high-type sellers, so that all the sellers are of the same type.

Proposition 5. In a monopoly setting and if users are optimal coordinators, the level of investment in quality is efficient, but the whole consumer surplus is extracted under discrimination. A ban on discrimination may lead to overinvestment.

3.4 A duopoly model

In this section we will study a TSM with two platforms, Platform 1 and Platform 2, competing with each other. We will consider different equilibria, including those where only one or no platforms enter the market.

An example of a TSM that is close to duopolistic is the cell phone applications industry: two main mobile operating systems are Google Play Store on Android operation system and Apple's App Store.

In the model we consider that all users are singlehoming (always subscribing to only one platform). For example, it is true for the mobile phone applications ecosystem. On the one side, mobile users usually posess only one device, so they are usually connected via only one operation system. On the other side, mobile application developers are often specialized on only one operation system, since the programming languages are different. Singlehoming is also a usual pattern in the online advertisement. Indeed, on the one side advertisers often collaborate with only one online advertisement service, especially if it allows access to a great choice of advertisement locations. Websites choose only one advertisement platform on their side. Singlehoming is also a reasonable approximation for the TSM of internet provision which connects online service providers with users. Both of them usually choose to subscribe to only one internet service provider.

In this section we suppose that all the externalities are positive.

Notations are the same as in the previous chapter, subscripts $i = 1, 2$ are the platforms' indicators.

3.4.1 Duopoly and optimally coordinating users

In this section we suppose that users' expectations satisfy the optimal coordination assumption: users choose the equilibrium which is Pareto-optimal for all of them. This assumption allows for *a priori* symmetry between two platforms in terms of users' expectations.

Each user has a choice between the following three options:

- to join Platform 1,
- to join Platform 2,
- not to join any platfom.

This choice depends on the prices and on the expected number of users on the other side.

Discrimination

In the proposition below we show that under discrimination possible equilibria may be of only two configurations: either only one firm is active, or both firms are active and are specialised on different sellers' types.

Proposition 6. In a duopoly setting and if users are optimal coordinators, under discrimination, there is only one equilibrium configuration that can be stable on a competitive market: the dominant-firm equilibrium with all users subscribing to one platform:

$$n_i^{Sh} = \alpha, \quad n_i^{Sl} = 1 - \alpha, \quad n_i^B = 1, \quad i = 1, 2.$$

Proof. See Appendix. □

In the dominant-firm equilibrium either Platform 1 or Platform 2 is active: platforms are completely symmetric in terms of costs and users' expectations.

Let us consider in details the dominant-firm equilibrium where only one platform, Platform i, is active. From now on in this chapter we make a simplifying assumption that $a^{Sl} = a^{Sh}$ (externalities received by all the sellers are the same). Our objective is to study the interaction of sellers' prices with externalities a_h^B and a_l^B they create when they are differentiated in this externality. For example, to check whether the platform charges less to sellers who create more benefit for the other side.

When users are optimal coordinators and discrimination is feasible, the dominant firm's problem is to maximize profit

$$\alpha p_i^{Sh} + (1-\alpha)p_i^{Sl} + p_i^B \to \max_{p_i^{Sh}, p_i^{Sl}, p_i^B},$$

subject to non-deviation constraints

$$\begin{cases} \alpha p_i^{Sh} + (1-\alpha)p_i^{Sl} + p_i^B \leq 0, & OptCoord \\ a^S + \alpha \min\{0, p_i^{Sh}\} + (1-\alpha)\min\{0, p_i^{Sl}\} + p_i^B - \alpha a_h^B - (1-\alpha)a_l^B \leq 0, & B \to Sh + Sl \\ \alpha(p_i^{Sh} - a^S) + (1-\alpha)(p_i^{Sl} - a^S) + \alpha a_h^B + (1-\alpha)a_l^B + \min\{0, p_1^B\} \leq 0, & Sh + Sl \to B \\ \alpha(p_i^{Sh} - a^S) + (1-\alpha)p_i^{Sl} + \min\{p_i^B, (1-\alpha)a_l^B\} + \alpha a_h^B \leq 0, & Sh \to B + Sl \\ \alpha(p_i^{Sh} - a^S) + n_2^B(p_i^B + \alpha a_h^B - (1-\alpha)a_l^B) \leq 0, & Sh \to nB \\ (1-\alpha)(p_i^{Sl} - a^S) + \alpha p_i^{Sh} + \min\{p_i^B, \alpha a_h^B\} + (1-\alpha)a_l^B \leq 0, & Sl \to B + Sh \\ (1-\alpha)(p_i^{Sl} - a^S) + n_2^B(p_i^B - (1-\alpha)a_l^B - \alpha a_h^B) \leq 0, & Sl \to nB \end{cases}$$

and users' participation constraints (of users B, Sh and Sl correspondingly):

$$\begin{cases} p_i^B \leq \alpha a_h^B + (1-\alpha)a_l^B, & Participation\,B \\ p_i^{Sh} \leq a^S, & Participation\,Sh \\ p_i^{Sl} \leq a^S, & Participation\,Sl \end{cases}$$

Proof. See Appendix. □

Each constraint corresponds to one of deviation strategies by the non-active platform and states that the deviation profit should be non-positive. In particular, the first constraint implies that the profit cannot be greater than zero. Otherwise the second platform would slightly undercut prices and users would migrate to the second platform by optimally coordinating. Other constraints correspond to divide-and-conquer deviation strategies where the incentive platform starts with attracting only one side first. For example, the constraint $Sh + Sl \to B$ states that if the deviating platform chooses to attract first sellers and then buyers, the corresponding profit is zero.

Under pure monopoly the platform never had interest to discriminate between Sh and Sl users when externalities were positive and $a^S = a^{Sh} = a^{Sl}$. Here, in the case of competition, constraints are asymmetric with respect to p^{Sh} and p^{Sl}, which means that the active platform wants to discriminate between them because they create different externalities which differently impact inactive platform's deviation strategies, even though utility they get is the same.

No discrimination

If discrimination is forbidden, the inactive platform has a smaller range of deviation strategies: it is left with only two divide-and-conquer strategies compared to the discrimination case. The problem of the dominant platform rewrites:

$$\begin{cases} p_1^S + p_1^B \to \max\limits_{p_1^S, p_1^B}, \\ p_1^B \leq \alpha a_h^B + (1-\alpha) a_l^B, & ParticB \\ p_1^S \leq a^S, & ParticS \\ p_1^S + p_1^B \leq 0 & OptCoord \\ p_1^S + \min\{p_1^B, 0\} \leq a^S - \alpha a_h^B - (1-\alpha) a_l^B, & S \to B \\ p_1^B + \min\{p_1^S, 0\} \leq \alpha a_h^B + (1-\alpha) a_l^B - a^S, & B \to S \end{cases}$$

If there is no discrimination, the only sustainable equilibrium configuration is the dominant-firm one. The proof is similar to the case of discrimination. The equilibrium with two active platforms is not sustainable anymore.

Proposition 7. In a duopoly setting and if users are optimal coordinators, under no discrimination there are only dominant-firm equilibria: $n_i^{Sh} = \alpha$, $n_i^{Sl} = 1 - \alpha$, $n_i^B = 1$, $i = 1, 2$. Equilibrium price levels are given as follows:

if $a^S > \alpha a_h^B + (1-\alpha)a_l^B$, then

$$\begin{cases} a^S - \alpha a_h^B - (1-\alpha)a_l^B \leq p_1^S \leq a^S, \\ -a^S \leq p_1^B \leq \alpha a_h^B + (1-\alpha)a_l^B - a^S, \\ p_1^S + p_1^B = 0, \end{cases}$$

if $a^S < \alpha a_h^B + (1-\alpha)a_l^B$, then

$$\begin{cases} -\alpha a_h^B - (1-\alpha)a_l^B \leq p^S \leq a^S - \alpha a_h^B - (1-\alpha)a_l^B, \\ a_h^B + (1-\alpha)a_l^B - a^S \leq p_1^B \leq \alpha a_h^B + (1-\alpha)a_l^B, \\ p_1^S + p_1^B = 0. \end{cases}$$

Proof. See Appendix. □

Analysis of anti-discrimination policy effects

Let us compare equilibria with and without discrimination. In both cases the profit of both active and passive platforms is zero because of competition between platforms and users' optimal coordination. With no discrimination the number of price constraints in the platform's problem is lower because of a lower number of deviation strategies.

Let us discuss how the result will change if we introduce an additional constraint of *non-negative prices* applied to all platforms. In this case the inactive platform's divide-and-conquer deviation strategies based on negative prices are not feasible any more, and the corresponding constraints disappear from the active platform's problem. As a result, prices are less restricted from above — only by participation constraints and one non-deviation constraint — but the zero-profit condition still holds thanks to the optimal coordination of users. So, under optimal coordination the possibility to charge negative prices has an impact on the surplus distribution between two sides and not on the platforms' profits.

3.4.2 Duopoly and competition between incumbent and entrant

Suppose that users' beliefs are in favour of the incumbent, Platform 1. If it is rational, they expect other users to join Platform 1. Given the prices, they coordinate on the equilibrium that gives Platform 1 the maximal surplus. It means that whenever possible they coordinate on the equilibrium where only Platform 1 is active. Then it is more difficult for the entrant, Platform 2, to gain the market than under optimal coordination.

We study whether discrimination helps the incumbent to hold the market or, on the contrary, helps the entrant to gain it. We compare profit of the incumbent under discrimination and no discrimination.

Proposition 8. In the competition between an incumbent and an entrant, both if discrimination is feasible and not feasible, an equally efficient entrant cannot replace the incumbent on the market.

Proof. See Appendix. □

A new entrant can enter the market only under condition of being more efficient than the incumbent. We show that in this case the entrant can more easily hold the market position under discrimination.

Proposition 9. An entrant may replace the incumbent platform only if the entrant is more cost-efficient. This efficient equilibrium is more easily achievable under discrimination.

Proof. See Appendix. □

3.4.3 Duopoly model with differentiation on the buyer side

In this section we modify our assumptions on the buyers' preferences. Sellers' preferences are the same as previously, but the buyers' tastes become horizontally differentiated. Indeed, while mobile application sellers do not have any personal preferences on mobile application platforms, consumers choose a mobile device depending on its multiple characteristics, and their priorities and opinions differ.

Suppose that both buyers and sellers singlehome. Sellers' demand is given as before, buyers' demand is given below.

Buyers' demand. Buyers are uniformly distributed on the interval of size 1, platforms are situated at the extremities of this interval. Utility of a buyer situated at the coordinate x from subscribing to Platform 1 and Platform 2 respectively:

$$\begin{aligned} U_1^B(n_1^{Sh}, n_1^{Sl}) =& n_1^{Sh} a_h^B + n_1^{Sl} a_l^B - tx - p_1^B, \\ U_2^B(n_2^{Sh}, n_2^{Sl}) =& n_2^{Sh} a_h^B + n_2^{Sl} a_l^B - t(1-x) - p_2^B, \end{aligned}$$

where t is parameter of the degree of differentiation.

Let us find demand on Platform 1. For the boundary user who is indifferent between subscribing to one or another platform it holds that

$$n_1^{Sh} a_h^B + n_1^{Sl} a_l^B - tx - p_1^B = n_2^{Sh} a_h^B + n_2^{Sl} a_l^B - t(1-x) - p_2^B.$$

It follows that Platform 1's demand is equal to

$$n_1^B(n_1^{Sh}, n_1^{Sl}, n_2^{Sh}, n_2^{Sl}) = x = \frac{(n_1^{Sh} - n_2^{Sh}) a_h^B + (n_1^{Sl} - n_2^{Sl}) a_l^B + t + (p_2^B - p_1^B)}{2t}.$$

Platform 2's demand is equal to

$$n_2^B(n_1^{Sh}, n_1^{Sl}, n_2^{Sh}, n_2^{Sl}) = 1 - x = \frac{(n_2^{Sh} - n_1^{Sh}) a_h^B + (n_2^{Sl} - n_1^{Sl}) a_l^B + t + (p_1^B - p_2^B)}{2t}.$$

The non-subscription configuration is never socially optimal since the corresponding welfare is always zero. There are two possible configurations for social optimum: one active platform and two active platforms. The former is optimal if buyers' preferences are characterised by few differentiation, the later is optimal if, on the contrary, degree of differentiation are high.

The social planner's problem writes:

$$\begin{cases} n_1^S \left(a^S n_1^B - \frac{t}{2}(n_1^B)^2 \right) + n_2^S \left(a^S n_2^B - \frac{t}{2}(n_2^B)^2 \right) \rightarrow \max\limits_{n_1^S, n_2^S, n_1^B, n_2^B}, \\ n_1^S + n_2^S \leq 1, \\ n_1^B + n_2^B \leq 1. \end{cases}$$

The following three cases are considered depending on the set of active constraints, which in their turn depend on the proportion between externality and taste for diversity.

1) $\frac{a}{t} \leq \frac{1}{2}$:

$$\begin{cases} n_1^B = n_2^B = \frac{a}{t}, \\ n_1^B + n_2^B \leq 1, \\ n_1^S + n_2^S = 1. \end{cases}$$

Buyers' taste for differentiation is so strong and the force of externalities they obtain is so weak that it is more efficient to dispatch them between two active platforms.

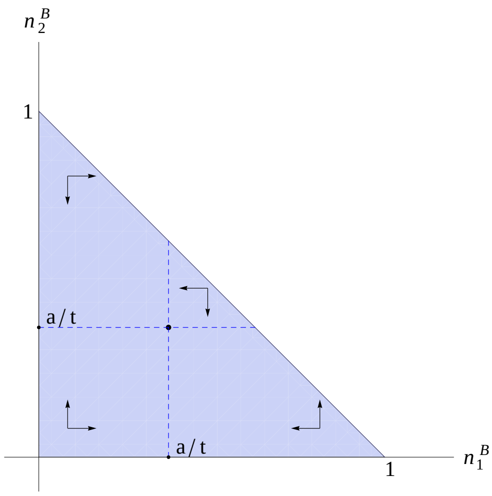

Figure 3.5: case 1

2) $\frac{1}{2} < \frac{a}{t} \leq 1$:

$$\begin{cases} n_1^B + n_2^B = 1, \\ n_1^B \leq \frac{a}{t}, \\ n_2^B \leq \frac{a}{t}. \end{cases}$$

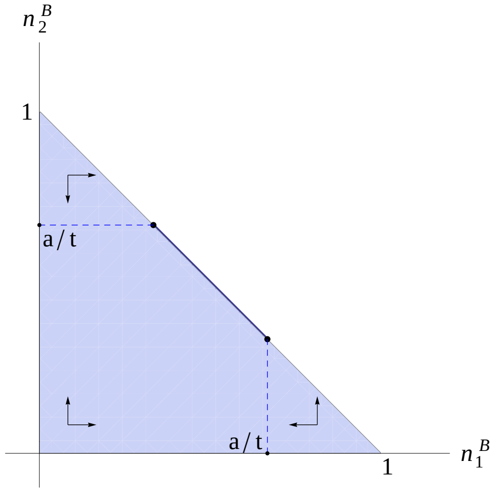

Figure 3.6: case 2

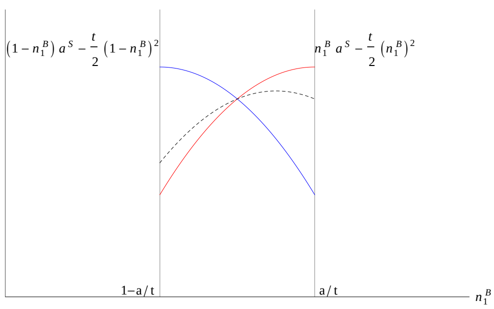

Figure 3.7: case 2

Optimum is $n_1^S = 1$, $n_1^B = \frac{a}{t}$, $n_2^S = 0$, $n_2^B \in [0; 1 - \frac{a}{t}]$. Only one platform is active, all sellers and only a part of buyers subscribe to it. Other buyers stay out of the market.

3) $1 < \frac{a}{t}$:

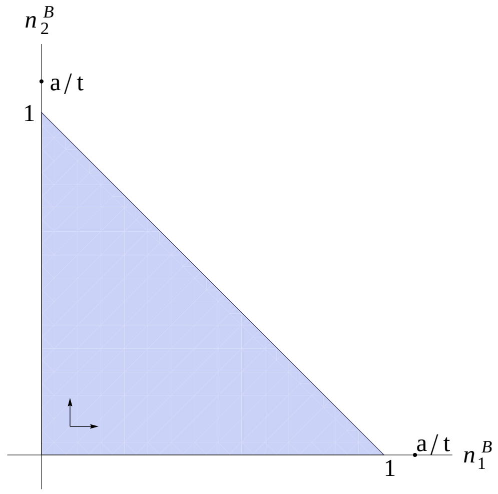

Figure 3.8: case 3

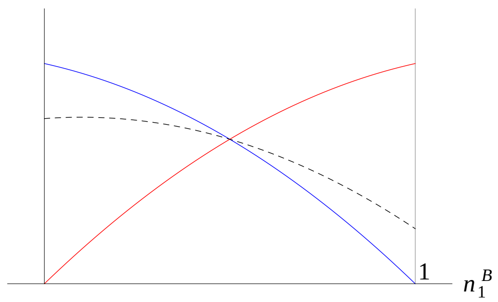

Figure 3.9: case 3

Optimum: $n_1^S = 1$, $n_1^B = 1$, $n_2^S = 0$, $n_2^B = 0$ or $n_1^S = 0$, $n_1^B = 0$, $n_2^S = 1$, $n_2^B = 1$. Buyers' taste for differenciation is so low and the force of the externality they obtain is so strong that it is more efficient for all users to crowd on only one active platform.

Further development of such model where platforms are differentiated is a perspective for future research.

3.5 Conclusion: price discrimination on two-sided markets

We have studied anti-discrimination policy on TSM and its impact on the equilibrium number of platforms, on the prices and on the users' affiliation choices, as well as on the gain of different market participants and on the social welfare. We have found that it largely depends on the following market characteristics: degree of competition, sign of externalities, possibility to give to users free subscription bonuses, market maturity, and presence of fixed costs. We have studied how these factors influence the outcome. We have illustrated the results with examples from telecommunications industry.

Users on two sides of the market are called 'sellers' and 'buyers'. Sellers are not homogeneous and may be divided into two groups depending on the externality level they generate, with platforms being capable to discriminate between two groups.

First, let us outline the results obtained for the case where only one platform is present on the market with no potential entrants. These results depend on users' expectations of the number of users on the other side which has a direct impact on the externality level.

By definition, users' beliefs respect the optimal coordination rule if users are able to coordinate on an equilibrium that gives them a maximum surplus. Under optimal coordination and if discrimination is feasible, all users are always subscribing to the platform since it maximizes their surplus. This configuration is efficient from the point of view of social welfare, since it maximizes positive externalities, however, discrimination serves as an instrument of surplus extraction from users. If discrimination is not feasible, two equilibrium configurations are possible. In the first one, similarly to the no discrimination case, all users are subscribing, but a greater part of surplus is left to consumers. In the second one, the platform sets prices excluding those users who generate a lower externality. The risk of exclusion increases as their number and the externality they generate decreases. Since exclusion of a part of users is inefficient from the welfare perspective and also leads to a zero users' surplus, in this case the ban on discrimination is inefficient. Therefore, anti-discrimination policy is more likely to have a positive effect when the gap between externality values generated or received by two groups of heterogeneous users is small. For example, a mobile software platform can charge a high entry price for application developers, so that only mainstream applications with a high expected profit decide to join the platform.

Favorable users' expectations mean that whenever it is rational, potential users expect other users to join the platform. It is applicable for example to a well established internet service. The result is similar to the case of users' optimal coordination. It means that if service is already well known by the users, for example like Google Search, allowing discrimination among advertisers leads only to the extraction of consumer surplus.

For a newly created two-sided service, users' expectations are often unfavorable for the platform: users tend to assume that they are alone on the platform and therefore cannot obtain any utility. In this case, a platform has to accumulate a critical number of users on one of the sides by proposing a free service and then to charge the other side. Those users who create a higher externality are likely to get subscription for free. Discrimination allows to split up the users on one of the sides in order to maximize potential profit and therefore to simplify the entry. Discrimination is more likely to be necessary on a newly created market to break through unfavourable users' expectations and when entry investments are high than on a well established market where it serves solely as an instrument of profit extraction.

The entry on the market becomes more difficult if externalities on one of the sides are negative: the profit is lower and the number of entry strategies is more limited. For example, if buyers get a negative utility, the only possible strategy of entry is to attract buyers first and then to extract the surplus from sellers. Such strategy is often used by websites that first become popular among internet-users by proposing free content, and then attract advertisers to commercialize the project. An extensive audience attracts advertisers, while banners create disutility for internet-users. Discrimination is sometimes used on this market: more relevant and high quality advertisements cost less to advertisers since they generate less negative externalities.

We extended the model to internalise sellers' quality by assuming that sellers may increase the externality they generate and receive through an investment. The platform may incite or not the investment by setting an appropriate price gap between 'low-type' and 'high-type' sellers. The impossibility to discriminate leads to a higher or equal level of investment than under no discrimination: the platform incites investment by low-type users by setting relatively high prices so that subscription is too expensive for low type users and they prefer to become high-type users. This strategy allows the platform to obtain a higher profit: the platform manages to extract more surplus under no discrimination in the case the low-type sellers are upgraded and alligned with the high-type sellers, so that all the sellers are of the same type.

Second, let us outline the results obtained for the case where two platforms are competing. In this case, each platform's pricing objective is to prevent migration of users to the other platform. Similarly to the monopoly, the result depends on the users' expectations.

Optimal coordination of users allows for only dominant-firm equilibria under no discrimination and under discrimination. Thanks to coordination, users always switch to a unique platform to maximise externalities.

A new entrant can enter the market only under condition of being more cost-efficient than the incumbent. We show that in this case the entrant can become the dominant platform and that this efficient equilibrium is more easily achievable under discrimination.

We have analyzed whether additional profit extracted on one side thanks to discrimination is passed on to the other side *via* lower prices. We have found that it depends on the users' expectations. When users are optimal coordinators, a monopoly platform does not share the surplus with users, there is no motivation to do so in the absence of competition. However, it has to share a part of the surplus in the case of a newly create service. Under optimal coordination in the duopoly setting platforms do pass the additional profit on to the users on the other side of the market. Discrimination under duopoly does not allow for extracting the surplus from users thanks to competitive pressure and users' optimal coordination; the platform's profit is zero and the consumers' surplus is positive. However an incumbent platform gains a positive profit even in duopoly thanks to the favourable users' beliefs.

Certain issues with respect to discrimination on two-sided telecommunications markets are left for future research. The case of horizontal differentiation of customers should be studied in order to study equilibria with two active platforms. Also, a dynamic approach would help to account for platforms' dynamic strategies of gradual client base extention on a growing market. A model of investmets in capacity and service quality would help to answer the question whether telecommunications operators are able to make investments necessary to support the growing traffic. It would be interesting to test the model results on price data of an online two-sided service, studying price evolution with time, number of users and market competitiveness.

Conclusion

When estimating the effects of a potentially anticompetitive practice on a two-sided telecommunications market, a competition authority should account for its specific characteristics.

The literature review has revealed that the question of price structure is the question the most widely discussed in the TSM literature. However, further research is necessary in this area. That is why we have chosen to concentrate our attention on the tariff practices.

Section 2 deals with excessive pricing. We have studied the pricing system of an online tax declaration service. Using the TSM concept, we have explained that a relatively higher price level on one side of the market is not necessarily a sign of an anti-competitive strategy but may be simply a result of maximizing the positive external effects. We have constructed a simple model to illustrate this point, which allows to estimate consumer surplus of different groups of users.

Section 3 deals with price discrimination. We have studied anti-discrimination policy on TSM and its impact on the equilibrium number of platforms, on the prices and on the users' affiliation choices, as well as on the gain of different market participants and on the social welfare. We have found that it largely depends on the following market characteristics: degree of competition, sign of externalities, possibility to give to users free subscription bonuses, market maturity, and presence of fixed costs. We have studied how these factors influence the outcome. We have illustrated the results with examples from telecommunications industry.

Appendix

Monopoly, perfect discrimination

Proof. Below we will consider three most complicated strategies:

- Sh users are attracted first and then all the other users join;
- Sh users are attracted first and then only buyers join;
- Sl users are attracted first and then all the other users join.

Let us consider the case where the platform attracts Sh-users first: $p^{Sh} = 0$. The remaining groups of users decide on whether to join or not. Let us write the table of their gains:

B \ Sl	join	not join
join	$(1-\alpha)a_l^B + \alpha a_h^B - p^B$ $a^{Sl} - p^{Sl}$	$\alpha a_h^B - p^B$ 0
not join	0 $-p^{Sl}$	0 0

Table 3.3: Affiliation game between B and Sl with unfavourable expectations in a monopoly

Once Sh-users are on the platform, the intermediary has a choice between attracting all the remaining users (we will denote this strategy $Sh \to B + Sl$) and only buyers (we will denote this strategy $Sh \to B$). The last strategy may be profitable in the case serving Sl-users brings a negative marginal profit.

Case $Sh \to B + Sl$

If intermediary decides to attract all the users, the following constraints on prices must be respected. First, it must hold that subscribing to the platform 2 is a Nash equilibrium - neither buyers nor low-type sellers want to leave the platform:

$$\alpha a_h^B + (1-\alpha)a_l^B - p^B \geq 0$$
$$a^{Sl} - p^{Sl} \geq 0.$$

These are participation constraints.

Second, it must hold that subscribing to no platform is not an equilibrium, otherwise users would have preferred staying unsubscribed. At least one type of users prefer to subscribe when:

$$\text{either } \alpha a_h^B - p^B \geq 0, \text{ or } \; -p^{Sl} \geq 0.$$

It follows that platform should set such prices that one of these two conditions hold. If the first condition holds, the corresponding prices are:

$$p^B \leq \min\left\{\alpha a_h^B + (1-\alpha)a_l^B;\ \alpha a_h^B\right\} = \alpha a_h^B$$
$$p^{Sl} \leq a^{Sl}.$$

If the second condition holds, the corresponding prices are

$$p^B \leq \alpha a_h^B + (1-\alpha)a_l^B$$
$$p^{Sl} \leq \min\{a^{Sl}; 0\} = 0.$$

The first option gives a profit of $\alpha a_h^B + (1-\alpha)a^{Sl}$ (we remind that $p^{Sh} = 0$). The second - a profit of $\alpha a_h^B + (1-\alpha)a_l^B$. Platform chooses between these two options by comparing profits. The choice depends on whether a^{Sl} or a_l^B is greater.

Case $Sh \to B)$

If, once Sh-users are on the platform, the intermediary decides not to attract all the users, but only buyers, so that Sl-users are not subscribing to any platform, then it must hold that it is a Nash equilibrium for B and Sl:

$$\alpha a_h^B - p^B \geq 0,$$
$$0 \geq a^{Sl} - p^{Sl}.$$

Joining no platform is not an equilibrium, it holds automatically that buyers prefer to subscribe to the platform and get a positive utility:

$$0 \leq a_h^B - p^B.$$

The resulting profit is $\alpha a_h^B + (1-\alpha)a^{Sl}$. However, the same profit can be obtained when all users participate, so it does not change the final profit value.

Case $Sl \to B + Sh$

Symmetrically, suppose that the platform has attracted Sl-users first. By a similar reasoning as for the case $Sh \to B + Sl$, it will give a profit of

$$\max\left\{(1-\alpha)a_l^B + \alpha a^{Sh}; (1-\alpha)a_l^B + \alpha a_h^B\right\}.$$

Strategy choice

The platform chooses between the five strategies of conquering the market by comparing profits. The resulting profit is the maximum of profits given by each of described strategies:

$$\pi^D = \max\left\{\alpha a^{Sh} + (1-\alpha)a^{Sl}; \alpha a_h^B + (1-\alpha)a_l^B; \alpha a_h^B + (1-\alpha)a^{Sl}; \alpha a^S + (1-\alpha)a_l^B\right\}.$$

Each of these profit values does not purely depends on the externality values a^S, a_h^B, a_l^B but on these externalities weighted by the corresponding number of users: αa^S, $(1-\alpha)a^S$, αa_h^B, $(1-\alpha)a_l^B$. It shows that platform's strategy depends on each user's characteristics and the size of each group of users.

	$a^{Sh} \geq a_h^B$	$a^{Sh} < a_h^B$
$a^{Sl} \geq a_l^B$	$\alpha a^{Sh} + (1-\alpha)a^{Sl}(p^B = 0)$	$\alpha a_h^B + (1-\alpha)a^{Sl}(p^{Sh} = 0)$
$a^{Sl} < a_l^B$	$\alpha a^{Sh} + (1-\alpha)a_l^B(p^{Sl} = 0)$	$\alpha a_h^B + (1-\alpha)a_l^B(p^{Sh} = 0, p^{Sl} = 0)$

Table 3.4: Equilibrium configurations

Sellers' price is equal either to 0 or to the full utility they obtain: $p^{Sh} = \{0, a^{Sh}\}$ and $p^{Sl} = \{0, a^{Sl}\}$. Buyers' price can take four values:

$$p^B = \{0, \alpha a^B, (1-\alpha)a_l^B, \alpha a_h^B + (1-\alpha)a_l^B\}.$$

The only cofiguration where not all users are served is the case $Sh \to B$. It gives the same profit as in the case $Sh \to B + Sl$. If we suppose that for the same profit the equilibrium that holds is the one where all the users are subscribing, then discrimination always allows to reach the optimum.

Duopoly and optimal coordination: possible equilibria under discrimination (proof of Proposition 7)

Let us consider all the possible equilibrium configurations.

1. One active platform. All users subscribe to one platform. This configuration is studied in more details in the next section.

2. Two active platforms. Buyers must be distributed between two platforms ($0 < n_i^B$, $n_j^B < 1$) because otherwise the platform with no buyers at all couldn't have attracted sellers. It means that buyers should be indifferent between two options – subscribing to one or the other platform:

$$a_h^B n_i^{Sh} + a_l^B n_i^{Sl} - p_i^B = a_h^B n_j^{Sh} + a_l^B n_j^{Sl} - p_j^B \geq 0.$$

We suppose that if utility is zero users prefer to subscribe to a platform rather than stay apart. For the sellers, there are several possible configurations: 2a, 2b and 2c below.

2a. Let us consider the following equilibrium configuration: a part of each sellers' type is subscribed to one platform, the rest of sellers - to the other platform: $0 < n_i^{Sh} < \alpha$ and $0 < n_i^{Sl} < 1 - \alpha$. The necessary condition to maintain the equilibrium is for each group of sellers to be indifferent between subscribing to each of the platforms:

$$a^{Sh} n_i^B - p_i^{Sh} = a^{Sh} n_j^B - p_j^{Sh} \geq 0$$

$$a^{Sl} n_i^B - p_i^{Sl} = a^{Sl} n_j^B - p_j^{Sl} \geq 0$$

However, such configuration is unstable. Indeed, all users can switch to one platform and every group of users could get more utility. If everybody switches to i, the utility of buyers, high-type sellers and low-type sellers respectively will be higher than in the current equilibrium:

$$U^B = a_h^B \alpha + a_l^B (1 - \alpha) - p_i^B > a_h^B n_i^{Sh} + a_l^B n_i^{Sl} - p_i^B = a_h^B n_j^{Sh} + a_l^B n_j^{Sl} - p_j^B,$$

$$U^{Sh} = a^{Sh} - p_i^{Sh} > a^{Sh} n_i^B - p_i^{Sh} = a^{Sh} n_j^B - p_j^{Sh},$$

$$U^{Sl} = a^{Sl} - p_i^{Sl} > a^{Sl} n_i^B - p_i^{Sl} = a^{Sl} n_j^B - p_j^{Sl}.$$

Hence, the distribution of users where both sellers' groups are distributed between two platforms, is not possible in equilibrium.

2b. Let us consider the following equilibrium configuration: all Sh-users are subscribed to one platform i $(i, j = 1, 2,\ j \neq i)$: $n_i^{Sh} = \alpha$ while Sl-users are dispatched between two platforms: $0 < n_i^{Sl} < 1 - \alpha$. It means that Sh-users are better off on Platform i:

$$a^{Sh} n_i^B - p_i^{Sh} \geq a^{Sh} n_j^B - p_j^{Sh}.$$

Sl-users are indifferent between subscribing to one or another platform:

$$a^{Sl} n_i^B - p_i^{Sl} = a^{Sl} n_j^B - p_j^{Sl}.$$

However, such configuration is unstable. Indeed, all users can switch to Platform i and get a higher utility.

2c. All Sh-users are subscribed to Platform i $(i, j = 1, 2,\ j \neq i)$, all Sl-users - to Platform j. The sellers' preference conditions will write:

$$a^{Sh} n_i^B - p_i^{Sh} \geq \max\{0, a^{Sh} n_j^B - p_j^{Sh}\},$$

$$a^{Sl} n_j^B - p_j^{Sl} \geq \max\{0, a^{Sl} n_i^B - p_i^{Sl}\}.$$

For buyers it should hold that they are indifferent:

$$\alpha a_h^B - p_i^B = (1-\alpha) a_l^B - p_j^B.$$

If all users switch to the platform i, Sl-users are not better off if

$$(a^{Sl} - p_i^{Sl}) < (a^{Sl} n_j^B - p_j^{Sl}).$$

Similarly, Sh-users do not switch to Platform j if $a^{Sh} n_i^B - p_i^{Sh} > a^{Sh} - p_j^{Sh}$. It should hold that both intermediaries' profits are non-negative:

$$n_i^B p_i^B + \alpha p_i^{Sh} \geq 0,$$

$$n_j^B p_j^B + (1-\alpha) p_j^{Sl} \geq 0.$$

Let us analyse stability of this equilibrium.

If p_i^B was positive, then platform i could slightly decrease its buyers price and get a higher profit since all the buyers will migrate to it and vice versa. Consequently, it must hold that $p_i^B \leq 0$ and $p_j^B \leq 0$. Then, for both profits to be non-negative, it must hold that $p_i^{Sh} \geq 0$ and $p_j^{Sl} \geq 0$.

At least one of B prices is negative. Suppose $p_j^B < 0$. Then $p_j^{Sl} > 0$. But then Platform i will cut down price from

$$p_i^{Sl} > p_j^{Sl} + a^{Sl}(1 - n_j^B) > 0$$

to

$$p_i^{Sl} = p_j^{Sl} + a^{Sl}(1 - n_j^B) > 0.$$

It will allow Platform i to get an additional positive profit equal to

$$(1-\alpha)(p_j^{Sl} + a^{Sl}(1-n_j^B)) > 0.$$

Consequently, only dominant-firm equilibria are sustainable.

□

Duopoly and optimal coordination: dominant-firm equilibrium under discrimination

Proof. Take $i = 1$. Let us consider deviation strategies that can be adopted by the platform 2 trying to enter the market.

Equilibrium requires that all these strategies are non-profitable.

Optimal coordination strategy

Opt Coord) Based on users' ability to optimally coordinate, platform 2 charges slightly less to all groups of users and gains the whole market. It is a consequence of discontinuous demands because of network effects and users' beliefs. In order for the dominant-firm equilibrium to be stable, the deviation profit should not be greater than zero:

$$\alpha p_1^{Sh} + (1-\alpha)p_1^{Sl} + p_1^B \leq 0$$

It implies that the active intermediary's profit can never be greater than zero.

Divide-and-conquer strategies

Platform 2 adopts a strategy consisting in attracting a part of users by a negative price, and then extracting surplus from the remaining users who will come to join them on Platform 2.

B → Sh + Sl) Potential entrant may attract all buyers first and then extracts profit from sellers. Specifically, it attracts buyers by charging p_2^B such that buyers are better off on Platform 2 even if there are no sellers

$$-p_2^B \geq \alpha a_h^B + (1-\alpha)a_l^B - p_1^B \geq 0$$

This utility is non-negative as it satisfies the participation constraints imposed on Platform 1.

Once the buyers are already on the platform, p_2^{Sh} is chosen so that

$$a^S - p_2^{Sh} \geq \max\{0, -p_1^{Sh}\}$$

and p_2^{Sl} is chosen so that

$$a^S - p_2^{Sl} \geq \max\{0, -p_1^{Sl}\}.$$

Platform 2 sets prices so that to maximize profit, all the constraints are active:

$$\begin{aligned} p_2^B &= -\alpha a_h^B - (1-\alpha)a_l^B - p_1^B, \\ p_2^{Sh} &= a^S + \min\{0, p_1^{Sh}\}, \\ p_2^{Sl} &= a^S + \min\{0, p_1^{Sl}\}. \end{aligned}$$

Substituting it into the profit function, we obtain the profit of platform 2:

$$\alpha(a^S + \min\{0, p_1^{Sh}\}) + (1-\alpha)(a^S + \min\{0, p_1^{Sl}\}) - p_1^B - \alpha a_h^B - (1-\alpha)a_l^B$$

$\mathbf{Sh} + \mathbf{Sl} \rightarrow \mathbf{B}$) Platform 2 attracts only sellers first. It should charge the prices such that $-p_2^{Sh} \geq a^S - p_1^{Sh}$ and $-p_2^{Sl} \geq a^S - p_1^{Sl}$. Then it extracts profit from buyers by charging

$$\alpha a_h^B + (1-\alpha)a_l^B - p_2^B \geq \max\{0, -p_1^B\}.$$

It gives the deviation profit of

$$\alpha(p_1^{Sh} - a^S) + (1-\alpha)(p_1^{Sl} - a^S) + \alpha a_h^B + (1-\alpha)a_l^B + \min\{0, p_1^B\}.$$

Sh) Another group of divide-and-conquer strategies consists in attracting only Sh-users first. They will switch if:

$$-p_2^{Sh} \geq \max\{a^S - p_1^{Sh}, 0\} = a^S - p_1^{Sh}.$$

Sh → B + Sl) Then, both buyers and sellers of low type follow sellers of high type and it is possible to extract the whole surplus from these two groups. They should be better off on Platform 2 than on Platform 1. They can coordinate on one of these platforms:

$$\alpha a_h^B + (1-\alpha)a_l^B - p_2^B \geq \max\{(1-\alpha)a_l^B - p_1^B, 0\},$$
$$a^S - p_2^{Sl} \geq \max\{a^S - p_1^{Sl}, 0\}.$$

It is equivalent to

$$p_2^B \leq \alpha a_h^B + \min\{p_1^B, (1-\alpha)a_l^B\},$$
$$p_2^{Sl} \leq \min\{p_1^{Sl}, a^S\} = p_1^{Sl}.$$

The resulting profit is

$$\alpha(p_1^{Sh} - a^S) + (1-\alpha)p_1^{Sl} + \min\{p_1^B, (1-\alpha)a_l^B\} + \alpha a_h^B.$$

Sh → nB) Only a part of buyers n_2^B switch to the second platform. Sl-users prefer to stay with Platform 1. For buyers it should hold that:

$$\alpha a_h^B - p_2^B = (1-\alpha)a_l^B - p_1^B.$$

The corresponding profit must be equal to

$$\alpha(p_1^{Sh} - a^S) + n_2^B(p_1^B + \alpha a_h^B - (1-\alpha)a_l^B).$$

How to determine n_2^B? It should be such that Sl-users prefer to stay with Platform 1 and Sh-users prefer to switch:

$$n_1^B a^S - p_1^{Sh} \leq n_2^B a^S - p_2^{Sh},$$

$$n_1^B a^S - p_1^{Sl} \geq n_2^B a^S - p_2^{Sl}.$$

The first condition holds automatically because $-p_2^{Sh} \geq a^S - p_1^{Sh}$ holds. The second condition holds if p_2^{Sl} is sufficiently high.

Sl) Platform 2 attracts only Sl-users first. The price should satisfy

$$-p_2^{Sl} \geq a^S - p_1^{Sl}.$$

$\mathbf{Sl} \rightarrow \mathbf{B} + \mathbf{Sh}$) Both buyers and sellers follow l-sellers if:

$$\alpha a_h^B + (1-\alpha)a_l^B - p_2^B \geq \max\{\alpha a_h^B - p_1^B, 0\},$$

and

$$a^S - p_2^{Sh} \geq \max\{a^S - p_1^{Sh}, 0\} = a^S - p_1^{Sh},$$

which is equivalent to

$$p_2^B \leq \min\{p_1^B, \alpha a_h^B\} + (1-\alpha)a_l^B$$

and

$$p_2^{Sh} \leq p_1^{Sh}.$$

Corresponding profit equals

$$(1-\alpha)(p_1^{Sl} - a^S) + \alpha p_1^{Sh} + \min\{p_1^B, \alpha a_h^B\} + (1-\alpha)a_l^B.$$

$\mathbf{Sl} \rightarrow \mathbf{nB}$) Only a part of buyers follow l-sellers. Buyers should be indifferent:

$$(1-\alpha)a_l^B - p_2^B = \alpha a_h^B - p_1^B.$$

Corresponding deviation profit will be equal to

$$(1-\alpha)(p_1^{Sl} - a^S) + n_2^B(p_1^B - (1-\alpha)a_l^B - \alpha a_h^B).$$

□

Duopoly and optimal coordination: possible equilibria under no discrimination (proof of Proposition 8)

Proof. **2 active platforms**

Buyers are distibuted between two platforms: $0 < n_i^B, n_j^B < 1$. Then, buyers are indifferent between subscribing to one or the other platform:

$$a_h^B n_i^{Sh} + a_l^B n_i^{Sl} - p_i^B = a_h^B n_j^{Sh} + a_j^B n_j^{Sl} - p_j^B \geq 0.$$

We consider different cases of sellers' distribution:

(2a) $0 < n_i^{Sh} < \alpha$ and $0 < n_i^{Sl} \leq 1-\alpha$:

We write the condition that sellers are indifferent:

$$a^{Sh} n_i^B - p_i^S = a^{Sh} n_j^B - p_j^B \geq 0,$$

$$a^{Sl} n_i^B - p_i^S = a^{Sl} n_j^B - p_j^S.$$

However, such configuration is unstable: all users can switch to one platform and obtain a higher utility.

(2b) case $n_i^{Sh} = \alpha$, $n_j^{Sh} = 0$ and $0 < n_i^{Sl} < 1-\alpha$, $0 < n_j^{Sl} < 1-\alpha$:

We obtain the following conditions:

$$a^{Sh} n_i^B - p_i^S \geq a^{Sh} n_j^B - p_j^S,$$

$$a^{Sl}n_i^B - p_i^S = a^{Sl}n_j^B - p_j^S.$$

Such configuration is unstable, because all users switch to Platform i.

(2c) case $0 < n_i^{Sh} < \alpha$, $0 < n_j^{Sh} < \alpha$, $n_j^{Sl} = 1 - \alpha$, $n_i^{Sl} = 0$:

similarly to (2b), all users switch to Platform i.

(2d) case $n_i^{Sh} = \alpha$, $n_j^{Sh} = 0$ and $n_j^{Sl} = 1 - \alpha$, $n_i^{Sl} = 0$:

$$a^{Sh}n_i^B - p_i^S \geq \max\{0; a^{Sh}n_j^B - p_j^S\},$$

$$a^{Sl}n_i^B - p_i^S \geq \max\{0; a^{Sl}n_j^B - p_j^S\},$$

$$\alpha a_h^B - p_i^B = (1-\alpha)a_l^B - p_j^B.$$

If all users switch to Platform i, Sl-users lose in the case

$$a^{Sl} - p_i^S \leq a^{Sl}n_j^B - p_j^S,$$

which is equivalent to

$$0 < (1 - n_j^B)a^{Sl} \leq p_i^S - p_j^S.$$

In the same time, if all users switch to Platform j, Sh users lose in the case

$$a^{Sh} - p_j^S \leq a^{Sh}n_i^B - p_i^S$$

or

$$0 < (1 - n_i^B)a^{Sh} \leq p_j^S - p_i^S.$$

Clearly, these conditions cannot hold simultaneously. Consequently, all users will switch to one of two platforms and the configuration is unstable.

Dominant-firm equilibria

Given Platform 2's deviation strategies, the problem of Platform 1 writes:

$$\begin{cases} p_1^S + p_1^B \to \max\limits_{p_1^S, p_1^B}, & \\ p_1^B \le \alpha a_h^B + (1-\alpha) a_l^B, & \text{Participation } B \\ p_1^S \le a^S, & \text{Participation } S \\ p_1^S + p_1^B \le 0, & \text{Optomal Coordination} \\ p_1^S + \min\{p_1^B, 0\} \le a^S - \alpha a_h^B - (1-\alpha) a_l^B, & S \to B \\ p_1^B + \min\{p_1^S, 0\} \le \alpha a_h^B + (1-\alpha) a_l^B - a^S, & B \to S \end{cases}$$

In all cases, the value of the objective function is bounded by 0. We show that this value is always reachable: $p_1^S + p_1^B = 0$. Prices cannot be simultaneously positive because their sum is zero. The interval of possible prices is given by three cases below:

- (a) if $a^S - \alpha a_h^B - (1-\alpha) a_l^B > 0$, then prices are given as

$$\begin{cases} & p_1^S + p_1^B & = & 0, \\ -a^S \le & p_1^B & \le & \alpha a_h^B + (1-\alpha) a_l^B - a^S, \\ a^S - \alpha a_h^B - (1-\alpha) a_l^B \le & p_1^S & \le & a^S. \end{cases}$$

- (b) if $a^S - \alpha a_h^B - (1-\alpha) a_l^B < 0$, then prices are given as

$$\begin{cases} & p_1^S + p_1^B & = & 0, \\ -a^B \le & p_1^S & \le & a^S - \alpha a_h^B - (1-\alpha) a_l^B, \\ \alpha a_h^B + (1-\alpha) a_l^B - a^S \le & p_1^B & \le & \alpha a_h^B - (1-\alpha) a_l^B. \end{cases}$$

- (c) if $a^S - \alpha a_h^B - (1-\alpha) a_l^B = 0$, then prices are given as

$$\begin{cases} & p_1^S + p_1^B & = & 0 \\ -a^S \le & p_1^B & \le & \alpha a_h^B + (1-\alpha) a_l^B \\ -\alpha a_h^B - (1-\alpha) a_l^B \le & p_1^S & \le & a^S \end{cases}$$

Case (a). Let us consider the case $a^S - \alpha a_h^B - (1-\alpha) a_l^B > 0$.

We have that

$$p_1^S + \min\{p_1^B, 0\} \leq p_1^S + p_1^B \leq 0 \leq a^S - \alpha a_h^B - (1-\alpha)a_l^B,$$

hence we can safely ignore the fourth condition. If $p_1^S < 0$, then the last condition rewrites

$$p_1^B + \min\{p_1^S, 0\} = p_1^B + p_1^S \leq \alpha a_h^B + (1-\alpha)a_l^B - a^S < 0$$

and zero objective value cannot be reached; thus we look for solutions in the domain $p_1^S \geq 0$. Our problem becomes

$$\begin{cases} p_1^S + p_1^B \to \max_{p_1^S, p_1^B}, \\ p_1^B \leq \alpha a_h^B + (1-\alpha)a_l^B, \\ 0 \leq p_1^S \leq a^S, \\ p_1^S + p_1^B = 0, \\ p_1^B \leq \alpha a_h^B + (1-\alpha)a_l^B - a^S \leq 0. \end{cases}$$

which immediately leads to the solution

$$\begin{array}{rcl} p_1^S + p_1^B & = & 0, \\ -a^S \leq & p_1^B & \leq \alpha a_h^B + (1-\alpha)a_l^B - a^S, \\ a^S - \alpha a_h^B - (1-\alpha)a_l^B \leq & p_1^S & \leq a^S. \end{array}$$

Case (b). Given the symmetry of the problem, one can easily write the solution for the case $a^S - \alpha a_h^B - (1-\alpha)a_l^B < 0:$

$$\begin{array}{rcl} p_1^S + p_1^B & = & 0, \\ -a^B \leq & p_1^S & \leq a^S - \alpha a_h^B - (1-\alpha)a_l^B, \\ \alpha a_h^B + (1-\alpha)a_l^B - a^S \leq & p_1^B & \leq \alpha a_h^B - (1-\alpha)a_l^B. \end{array}$$

Case (c). One particular case stands out of the structure “one price is always positive, one price is always negative". If we take $a^S - \alpha a_h^B - (1-\alpha)a_l^B = 0$, then the system rewrites

$$\begin{cases} p_1^S + p_1^B \to \max\limits_{p_1^S, p_1^B}, \\ p_1^B \leq \alpha a_h^B + (1-\alpha)a_l^B, \\ p_1^S \leq a^S, \\ p_1^S + p_1^B \leq 0, \\ p_1^S + \min\{p_1^B, 0\} \leq 0, \\ p_1^B + \min\{p_1^S, 0\} \leq 0. \end{cases}$$

which leads to the solution

$$\begin{array}{rcl} p_1^S + p_1^B & = & 0, \\ -a^S \leq & p_1^B & \leq \alpha a_h^B + (1-\alpha)a_l^B, \\ -\alpha a_h^B - (1-\alpha)a_l^B \leq & p_1^S & \leq a^S. \end{array}$$

Thus, the objective value $p_1^S + p_1^B = 0$ can be always reached. □

Duopoly and competition between incumbent and entrant: possible equilibria under discrimination (proof of Proposition 9)

Equilibria with only Platform 1 active

Let us consider Platform 1-active equilibria.

Platform 2 has multiple deviation strategies.

We start with the first deviation strategy where Platform 2 prefers to first attract buyers and then sellers. Platform 2 charges buyers such price that they prefer to join even though it does not have any subscribers:

$$a^B - p_1^B \leq -p_2^B,$$

where $a^B = \alpha a_h^B + (1-\alpha)a_l^B$. Then, the table of gains for the remaining users writes:

Sl \ Sh	Platform 1	Platform 2	none
Platform 1	$-p_1^{Sl}$ $-p_1^{Sh}$	$-p_1^{Sl}$ $a^S - p_2^{Sh}$	$-p_1^{Sl}$ 0
Platform 2	$a^S - p_2^{Sl}$ $-p_1^{Sh}$	$a^S - p_2^{Sl}$ $a^S - p_2^{Sh}$	$a^S - p_2^{Sl}$ 0
none	0 $-p_1^{Sh}$	0 $a^S - p_2^{Sh}$	0 0

Table 3.5: Affiliation game between Sl and Sh with expectations in favour of Platform 1

Platform 2 has three alternatives: either it attracts both Sh and Sl, or only Sh, or only Sl.

Option 1: both Sh and Sl-users are attracted (‘$\mathbf{B} \rightarrow \mathbf{Sh} + \mathbf{Sl}$’)

It must be a Nash equilibrium for Sl and Sh-users:

$$a^S - p_2^{Sh} \geq \max\{0; -p_1^{Sh}\},$$

$$a^S - p_2^{Sl} \geq \max\{0; -p_1^{Sl}\}.$$

It must also hold that subscribing to Platform 1 for Sl and Sh is not a Nash equilibrium:

$$-p_1^{Sh} \leq \max\{a^S - p_2^{Sh}; 0\},$$

$$-p_1^{Sh} \leq \max\{a^S - p_2^{Sh}; 0\}.$$

These conditions follow from the previous conditions and so hold automatically.

The corresponding deviation profit must be non-positive:

$$p_1^B - a^B + \alpha(a^S - \max\{-p_1^{Sh}; 0\}) + (1-\alpha)(a^S - \max\{-p_1^{Sl}; 0\}).$$

Option 2: only Sh-users are attracted (‘$\mathbf{B} \rightarrow \mathbf{Sh}$’)

Platform 2 charges p_2^{Sh} and p_2^{Sl} such that only Sh-users subscribe. It is a Nash equilibrium whenever

$$a^S - p^{Sh} \geq \max\{0; -p_1^{Sh}\},$$
$$0 \geq \max\{a^S - p_2^{Sl}; -p_1^{Sl}\}.$$

It must also hold that subscribing to Platform 1 is not an equilibrium:

$$-p_1^{Sh} \leq \max\{a^S - p_2^{Sh}; 0\},$$

$$-p_1^{Sl} \leq \max\{a^S - p_2^{Sl}; 0\}.$$

That holds automatically. The corresponding profit is

$$p_1^B - a^B + \alpha(a^S - \max\{0; -p_1^{Sh}\}) \leq 0$$

We note that this profit is lower than in the option 1, so this option is never chosen by the platform.

Option 3: only Sl-users are attracted ('**B** $\rightarrow$ **Sl**')

This symmetric strategy will give a profit of

$$p_1^B - a^B + (1-\alpha)(a^S - \max\{0; -p_1^{Sl}\}) \leq 0$$

This profit is also lower than in option 1, so this option is never chosen by the platform.

Now let us consider the strategy where Platform 2 attracts sellers first and then buyers ('**Sh** + **Sl** $\rightarrow$ **B**'). This strategy was accessible without discrimination. It charges sellers such price that

$$a^S - p_1^{Sl} \leq -p_2^{Sl},$$
$$a^S - p_1^{Sh} \leq -p_2^{Sh}.$$

Then it charges p_2^B such that

$$a^B - p_2^B \geq \max\{0; -p_1^B\}$$

The profit is $a^B - \max\{0; -p_1^B\} + \alpha(p_1^{Sh} - a^S) + (1-\alpha)(p_1^{Sl} - a^S)$

The third strategy consists in first attracting only a part of sellers (Sl). Then the table of gains for the remaining users is

B \ Sh	Platform 1	Platform 2	none
Platform 1	$\alpha a_h^B - p_1^B$ $a^S - p_1^{Sh}$	$-p_1^B$ $-p_2^{Sh}$	$-p_1^B$ 0
Platform 2	$(1-\alpha)a_l^B - p_2^B$ $-p_1^{Sh}$	$a^B - p_2^B$ $a^S - p_2^{Sh}$	$(1-\alpha)a_l^B - p_2^B$ 0
none	0 $-p_1^{Sh}$	0 $a^S - p_2^{Sh}$	0 0

Table 3.6: Affiliation game between B and Sh with expectations in favour of platform 1

Subscribing to Platform 2 must be a Nash equilibrium:

$$a^B - p_2^B \geq \max\{-p_1^B; 0\},$$

$$a^S - p_2^{Sh} \geq \max\{-p_1^{Sh}; 0\}.$$

It must also hold that subscribing to Platform 1 instead is not an equilibrium:

$$\alpha a_h^B - p_1^B \leq \max\{(1-\alpha)a_l^B - p_2^B; 0\}$$

or

$$a^S - p_1^{Sh} \leq \max\{-p_2^{Sh}; 0\}.$$

The second condition can never hold because it would imply

$$p_2^{Sh} = p_1^{Sh} - a^S \leq 0.$$

This condition implies $p_2^{Sh} = p_1^{Sh} - a^S \leq 0$, but it means considering the case '**Sh** + **Sl** $\rightarrow$ **B**' that has already been considered. That is why the first condition must hold.

$$a^B \geq \max\{-p_1^B; 0\}; \alpha_h^B - p_1^B \leq \max\{(1-\alpha)a_l^B - p_2^B; 0\}.$$

The solution will be:

$$p_2^B = \begin{cases} (1-\alpha)a_l^B + \alpha a_h^B, & \text{if } p_1^B \geq \alpha a_h^B, \\ (1-\alpha)a_l^B - \alpha a_h^B + p_1^B, & \text{otherwise.} \end{cases}$$

The corresponding profit is

$$\begin{cases} (1-\alpha)a_l^B + \alpha a_h^B + \alpha(a^S + \min\{0; p_1^{Sh}\}) + (1-\alpha)(p_1^{Sl} - a^S), & \text{if } p_1^B \geq \alpha a_h^B, \\ (1-\alpha)a_l^B - \alpha a_h^B + p_1^B + \alpha(a^S + \min\{0; p_1^{Sh}\}) + (1-\alpha)(p_1^{Sl} - a^S), & \text{otherwise.} \end{cases}$$

There is another strategy for Platform 2: it could attract Sl-users and then B-users. For it to be an equilibrium it must hold that:

$$(1-\alpha)a_l^B - p_2^B \geq \max\{0; -p_1^B\},$$

$$0 \geq \max\{-p_1^{Sh}; a^S - p_2^{Sh}\}.$$

Additionally, joining Platform 1 should not be an equilibrium. In order to reach it, p_2^{Sh} should be sufficiently high:

$$a^S - p_1^{Sh} \leq \max\{0; -p_2^{Sh}\}$$

The profit in this case is

$$(1-\alpha)a_l^B + \min\{0; p_1^B\} + (1-\alpha)(p^{Sl} - a^S)$$

This profit always gives a lower profit than the previous strategy. Consequently, this deviation strategy is not profitable whenever the preceding strategy is not profitable.

The symmetric strategy '$Sl \to B + Sh$' gives the profit of

$$\begin{cases} \alpha a_h^B + (1-\alpha)a_l^B + (1-\alpha)(a^S + \min\{0; p_1^{Sl}\}) + \alpha(p_1^{Sh} - a^S), & \text{if } p_1^B \geq (1-\alpha)a_l^B, \\ -(1-\alpha)a_l^B - \alpha a_h^B + p_1^B + (1-\alpha)(a^S + \min\{0; p_1^{Sl}\}) + \alpha(p_1^{Sh} - a^S), & \text{otherwise.} \end{cases}$$

Then Platform 1's problem writes:

$$
\begin{cases}
p_1^B + \alpha p_1^{Sh} + (1-\alpha) p_1^{Sl} \to \max & \\
p_1^B \leq a^B & \text{participation } B \\
p_1^{Sh} \leq a^S & \text{participation } Sh \\
p_1^{Sl} \leq a^S & \text{participation } Sl \\
p_1^B + \alpha \min\{p_1^{Sh}; 0\} + (1-\alpha) \min\{p_1^{Sl}; 0\} \leq a^B - a^S & B \to Sh + Sl \\
\min\{0; p_1^B\} + \alpha p_1^{Sh} + (1-\alpha) p_1^{Sl} \leq a^S - a^B & Sh + Sl \to B
\end{cases}
$$

$$
\begin{cases}
\alpha \min\{0; p_1^{Sh}\} + (1-\alpha) p_1^{Sl} \leq (1-2\alpha) a^S - (1-\alpha) a_l^B - \alpha a_h^B, & \text{if } p_1^B \geq \alpha a_h^B \\
p_1^B + \alpha \min\{0; p_1^{Sh}\} + (1-\alpha) p_1^{Sl} \leq (1-2\alpha) a^S - (1-\alpha) a_l^B + \alpha a_h^B, & \text{otherwise}
\end{cases}
$$

$(Sh \to B + Sl)$

$$
\begin{cases}
(1-\alpha) \min\{0; p_1^{Sl}\} + \alpha p_1^{Sh} \leq -\alpha a_h^B - (1 - \alpha a_l^B - (1-2\alpha) a^S), & \text{if } p_1^B \geq (1-\alpha) a_l^B \\
p_1^B + (1-\alpha) \min\{0; p_1^{Sl}\} + \alpha p_1^{Sh} \leq -\alpha a_h^B + (1 - \alpha a_l^B - (1-2\alpha) a^S), & \text{otherwise}
\end{cases}
$$

$(Sl \to B + Sh)$

Let us show that Platform 1 indeed always gets a zero profit whenever $a^S = 0$. The constraint $B \to Sh + Sl$ is never active. Let us consider the following cases:

a) $p_1^B \leq 0$ Let us analyse the following constraints:

$$
\begin{aligned}
p_1^{Sh} &\leq 0 \quad ParticSh \\
p_1^{Sl} &\leq 0 \quad ParticSl \\
p_1^B + \alpha p_1^{Sh} + (1-\alpha) p_1^{Sl} &\leq -a^B \quad Sh + Sl \to B
\end{aligned}
$$

From the last constraint it follows that the objective function takes only negative value, so that platform is never active.

b) $0 < p_1^B \leq \min\{\alpha a_h^B, (1-\alpha) a_l^B\}$ Let us analyse the following constraints:

$$\begin{aligned} p_1^{Sh} &\leq 0 \quad ParticSh \\ p_1^{Sl} &\leq 0 \quad ParticSl \\ \alpha p_1^{Sh} + (1-\alpha)p_1^{Sl} &\leq a^S - a^B \quad Sh + Sl \to B \end{aligned}$$

it gives

$$p_1^B + \alpha p_1^{Sh} + (1-\alpha)p_1^{Sl} \leq -a^B + \min\{\alpha a_h^B, (1-\alpha)a_l^B\} < 0$$

The profit is negative.

c) we suppose $\alpha a_h^B < (1-\alpha)a_l^B$ and take $\alpha a_h^B \leq p_1^B < (1-\alpha)a_l^B$ Let us take the following constraints:

$$\begin{aligned} p_1^{Sh} &\leq 0 \quad \text{participation } Sh \\ p_1^{Sl} &\leq 0 \quad \text{participation } Sl \\ \alpha p_1^{Sh} + (1-\alpha)p_1^{Sl} &\leq -a^B \quad Sh + Sl \to B \end{aligned}$$

It gives

$$p_1^B + \alpha p_1^{Sh} + (1-\alpha)p_1^{Sl} \leq -a^B + (1-\alpha)a_l^B < 0.$$

The profit is negative.

Now suppose $\alpha a_h^B \geq (1-\alpha)a_l^B$ and take $\alpha a_h^B \geq p_1^B > (1-\alpha)a_l^B$ Let us take the same constraints:

$$\begin{aligned} p_1^{Sh} &\leq 0 \quad \text{participation } Sh \\ p_1^{Sl} &\leq 0 \quad \text{participation } Sl \\ \alpha p_1^{Sh} + (1-\alpha)p_1^{Sl} &\leq -a^B \quad Sh + Sl \to B \end{aligned}$$

It gives

$$p_1^B + \alpha p_1^{Sh} + (1-\alpha)p_1^{Sl} \leq -a^B + \alpha a_h^B < 0$$

The profit is negative.

d) $p_1^B \geq \max\{\alpha a_h^B; (1-\alpha a_l^B)\}$ Let us analyse all the constraints:

$$\begin{cases} p_1^B \leq a^B & \text{partic}B \\ p_1^{Sh} \leq 0 & \text{partic}Sh \\ p_1^{Sl} \leq 0 & \text{partic}Sl \\ \alpha p_1^{Sh} + (1-\alpha)p_1^{Sl} \leq a^S - a^B & Sh + Sl \to B \\ \alpha \min\{0; p_1^{Sh}\} + (1-\alpha)p_1^{Sl} \leq (1-2\alpha)a^S - (1-\alpha)a_l^B - \alpha a_h^B & \\ (1-\alpha)\min\{0; p_1^{Sl}\} + \alpha p_1^{Sh} \leq -\alpha a_h^B - (1-\alpha a_l^B - (1-2\alpha)a^S) & \text{if } p_1^B \geq (1-\alpha)a_l^B \end{cases}$$

All these constraints are satisfied for $p_1^B = a^B$ and $\alpha p_1^{Sh} + (1-\alpha)p_1^{Sl} \leq -a^B$. The corresponding profit is zero.

3. Equilibria with only Platform 2 active

Now let us consider Platform 2-active equilibria. Let us show that such equilibrium is not sustainable, so that the entrant can never conquer the market.

Platform 1's deviation strategy consists in charging such prices that joining Platform 1 is a Nash equilibrium. So, it is sufficient to charge:

$$\begin{cases} a^B - p_1^B \geq \max\{0; -p_2^B\} \\ a^S - p_1^{Sh} \geq \max\{0; -p_2^{Sh}\} \\ a^S - p_1^{Sl} \geq \max\{0; -p_2^{Sl}\} \end{cases}$$

Platform 2 has to charge such prices that the corresponding profit is non-positive:

$$a^B + \min\{0; p_2^B\} + \alpha(a^S + \min\{0; p_2^{Sh}\}) + (1-\alpha)(a^S + \min\{0; p_2^{Sl}\}) \leq 0$$

Let us confront this constraint with participation constraints of Platform 2:

$$\begin{cases} a^S - p_2^{Sh} \geq 0 \\ a^S - p_2^{Sl} \geq 0 \\ a^B - p_2^B \geq 0 \end{cases}$$

Let us consider the following cases depending on the signs of prices.

If $p_2^B \geq 0$, $p_2^{Sh} \geq 0$ and $p_2^{Sl} \geq 0$, then the constraint rewrites

$$p^B + \alpha p_2^{Sh} + (1-\alpha)p_2^{Sl} \leq -a^B - \alpha a^S - (1-\alpha)a^S,$$

but then the profit is strictly negative.

If $p_2^B \geq 0$, $p_2^{Sh} < 0$ and $p_2^{Sl} < 0$, then the constraint rewrites

$$\alpha p_2^{Sh} + (1-\alpha)p_2^{Sl} \leq -a^B - \alpha a^S - (1-\alpha)a^S.$$

But then for Platform 2's profit to be non-negative, it needs to extract at least $a^B + \alpha a^S + (1-\alpha)a^S$ from buyers, which is impossible given the participation condition. Similarly, there does not exist any solution with the positive value of the objective function and two negative prices.

If only one of prices is negative, $p_2^B < 0$, $p_2^{Sh} \geq 0$ and $p_2^{Sl} \geq 0$, then the constraint rewrites

$$p^B \leq -a^B - \alpha a^S - (1-\alpha)a^S,$$

but then the platform should extract $a^B + \alpha a^S + (1-\alpha)a^S$ from sellers, which is impossible given the participation constraints.

There does not exist such prices for which Platform 2's profit is non-negative. It is too difficult for Platform 2 to convince users to join.

Duopoly and competition between incumbent and entrant: possible equilibria under no discrimination (proof of Proposition 9 continued)

Proof. Below we consider all three possible equilibrium configurations: two active platforms, only Platform 1 is active, only Platform 2 is active.

Equilibria with two active platforms

Let us show that the configuration with two active platforms is never stable. Buyers have to be indifferent between subscribing to Platform 1 and to Platform 2:

$$n^S h_1 a_h^B + n^S l_1 a_l^B - p_1^B = n^S h_2 a_h^B + n^S l_2 a_l^B - p_2^B \geq 0.$$

A similar condition should hold for sellers:

$$n_1^B a^S - p_1^S = n_2^B a^S - p_2^S \geq 0.$$

But then all users could switch to Platform 1 so that it gets a higher profit and users get a higher utility. The new equilibrium would be stable because all users would get a maximal utility for given prices and prefer to stay on Platform 1 to other options:

$$\begin{cases} a^S - p_1^S \geq \max\{0; -p_2^S\} \\ a^B - p_1^B \geq \max\{0; -p_2^B\}. \end{cases}$$

Consequently, there are no equilibria with two active platforms.

Dominant-firm equilibria

Since there are no market-sharing equilibria, users of each type have only three options: subscribe to Platform 1, to Platform 2, to neither of them. Let us write down the table of gains for the affiliation game between buyers and sellers:

buyers \ sellers	Platform 1	Platform 2	none
Platform 1	$a^B - p_1^B$ $a^S - p_1^S$	$-p_1^B$ $-p_2^S$	$-p_1^B$ 0
Platform 2	$-p_2^B$ $-p_1^{Sl}$	$a^B - p_2^B$ $a^S - p_2^S$	$-p_2^B$ 0
none	0 $-p_1^S$	0 $-p_2^S$	0 0

Table 3.7: Affiliation game between B and S with unfavourable expectations under duopoly

Equilibria with only Platform 1 active

Let us consider Platform 1-dominant equilibrium. All users subscribe to Platform 1 whenever it is rational (whenever it is a Nash equilibrium):

$$\begin{cases} a^S - p_1^S \geq \max\{0; -p_2^S\} \\ a^B - p_1^B \geq \max\{0; -p_2^B\}. \end{cases}$$

Platform 2's deviation strategies consist in undermining this equilibrium by making either sellers or buyers leave Platform 1:

- Platform 2 attracts buyers by charging p_2^B such that $a^B - p_1^B \leq -p_2^B$ and then extracts surplus from sellers by charging p_2^S such that $a^S - p_1^S \geq \max\{0, -p_1^S\}$ (subscribing to Platform 2 is a Nash equilibrium). The corresponding profit is $p_1^B - a^B + a^S - \max\{0, -p_1^S\}$.
- The symmetric strategy gives a profit of $p_1^S - a^S + a^B - \max(0, -p_1^B)$.

These deviation profits should be non-positive. Also, participation constraints must hold. Platform 1's problem writes:

$$\begin{cases} p_1^B + p_1^S \to \max\limits_{p_1^B, p_1^S} \\ p_1^B \leq a^B \\ p_1^S \leq a^S \\ p_1^B + \min\{0, p_1^S\} \leq a^B - a^S \\ p_1^S + \min\{0, p_1^B\} \leq a^S - a^B \end{cases}$$

The equilibrium profit is non-negative:

$$\pi = \begin{cases} a^S, & \text{if } a^B > 2a^S, \\ a^B, & \text{if } a^S > 2a^B, \\ |a^B - a^S|, & \text{otherwise.} \end{cases}$$

Platform 1-active equilibrium is sustainable.

Equilibria with only Platform 2 active

Let us now consider Platform 2 equilibrium profit. For Platform 2 to be the only active platform, non-deviation conditions by Platform 1 must hold and also participation conditions:

$$a^S - p_2^S \geq 0,$$
$$a^B - p_2^B \geq 0.$$

For Platform 1 to conquer the whole market it is sufficient to charge such prices that it is a Nash equilibrium for all users to subscribe to Platform 1:

$$a^B - p_1^B \geq \max\{0; -p_2^B\},$$

$$a^S - p_1^S \geq \max\{0; -p_2^S\}.$$

The corresponding profit is $a^B - \max\{0; -p_2^B\} + a^S - \max\{0; -p_2^S\}$. This deviation profit should be non-positive:

$$\min\{0; p_2^B\} + \min\{0; p_2^S\} \leq -a^B - a^S.$$

Let us show that this condition never allows Platform 2 to get a non-negative profit. We consider all the possible combinations of signs for prices, given that both prices cannot be negative simultaneously:

- If $p_2^B \geq 0$ and $p_2^S \geq 0$, then the condition rewrites $0 \leq -a^B - a^S$ which is never true;
- If $p_2^B \geq 0$ ($p_2^B < 0$) and $p_2^S < 0$ ($p_2^S \geq 0$), then the condition rewrites $p_2^S \leq -a^B - a^S$ ($p_2^B \leq -a^B - a^S$). But taking into account participation constraint $a^B - p_2^B \geq 0$ ($a^S - p_2^S \geq 0$), the profit is negative: $\pi \leq a^B - a^B - a^S$ ($\pi \leq a^S - a^B - a^S$).

Hence, there does not exist Platform 2-active equilibrium. Under these assumptions, potential entrant is unable to penetrate the market. □

Duopoly and competition between incumbent and entrant: a more efficient entrant (proof of Proposition 10)

Suppose that there is a fixed cost for each platform F_1 and F_2. Also, suppose that the entrant is more efficient: $F_1 < F_2$, let us denote $\Delta F = F_1 - F_2$. We suppose that even the cost of the less efficient platform is lower than the cumulated market externalities: $F_1 < a^B + a^S$, where $a^B = \alpha a_h^B + (1-\alpha) a_l^B$.

Then, the efficient equilibrium is the one in which the entrant is active. Such equilibrium is only sustainable if there exist such $p_2^B, p_2^{Sh}, p_2^{Sl}$ that the profit of Platform 2 is non-negative and the deviation profit of Platform 1 is non-positive. Platform 2's problem writes:

$$\begin{cases} p_2^B + \alpha p_2^{Sh} + (1-\alpha) p_2^{Sl} - F_2 \to \max\limits_{p_2^B, p_2^{Sh}, p_2^{Sl}}, \\ p_2^B \leq a^B, \\ p_2^{Sh} \leq a^S, \\ p_2^{Sl} \leq a^S, \\ \min\{0; p_2^B\} + \alpha \min\{0; p_2^{Sh}\} + (1-\alpha) \min\{0; p_2^{Sl}\} - F_1 \leq -a^B - a^S. \end{cases}$$

Let us solve this problem by analysing different combinations of negative and positive prices.

a) All the prices are non-negative: $p_2^B \geq 0$, $p_2^{Sh} \geq 0$, $p_2^{Sl} \geq 0$. The problem rewrites

$$\begin{cases} p_2^B + \alpha p_2^{Sh} + (1-\alpha) p_2^{Sl} - F_2 \to \max\limits_{p_2^B, p_2^{Sh}, p_2^{Sl}}, \\ p_2^B \leq a^B, \\ p_2^{Sh} \leq a^S, \\ p_2^{Sl} \leq a^S, \\ -F_1 \leq -a^B - a^S. \end{cases}$$

This system is compatible only if the last inequality holds: $F_1 \geq a^B + a^{Sh}$. However, by assumption it does not hold and the system has no solutions.

b) One of prices is negative.

(b1) Let us take the example of negative buyer price: $p_2^B < 0$, $p_2^{Sh} \geq 0$, $p_2^{Sl} \geq 0$. The problem rewrites

$$\begin{cases} p_2^B + \alpha p_2^{Sh} + (1-\alpha)p_2^{Sl} - F_2 \to \max\limits_{p_2^B, p_2^{Sh}, p_2^{Sl}}, \\ p_2^B \leq a^B, \quad \text{(inactive)} \\ p_2^{Sh} \leq a^S, \\ p_2^{Sl} \leq a^S, \\ p_2^B - F_1 \leq -a^B - a^S. \end{cases}$$

The corresponding profit of Platform 2 is equal to

$$\min\{0; F_1 - a^B - a^S\} + a^S - F_2 = F_1 - a^B - F_2.$$

This profit is non-negative whenever

$$F_2 \leq F_1 - a^B.$$

(b2) A price combination with $p_2^{Sh} < 0$ gives a profit of

$$\alpha \min\{0; F_1 - a^B - a^S\} + (1-\alpha)a^S + a^B - F_2 = \alpha F_1 + (1-\alpha)a^B + (1-2\alpha)a^S - F_2.$$

This profit is non-negative when

$$F_2 \leq \alpha F_1 + (1-\alpha)a^B + (1-2\alpha)a^S.$$

(b3) A price combination with $p_2^{Sl} < 0$ gives a profit of

$$(1-\alpha)\min\{0; F_1 - a^B - a^S\} + \alpha a^S + a^B - F_2 = (1-\alpha)F_1 + \alpha a^B + a^S - F_2.$$

This profit is non-negative whenever $F_2 \leq (1-\alpha)F_1 + \alpha a^B + a^S$.

c) Two prices are negative.

(c1) Let us take the example of negative seller prices: $p_2^B \geq 0$, $p_2^{Sh} < 0$, $p_2^{Sl} < 0$. The problem rewrites

$$\begin{cases} p_2^B + \alpha p_2^{Sh} + (1-\alpha)p_2^{Sl} - F_2 \to \max\limits_{p_2^B, p_2^{Sh}, p_2^{Sl}}, \\ p_2^B \leq a^B, \\ p_2^{Sh} \leq a^S, \quad \text{(inactive)} \\ p_2^{Sl} \leq a^S, \quad \text{(inactive)} \\ \alpha p_2^{Sh} + (1-\alpha)p_2^{Sl} - F_1 \leq -a^B - a^S. \end{cases}$$

The corresponding Platform 2's profit is

$$F_1 - F_2 - a^S.$$

This profit is non-negative when $F_2 \leq F_1 - a^S$. This profit is always lower than the profit in cases (b2) and (b3), which are based on the discriminative strategies.

(c2) The case $p_2^{Sh} \geq 0$ gives the profit of

$$\alpha a^S + \min\{F_1 - a^B - a^S; 0\} - F_2 = F_1 - F_2 - (1-\alpha)a^S - a^B.$$

This profit is non-negative whenever $F_2 \leq F_1 - (1-\alpha)a^S - a^B$. This profit is always lower than in the case (b3).

(c3) Finally, the case $p_2^{Sl} \geq 0$ yields the profit

$$(1-\alpha)a^S + \min\{F_1 - a^B - a^S; 0\} - F_2 = F_1 - F_2 - \alpha a^S - a^B.$$

The profit is non-negative under the condition $F_2 \leq F_1 - \alpha a^S - a^B$. This profit is always lower than in the case (b2).

Platform 2 compares profits from each pricing strategies described above and chooses the strategy that is the most profitable. c) is always less profitable than b).

A Platform 2-dominant equilibrium is sustainable when

$$F_1 \leq \max\{F_1 - a^B; \alpha F_1 + (1-\alpha)a^B + (1-2\alpha)a^S; (1-\alpha)F_1 + \alpha a^B + a^S\}.$$

Case of no discrimination

The problem for Platform 2 writes:

$$\begin{cases} p_2^B + p_2^S - F_2 \to \max\limits_{p_2^B, p_2^S}, \\ p_2^B \leq a^B, \\ p_2^S \leq a^S, \\ \min\{0; p_2^B\} + \min\{0; p_2^S\} - F_1 \leq -a^B - a^S. \end{cases}$$

(a) The case where both prices are non-negative ($p_2^B \geq 0$, $p_2^S \geq 0$) is impossible since $a^B + a^S - F_1 \leq 0$.

(b1) In the case with one negative price ($p_2^B < 0$, $p_2^S \geq 0$) we rewrite the system as follwos: The system rewrites as

$$\begin{cases} p_2^B + p_2^S - F_2 \to \max\limits_{p_2^B, p_2^S}, \\ p_2^B \leq a^B, \quad \text{(inactive)} \\ p_2^S \leq a^S, \\ p_2^B - F_1 \leq -a^B - a^S. \end{cases}$$

Profit writes:

$$F_1 - a^B - a^S + a^S - F_2 = F_1 - F_2 - a^B.$$

(b2) In the similar case when another price is negative ($p_2^B \geq 0$, $p_2^S < 0$) we obtain the system

$$\begin{cases} p_2^B + p_2^S - F_2 \to \max\limits_{p_2^B, p_2^S}, \\ p_2^B \leq a^B, \\ p_2^S \leq a^S, \quad \text{(inactive)} \\ p_2^S - F_1 \leq -a^B - a^S. \end{cases}$$

The profit writes as

$$a^B + F_1 - a^B - a^S - F_2 = F_1 - a^S - F^2.$$

A Platform 2-dominant equilibrium is sustainable when

$$F_2 \leq \max\{F_1 - a^B; F_1 - a^S\}.$$

The condition of the Platform 2-dominant equilibrium existance is weaker under discrimination. Consequently, under discrimination it is easier for a new more efficient entrant to enter the market than under no discrimination.

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Part III

Différenciation tarifaire on-net/off-net : nouvelle approche théorique et modèle de simulation*

* Je remercie Nicolas Curien pour ce travail conjoint.

Introduction

La différenciation tarifaire entre les appels *on-net* (intra-réseau) et *off-net* (inter-réseaux), couramment pratiquée par les opérateurs mobiles européens, est actuellement la source de plusieurs contentieux. Ainsi en 2009, à La Réunion et à Mayotte, l'opérateur mobile français SRR a été contraint par l'Autorité de la concurrence, à titre conservatoire, de s'assurer que l'écart entre ses tarifs *on-net* et *off-net* ne dépasse pas l'écart entre les coûts correspondants ; au motif que, sinon, de telles offres différenciées peuvent constituer une pratique anti-concurrentielle[10]. En France métropolitaine, un cas similaire est aujourd'hui en cours d'instruction, l'opérateur Bouygues Telecom, troisième entrant sur le marché mobile, arguant que les deux premiers entrants, Orange et SFR, lui auraient porté un grave préjudice en introduisant en 2005 leurs offres incluant des minutes *on-net* illimitées[11].

De même, en juillet 2007, le troisième opérateur mobile allemand KPN a déposé une plainte auprès de la Commission européenne à l'encontre de T-mobile et Vodafone, estimant que la différenciation *on-net* / *off-net*, en créant artificiellement des effets de réseaux, a indûment renforcé la position déjà dominante des deux opérateurs historiques. Bien que le *Federal Cartel Office* n'ait finalement pas donné suite à cette action et mis un terme à son enquête à la fin de 2009, des plaintes semblables ont été portées dans d'autres pays, notamment l'Autriche, l'Italie et la Nouvelle Zélande (*cf.* Haucap et Heimeshoff (2011)).

Nombre de travaux théoriques ont étudié la concurrence entre réseaux de communication électronique. Au sein de cette littérature abondante, nous ne retiendrons ici que les

[10] Décision n° 09-MC-02 du 16 septembre 2009.

[11] Arrêt de la Cour d'appel de Paris (pôle 5, chambre 5-7) en date du 6 avril 2010 relatif au pourvoi formé par les sociétés France Telecom et Orange France contre la décision n° 09-S-03 de l'Autorité de la concurrence en date du 15 mai 2009 relatives à des pratiques mises en œuvre dans le secteur de la téléphonie mobile à destination de la clientèle résidentielle en France métropolitaine.

articles traitant de la différenciation tarifaire entre différentes directions de trafic, typiquement la différenciation *on-net* / *off-net*. La plupart des modèles proposés étudient un marché de duopole, symétrique ou asymétrique. Seuls quelques uns considèrent plus de deux opérateurs, ou bien dans le cas le plus général comme Hoernig (2009), ou bien dans des cas particuliers : celui d'un oligopole symétrique dans Calzada et Valetti (2008) et celui d'un oligopole asymétrique formé de quatre opérateurs – dont deux grands et deux petits – dans Dewenter et Haucap (2005). En dépit de leur grande variété, les différents modèles s'accordent pour révéler que l'introduction d'une différenciation des prix des appels selon leur destination modifie significativement les caractéristiques de l'équilibre concurrentiel.

Les principaux résultats qui se dégagent des travaux présentés dans cette section sont les suivants.

- Sur un marché avec opérateurs symétriques :
  - à court terme, la faculté de différencier les tarifs selon la destination d'appel, en renforçant l'intensité de la concurrence, tire à la baisse le niveau général des prix et accroît ainsi le surplus des consommateurs ;
  - à long terme, une différenciation tarifaire *on-net*/*off-net* peut réduire le degré de connectivité entre les deux réseaux sans modifier leurs parts de marché respectives, entraînant une baisse de surplus.
- Sur un marché avec opérateurs asymétriques :
  - un entrant dont le taux de couverture est moindre peut être évincé par l'opérateur historique ;
  - la différenciation tarifaire peut être abusivement utilisée par des opérateurs dominants pour brider le volume des appels *off-net* et rendre les petits opérateurs moins attractifs ;
  - à l'équilibre concurrentiel, tandis que le prix *on-net* s'établit au niveau optimal, le prix *off-net* est en revanche fixé au-dessus de ce niveau ;
  - en présence de clubs de sociabilité, la discrimination est cause d'inefficacité pour un opérateur nouvel entrant.
  - la différenciation *on-net*/*off-net* nuit à la concurrence en créant une barrière à l'entrée pour les petits opérateurs, qui sont dans l'incapacité de répliquer viablement la structure tarifaire des opérateurs installés.

Les deux articles pionniers, ayant servi de socle à beaucoup de développements ultérieurs, sont dus à Laffont *et al.* (1998-a et 1998-b). Ces articles abordent conjointement la tarification des terminaisons d'appels sur le marché de gros et la différenciation tarifaire *on-net* /*off-net* sur le marché de détail. Les auteurs y considèrent principalement un marché de duopole symétrique, comportant deux opérateurs de même taille et de même structure de coût, qui se livrent – selon un schéma de différenciation horizontale à la Hotelling – une concurrence en prix non linéaires (tarifs binômes comportant une partie fixe et une facturation proportionnelle au volume de trafic). Il apparaît notamment que les profits d'équilibre des opérateurs s'avèrent généralement moins élevés sous des prix discriminants selon la direction du trafic que sous des prix uniformes. En effet, la faculté de différencier les tarifs selon la destination d'appel, en renforçant l'intensité de la concurrence, tire à la baisse le niveau général des prix et accroît ainsi le surplus des consommateurs. Toutefois, utilisant la même "maquette" de duopole symétrique que Laffont *et al.* (1998-a), mais en tenant compte de l'externalité des appels reçus, Jeon *et al.* (2004) démontrent qu'une différenciation tarifaire *on-net*/*off-net* peut réduire le degré de connectivité entre les deux réseaux sans modifier leurs parts de marché respectives, d'où une baisse – et non une hausse – du bien-être des consommateurs.

Afin de rendre compte d'éventuelles stratégies d'éviction à l'encontre de petits opérateurs ou d'entrants potentiels, l'hypothèse de symétrie, en termes de parts initiales de marché et de niveaux d'efficacité technologique des opérateurs, doit impérativement être levée. Laffont *et al.* (1998-b) proposent une extension asymétrique de leur modèle de duopole symétrique, dans laquelle un opérateur historique fait face à un nouvel entrant dont le taux de couverture est moindre : si ce taux est suffisamment bas, l'entrant peut être évincé par l'historique, même dans le cas où ce dernier est réglementairement tenu de fixer un tarif d'interconnexion réciproque. Lopez et Rey (2009) montrent qu'en l'absence de discrimination *on-net*/*off-net*, les stratégies d'éviction ne sont pas profitables. Hoernig (2007) établit qu'un équilibre avec prédation conduit à un plus grand écart entre les prix *on-net* et *off-net* que l'équilibre concurrentiel, un "symptôme" toutefois difficile à déceler dans la pratique. Il montre en outre que les opérateurs de plus grande taille adoptent les prix *off-net* les plus élevés et il en conclut que la différenciation tarifaire peut être abusivement utilisée par des opérateurs dominants pour brider le volume des appels *off-net* et rendre les petits opérateurs moins attractifs. Birke et Swann (2006) analysent les données sur le marché britanique et révèlent la forte correlation négative entre le prix relatif des appels *off-net* et la proportion de ces appels dans le trafic total. Ils concluent que le prix élevé des appels *on-net* peut être utilisé pour exclure les potentiels nouveaux entrants. En plus, en présence de coûts de transfert élevés, les grands opérateurs conservent leur pouvoir de marché même après disparition de la différenciation.

Berger (2005) et Hoernig (2007) ont développé un modèle asymétrique à deux opérateurs, ensuite généralisé à un nombre quelconque d'opérateurs par Hoernig (2009). Ces travaux montrent qu'à l'optimum social, le prix *on-net* et le prix *off-net* sont égaux aux coûts marginaux correspondants, diminués de l'externalité de réception d'appel. A l'équilibre concurrentiel, tandis que le prix *on-net* s'établit au niveau optimal, le prix *off-net* est en revanche fixé au-dessus de ce niveau, d'un montant égal à l'externalité. En effet, pour les appels *on-net*, cette dernière peut être internalisée dans les recettes des opérateurs à travers la partie fixe du tarif binôme, si bien que le prix d'équilibre de la minute *on-net* reflète l'optimum sans distorsion ; en revanche, l'utilité que les appels *off-net* sortants procurent aux abonnés des réseaux destinataires ne pouvant être internalisée de cette manière, il en résulte une sur-tarification de la minute *off-net*. L'utilité de réception des appels *off-net* entrants peut, quant à elle, être internalisée *via* la partie fixe du tarif de détail ; ou encore, comme le suggèrent Baranès et Flochel (2008), *via* le tarif d'accès (*i.e.* de terminaison d'appel).

Gabrielsen et Vagstad (2008) relient le phénomène de différenciation tarifaire à l'existence de "clubs" de sociabilité. Chaque individu entretenant des relations privilégiées avec un petit nombre de correspondants, typiquement sa famille et ses amis, une discrimination *on-net*/*off-net* incite les membres d'un même club de sociabilité à s'abonner à un même réseau mobile puis à lui rester fidèle, afin d'éviter la surtarification du trafic *off-net*. Les auteurs en déduisent que proscrire la discrimination tarifaire au-delà de ce que justifie la différence de coûts mettrait fin à cette source de pouvoir de marché. Ils montrent également comment la discrimination est cause d'inefficacité pour un opérateur nouvel entrant. En effet, afin de capter une clientèle, un tel opérateur doit pratiquer un même tarif pour ses appels *on-net* et *off-net*, en sorte que les premiers clients qu'il rallie puissent appeler en *off-net* les membres de leurs clubs respectifs de sociabilité, non encore ralliés, au même prix que précédemment, c'est-à-dire au prix *on-net*. Or cette uniformité des prix de l'entrant est inefficace, puisqu'elle ne reflète pas le différentiel des coûts entre l'*on-net* et l'*off-net*.

Une autre thématique importante est celle du lien entre discrimination *on-net*/*off-net* et tarif de terminaison d'appel. Harbord et Pagnozzi (2010) ont recensé les articles abordant cette question et mené une comparaison internationale. Il en ressort principalement que la différenciation *on-net*/*off-net* nuit à la concurrence en créant une barrière à l'entrée pour les petits opérateurs, qui sont dans l'incapacité de répliquer viablement la structure tarifaire des opérateurs installés. De manière plus détaillée, les résultats dépendent sensiblement des modèles : ainsi, dans celui de Berger (2005), une augmentation du tarif de terminaison d'appel se traduit par une hausse du prix *off-net* et une baisse du prix *on-net* ; dans celui de Hoernig (2007), le prix *off-net* décroît au contraire en fonction du niveau du tarif de terminaison. Deux effets inverses sont à l'œuvre : d'un côté, une augmentation de ce tarif de gros accroît le coût comptable des appels *off-net* et pousse ainsi leur prix à la hausse, afin de maintenir les marges de profit retirées du trafic ; d'un autre côté, une baisse du tarif de terminaison, si elle est répercutée en baisse du prix de détail *off-net*, accroît l'appétence du consommateur pour un "petit" réseau, ce qui adoucit la concurrence pour le partage du marché et réduit les coûts de conquête d'abonnés. Le profil des stratégies de discrimination dépend donc d'un arbitrage entre ces deux effets et de la capacité des opérateurs à choisir les niveaux de leurs tarifs de terminaison d'appel. Dans le cadre d'un modèle de pur partage du marché, Gans et King (2001) ont isolé le second des deux effets précédents : deux opérateurs en positions symétriques gagneraient à fixer leurs tarifs de terminaison en dessous des coûts marginaux, car il en résulterait des tarifs de détail *off-net* moins élevés que les tarifs *on-net*, d'où une lutte moins âpre pour attirer le consommateur marginal. Lopez et Rey (2009) ont étendu ce résultat au contexte d'un partage de marché asymétrique.

Soit parce qu'ils reposent sur des hypothèses très particulières, soit au contraire parce qu'ils utilisent un cadre de modélisation très général et donc complexe, les modèles jusqu'ici existants n'ont pas permis de mener une analyse exhaustive de l'impact d'une différenciation *on-net*/*off-net* sur le bien-être social et sur ses composantes. A cet égard, Hoernig (2009) ne parvient pas à conclure de manière univoque et il suggère que le profil de la tarification optimale, uniforme ou discriminatoire, dépend vraisemblablement des caractéristiques des fonctions de demande.

L'ambition du modèle développé ici est de modéliser le marché du trafic mobile et de fournir un outil complet d'analyse des "comptes de surplus" dans le cas où l'approximation linéaire des fonctions de demande de trafic constitue une hypothèse raisonnable. Comme celui de Hoernig (2009), notre modèle considère un nombre quelconque d'opérateurs, prend en compte des asymétries de coûts et de parts de marché, incorpore l'externalité des appels reçus. Contrairement à l'étude théorique de Hoernig, notre analyse est plus appliquée.

Nous construisons un modèle théorique, nous développons une méthode détaillée pour calibrer ce modèle sur un marché national de trois opérateurs, et nous faisons son application numérique sur le marché français. La forme linéaire des fonctions de demande permet de calculer explicitement profits et surplus, de comparer les impacts de différentes structures tarifaires sur le bien-être et ses composantes. L'objectif principal de Hoernig est de caractériser l'équilibre avec la tarification on-net/off-net différenciée, sans comparer la tarification différenciée on-net/off-net avec la tarification uniforme. Un de nos objectifs est de comparer ces deux types de tarification, en estimant l'impact des variations de tarifs on-net et all-net sur le surplus de tous les acteurs du marché. Pour comparer la tarification différenciée avec la tarification uniforme et pour étudier l'impact du choix de type tarification sur la demande, il est pertinent d'étudier en détails les différents facteurs qui déterminent les décisions de consommateurs et qui ne sont pas pris en compte dans le modèle de Hoernig :

- Dans notre modèle la fonction d'utilité est caractérisée par la substitution entre différentes directions de trafic, ce qui permet de prendre en compte le lien entre le prix on-net sur le trafic off-net et du prix off-net sur le trafic on-net.
- La fonction d'utilité de notre modèle inclut l'effet de club : le 'club de sociabilité' d'un individu n'est pas réparti de manière homogène entre les clientèles des différents opérateurs mobiles, mais sont plus concentrés chez le même opérateur. Les différentes directions de trafic ne sont pas perçues de la même manière par les consommateurs et peuvent avoir différent impact sur l'utilité, ce qui influence le choix de consommateur et en particulier le degré de substitution entre les appels on-net et off-net.

Hoernig étudie les propriétés de l'équilibre dans le cas d'un marché parfaitement fluide. Dans notre modèle, nous avons pris en compte l'existence de barrières de changement d'opérateur pour les abonnées, et donc les choix d'affiliation des abonnés sont exogènes. Cette option de modélisation revient à considérer que les consommateurs, dont la rationalité est limitée et qui sont en outre plongés dans un marché imparfaitement transparent et assez peu fluide, ont choisi leurs réseaux respectifs d'affiliation sur la base d'un ensemble de critères ne se limitant pas à la seule tarification et restent fidèle à leur choix, au moins à court et moyen terme. C'est dans ce cadre de partage stable du marché qu'ils expriment leurs demandes de communication vers les différentes directions de trafic, en fonction des prix de la minute pratiqués par leur opérateur. Ce choix méthodologique est justifié par la rigidité du marché et un faible taux de churn entre opérateurs sur la période considéré, observés en pratique. Certains caractéristiques des marchés de téléphonie mobile se traduisent par des coûts de changement d'opérateur pour le consommateur (*switching costs*) relativement élevés et donc participent à la stabilisation des parts de marché. L'hypothèse d'un faible flux de migration de clients entre les opérateurs est particulièrement réaliste dans le cadre du marché français à cause des caractéristiques suivantes :

- La prédominance des contrats d'abonnement avec engagement long, avec de plus en plus de clients sous engagement.
  - Les programmes de fidélité incitent les clients à renouveler leur engagement pour bénéficier d'un nouveau terminal.
  - En France, la proportion des offres du type post-payé est très élevée. Par exemple, en 2010-2011 le taux d'abonnements post-payés est resté stable autour de 67%.
  - La plupart des contrats du type post-payé ont une clause d'engagement. En 2009, les ventes brutes d'abonnements post-payés avec engagement représentaient 98% des ventes brutes d'abonnement post-payées, parmi lesquelles 73% correspondaient à un engagement supérieur à 1 an.
  - En 2010-2011, le taux de ventes brutes d'abonnements post-payés avec engagement s'est maintenu autour de 95%, tandis que le taux de ventes brutes avec engagement supérieur à 1 an est passé de 65% à 81% sur la période. [12]
- Le verrouillage des terminaux. Les opérateurs vendent généralement les appareils bloqués contre l'utilisation avec une carte SIM d'un autre opérateur. Un appareil peut être débloqué après quelques mois d'utilisation. Un utilisateur qui change d'opérateur avant que cette période est terminée est obligé d'utiliser un autre appareil.

En résultat, entre début 2010 et fin 2011 le taux d'ancienneté du parc post-payé grand public depuis plus d'un an est resté stable autour de 80% sur la période. La migration de clients étaient encore plus rare au début des années 2000, la période choisi pour la simulation numérique. Comme la régulation pro-concurrentielle était moins développée, le changement d'opérateur étaient ralenti par les facteurs supplémentaires suivants :

- L'absence de la portabilité de numéro lors de changement d'opérateur avant 2003 et la lenteur et la complexité pour obtenir la portabilité du numéro entre 2003 et 2008. La perte de numéro est coûteuse surtout pour les clients professionnels. En 2005, la procédure de portabilité prenait deux mois.

[12] ARCEP, Avis n° 2012-1455 du 13 novembre 2012

- Une longue durée de résiliation avant 2008. En 2005, les délais moyens de résiliation étaient deux mois chez Bouygues Telecom et SFR, un mois et demi chez Orange France.[13]
- L'existence des clauses de reconduite tacite des abonnements. Certaines de ces clauses ont été jugées abusives par les Tribunaux (notamment la clause de reconduction tacite pour un an en l'absence de préavis de résiliation deux à trois mois avant le terme du contrat).[14]
- Une tarification de la mise en service d'une ligne mobile. Un abonnée ne pouvait pas bénéficier d'une subvention d'accès qu'à la condition de souscrire un abonnement d'un an minimum, voire deux ans dans certains cas.

A cause de tous les obstacles, les abonnées changeaient rarement d'opérateur au début des années 2000. Par exemple, selon une enquête de 2001, uniquement 6% des abonnés ont opté pour le changement de l'opérateur au cours de 12 derniers mois.[15] De plus, notre modèle permet d'analyser les "tensions"potentiellement génératrices de flux migratoires d'abonnés entre les opérateurs, susceptibles de modifier le partage du marché à long terme. Une indication qualitative des flux migratoires est obtenue à partir des variations de surplus par tête sous l'effet de changements tarifaires.

Dans la section 2, nous établissons les bases du modèle et nous précisons la structure des préférences. Puis, dans la section 3, les fonctions de demande de communication, pour chaque opérateur et dans chaque direction de trafic, sont déduites du système des préférences. Dans les sections 4 et 5, nous étudions respectivement l'optimum de premier rang et l'équilibre du marché, retrouvant et complétant ainsi les principaux résultats issus de la littérature. La section 6 est consacrée à l'étude théorique des impacts – sur le surplus collectif et sur ses composantes – de changements tarifaires "neutres", *i.e.* laissant inaffectés les revenus xe détail des opérateurs et donc les dépenses des consommateurs. Dans la section 7, nous procédons à un calibrage des paramètres du modèle au moyen de données relatives au marché mobile français, puis nous illustrons les résultats de la section 6 à travers une application numérique : cette application permet notamment de simuler les effets comparés de baisses tarifaires alternatives, *on-net* ou *all-net*, simultanément pratiquées

[13] ARCEP, Avis n° 05-A-09 du 4 avril 2005

[14] PENARD, Thierry, Comment analyser le succès de la téléphonie mobile en France ? CREREG, Université de Rennes 1, Septembre 2001

[15] Les relations des opérateurs de télécommunications avec leurs clients grand public : une étude réalisée par la Sofres pour le compte de l'ART, février 2001

par tous les opérateurs, à partir d'une situation initiale caractérisée par une tarification *all-net*. La section 8, enfin, résume nos principales conclusions.

1 Présentation du modèle

1.1 Hypothèses et notations

1.1.1 Parcs de clientèle, tarifs et trafics

On considère un marché mobile national de taille M, que se partagent n opérateurs. L'opérateur i $(i = 1, 2, \ldots, n)$ sert M_i clients, avec :

$$\sum_{i=1}^{n} M_i = M \ .$$

Sur ce marché, les parts de marché M_i/M sont stables au court terme.

On suppose qu'un opérateur peut tarifer différemment la minute de communication selon le réseau d'affiliation du destinataire de cette minute. Soit ainsi p_i^j le prix d'une minute de communication du réseau i vers le réseau j, ce prix étant choisi par l'opérateur i. Dans la suite, on notera :

$$\mathbf{p}_i = [p_i^1, p_i^2, \ldots, p_i^n] \ ,$$

le vecteur ligne des prix fixés par l'opérateur i dans les différentes directions de trafic.

La différenciation *on-net/off-net* correspond à la partition binaire :

$$\forall j \neq i \ , \ k \neq i : p_i^j = p_i^k = p_{-i} \neq p_i^i = p_{+i} \ ,$$

où p_{+i} est le prix *on-net* et p_{-i} le prix *off-net* fixés par l'opérateur i. L'absence totale de différenciation, ou tarification *all-net*, correspond quant à elle au profil uniforme :

$$\forall j : p_i^j = p_i \ ,$$

où p_i est le prix *all-net* de l'opérateur i.

On notera Q_i^j le trafic (exprimé en minutes de communication) originaire du réseau i et destiné au réseau j et respectivement Q_i, Q_{+i} et Q_{-i}, le trafic total sortant, le trafic *on-net*, et le trafic *off-net* sortant de l'opérateur i, soit :

$$Q_i = \sum_{j=1}^{n} Q_i^j = Q_{+i} + Q_{-i}, \quad Q_{+i} = Q_i^i, \quad Q_{-i} = \sum_{j \neq i} Q_i^j \ .$$

On notera :

$$\mathbf{Q}_i = [Q_i^1, Q_i^2, \ldots, Q_i^n]' \ ,$$

le vecteur colonne (le symbole " $'$ " désignant la transposition matricielle) des volumes de trafic issus du réseau i vers les différents réseaux destinataires. De même, on notera :

$$\mathbf{Q}^i = [Q_1^i, Q_2^i, \ldots, Q_n^i]' \ ,$$

le vecteur colonne des volumes de trafic adressés au réseau i par les différents réseaux émetteurs.

De manière stylisée, nous représenterons la clientèle d'un opérateur i par un individu représentatif, ou *i-représentant*, individu fictif dont les volumes de communication dans chaque direction de trafic sont égaux aux volumes moyens par tête. Ainsi, notant q_i^j le trafic émis par le *i-représentant* dans la direction de trafic j, on a :

$$q_i^j = \frac{Q_i^j}{M_i}, \quad \mathbf{q}_i = [q_i^1, q_i^2, \ldots, q_i^n]' = \frac{\mathbf{Q}_i}{M_i} \ .$$

Avec cette convention, tout se passe comme si la clientèle de l'opérateur i était composée de i-représentants tous identiques, en nombre M_i, chacun d'eux émettant le vecteur de trafic $\mathbf{Q}_i/M_i$ et recevant le vecteur de trafic $\mathbf{Q}^i/M_i$.

Enfin, dans toute la suite, nous noterons $\mathbf{1}$ le vecteur ligne dont les n composantes sont égales à l'unité, $\mathbf{1}_i$ le vecteur dont la i-ème composante est égale à l'unité toutes les autres étant nulles, et $\mathbf{1}_{-i} = \mathbf{1} - \mathbf{1}_i$ le vecteur dont la i-ème composante est nulle toutes les autres étant égales à l'unité. D'où, par exemple, les égalités :

$$Q_{+i} = \mathbf{1}_i \cdot \mathbf{Q}_i, \quad Q_{-i} = \mathbf{1}_{-i} \cdot \mathbf{Q}_i, \quad Q_i = \mathbf{1} \cdot \mathbf{Q}_i, \quad Q^i = \mathbf{1} \cdot \mathbf{Q}^i \ ,$$

dans lesquels le produit matriciel (ici produit scalaire de vecteurs) est noté " · "

Il convient maintenant de préciser la structure des préférences individuelles d'un i-représentant.

1.1.2 Structure des préférences individuelles

Le volume maximal de communication qu'un individu émettrait dans une direction de trafic donnée, en l'absence de toute facturation, est supposé proportionnel au nombre des destinataires potentiels dans la direction considérée. Autrement dit, le trafic individuel de satiété est d'autant plus élevé que plus important est le nombre des correspondants auxquels ce trafic peut être affecté et entre lesquels il peut être réparti. Ainsi, le plafond de communication d'un i-représentant dans la direction j vaut $\sigma_i M_j$, où le paramètre $\sigma_i > 0$, ou *potentiel de communication*, est d'autant plus grand que le consommateur est fortement enclin à communiquer. Le potentiel de communication σ_i s'interprète comme le volume individuel maximal de communication adressable à un "club" normalisé d'effectif 1 million et il possède la dimension physique d'une durée, *i.e.* s'exprime en minutes.

Notre modèle de préférences individuelles est donc de type *gravitaire*, une "planète téléphonique" de grande "masse", *i.e.* un grand parc d'abonnés, "attirant" davantage de trafic qu'une planète de petite masse, *i.e.* un petit parc. Ce cœur gravitaire des préférences individuelles va maintenant être enrichi d'une quadruple manière, afin de traduire respectivement un *effet de club*, un *effet de satiété*, un *effet de couplage* entre directions de trafic, et une *externalité de réception* d'appels.

1. *Effet de club.* Le "club de sociabilité" d'un individu donné n'est pas réparti de manière homogène entre les clientèles des différents opérateurs mobiles. Cette répartition hétérogène est notamment influencée par l'inter-dépendance des choix individuels d'affiliation, typiquement au sein du cercle de parents et d'amis, qu'encouragent les remises commerciales du type "*friends and family*" couramment pratiquées par les opérateurs. Pour en tenir compte, nous supposons que, hors effets de satiété et de couplage, le plafond de communication d'un i-représentant dans la direction de trafic j vaut, non pas $\sigma_i M_j$, mais plutôt $\sigma_i M_{j/i}$, où :

$$M_{j/i} = \omega_{j/i} M_j, \quad \omega_{i/i} \geq 1, \quad \omega_{j/i} \leq 1, \quad \sum_{j=1}^{n} M_{j/i} = M \ .$$

La grandeur $M_{j/i}$ s'interprète comme la *taille apparente* du réseau j, telle qu'elle est perçue par un i-représentant (le symbole "j/i" se lisant "j vu par i"), et le paramètre $\omega_{j/i}$ est le *coefficient de déformation* de la masse des clients de l'opérateur j, par un client de l'opérateur i.

2. *Effet de satiété.* Comme tout bien de consommation courante, la téléphonie mobile est sujette à un phénomène de satiété. Afin d'en rendre compte, nous considérerons que l'utilité marginale d'une minute de communication décroît linéairement en fonction du volume de trafic. Ainsi, l'utilité $\partial w_i / \partial q_i^j$ qu'un i-représentant retire d'une minute supplémentaire de trafic dans la direction j vaut, hors effet de couplage entre directions de trafic :

$$\frac{\partial w_i}{\partial q_i^j} = v_i M_{j/i}^{-2a} \left(M_{j/i} - \frac{q_i^j}{\sigma_i} \right) \ .$$

Le paramètre v_i mesure la *valeur psychologique* du temps de communication par un i-représentant tandis le paramètre $a \in [0, 1]$ mesure son *appétence pour le nombre de correspondants*. L'utilité de la "première" minute de communication dans la direction de trafic j vaut $v_i M_{j/i}^{1-2a}$.

- Lorsque $a = 0$, l'utilité de la première minute, soit $v_i M_{j/i}$, est proportionnelle au nombre des correspondants potentiels dans la direction de trafic j, *i.e.* au nombre de destinataires auxquels cette minute peut être affectée et entre lesquels elle peut être partagée : le consommateur n'est alors sensible qu'à la durée de communication globalement offerte et il est indifférent à la durée unitaire disponible par correspondant.
- Lorsque $a = 1/2$, l'utilité de la première minute est "intrinsèque", *i.e.* indépendante du nombre des correspondants potentiels, elle est la même dans chaque direction de trafic j.

- Lorsque $a = 1$, l'utilité de la première minute est inversement proportionnelle au nombre des correspondants potentiels, *i.e.* à l'effectif des destinataires entre lesquels elle se trouve "diluée" : le consommateur n'est alors sensible qu'au temps de communication disponible vers chacun de ses correspondants, quel que soit leur nombre.

L'utilité de la "dernière" minute, *i.e.* celle qui fait atteindre le plafond de communication $\sigma_i M_{j/i}$ dans la direction j, est nulle. Le plafond $\sigma_i M_{j/i}$ s'interprète donc comme la consommation de satiété d'un i-représentant dans la direction j, *i.e.* le niveau de trafic q_i^j qui réalise le maximum de son utilité individuelle w_i.

3. *Effet de couplage.* Un consommateur pouvant, dans une certaine mesure, déplacer des minutes de communication d'une direction vers une autre, l'utilité de disposer d'une minute supplémentaire dans une direction donnée dépend non seulement du volume de communication vers cette direction, mais également des volumes de communication vers les autres directions. En incorporant les effets indirects de couplage entre directions de trafic, l'utilité marginale d'émission d'appels s'écrit finalement sous la forme modifiée :

$$\frac{\partial w_i}{\partial q_i^j} = v_i \sum_{k=1}^{n} \frac{\xi_i^{j,k}}{M_{j/i}^a M_{k/i}^a} \left(M_{k/i} - \frac{q_i^k}{\sigma_i} \right) ,$$

où les coefficients $\xi_i^{j,k}$, tels que :

$$\xi_i^{j,j} = 1, \quad k \neq j : 0 \leq \xi_i^{j,k} = \xi_i^{k,j} < 1 ,$$

mesurent l'intensité du couplage – supposé symétrique – entre les directions de trafic j et k, pour un i-représentant.

4. *Externalité de réception.* Un consommateur retire de l'utilité, non seulement des appels qu'il émet, mais également de ceux qu'il reçoit. Nous admettrons qu'un i-représentant, qui reçoit Q_j^i/M_i minutes de communication en provenance du réseau j, retire de cette réception le bénéfice individuel :

$$r_j^i = \rho_i v_i M_{j/i}^{1-2a} \frac{Q_j^i}{M_i} .$$

Le paramètre ρ_i mesure l'intensité relative de l'externalité de réception d'appels. Plus précisément, hors effets de satiété et de couplage, l'utilité pour un i-représentant d'une minute émise vers le réseau j serait égale à $v_i M_{j/i}^{1-2a}$ si bien que ρ_i n'est autre que le ratio rapportant l'utilité d'une minute reçue à celle d'une minute émise, à effets de satiété et de couplage "contrôlés".

1.1.3 Fonction d'utilité

Posons :

$$
\begin{aligned}
\mathbf{M}_{\cdot/i} &= \mathrm{Diag}[M_{1/i}, M_{2/i}, \ldots, M_{n/i}], \\
\mathbf{X}_i = \mathbf{X}_i' &= \begin{pmatrix}
1 & \xi_i^{2,1} & \ldots & \xi_i^{n-1,1} & \xi_i^{n,1} \\
\xi_i^{1,2} & 1 & \ldots & \xi_i^{n-1,2} & \xi_i^{n,2} \\
\vdots & \vdots & \ddots & \vdots & \vdots \\
\xi_i^{1,n-1} & \xi_i^{2,n-1} & \ldots & 1 & \xi_i^{n,n-1} \\
\xi_i^{1,n} & \xi_i^{2,n} & \ldots & \xi_i^{n-1,n} & 1
\end{pmatrix}, \\
\mathbf{X}_i(a) &= \mathbf{M}_{\cdot/i}^{-a} \cdot \mathbf{X}_i \cdot \mathbf{M}_{\cdot/i}^{-a}, \\
\boldsymbol{\nabla}_{\mathbf{q}_i} &= \left[\frac{\partial}{\partial q_i^1}, \frac{\partial}{\partial q_i^2}, \ldots, \frac{\partial}{\partial q_i^n}\right] ,
\end{aligned}
$$

où la matrice $\mathbf{X}_i$ des coefficients de couplage est positive (et donc définie positive sur $\mathbb{R}^{+n}$). La spécification ci-dessus des utilités marginales s'écrit alors sous la forme vectorielle :

$$
\boldsymbol{\nabla}_{\mathbf{q}_i} w_i = v_i \left(\mathbf{1}.\mathbf{M}_i - \frac{\mathbf{q}_i'}{\sigma_i}\right) \cdot \mathbf{X}_i(a) .
$$

En intégrant par rapport au vecteur de trafic individuel émis $\mathbf{q}_i$, on obtient l'expression quadratique de l'utilité w_i d'un i-représentant au titre du trafic qu'il émet, soit :

$$
w_i = u_i + v_i \left(\mathbf{1}.\mathbf{M}_i - \frac{\mathbf{q}_i'}{2\sigma_i}\right) \cdot \mathbf{X}_i(a) \cdot \mathbf{q}_i ,
$$

où u_i est une constante. A l'utilité w_i du trafic émis, s'ajoute le bénéfice externe apporté par le trafic reçu, soit :

$$
r^i = \sum_{j=1}^{n} r_j^i = \rho_i v_i \sum_{j=1}^{n} M_{j/i}^{1-2a} \frac{Q_j^i}{M_i} = \rho_i v_i \mathbf{1}.\mathbf{M}_{\cdot/i}^{1-2a} \cdot \frac{\mathbf{Q}^i}{M_i} .
$$

En sommant sur l'ensemble des i-représentants, en nombre M_i, on obtient finalement l'utilité agrégée W_i que la clientèle de l'opérateur i retire de l'émission d'appels, ainsi que le bénéfice externe R^i que procure à cette clientèle la réception d'appels, soit :

$$W_i = M_i u_i + v_i \left(\mathbf{1}.\mathbf{M}_{./i} - \frac{\mathbf{Q}'_i}{2\sigma_i M_i} \right) \cdot \mathbf{X}_i(a) \cdot \mathbf{Q}_i$$
$$R^i = \rho_i v_i \mathbf{1}.\mathbf{M}^{1-2a}_{./i} \cdot \mathbf{Q}^i \ .$$

L'utilité consolidée $W_i + R^i$ des clients d'un opérateur i comporte ainsi trois composantes : une composante fixe $M_i u_i$, indépendante des volumes de trafic émis et reçus ; une composante "interne" $W_i - M_i u_i$, variable en fonction des volumes de communication Q_i^j émis vers les différentes destinations $j = 1, 2, \ldots, n$; et une composante "externe" R^i, variable en fonction des volumes Q_j^i reçus en provenance des différentes origines $j = 1, 2, \ldots, n$.

Ainsi complètement spécifié, le modèle de consommation repose sur les paramètres de base suivants :

- M_i, la base de clientèle de l'opérateur i (en millions d'abonnés) ;
- $\omega_{j/i} = M_{j/i}/M_j$, le coefficient de déformation de la masse des clients de l'opérateur j, par un client de l'opérateur i ;
- a, le coefficient d'appétence pour le nombre de correspondants ;
- v_i, la valeur psychologique (en euros) qu'un client de l'opérateur i attribue à la "première" minute de communication vers un parc normalisé d'effectif 1 million ;
- σ_i, le potentiel de communication (en minutes) d'un client de l'opérateur i, vers un parc normalisé d'effectif 1 million ;
- $\xi_i^{j,k}$, la propension d'un client de l'opérateur i à substituer du trafic entre les directions de trafic j et k ;
- ρ_i, l'intensité de l'externalité de réception d'appels sur le réseau i, égale au ratio de la valeur psychologique d'une minute reçue à celle d'une minute émise.

1.2 Fonctions de demande

1.2.1 Propriétés générales

Supposons que les appels reçus ne sont pas facturés. Considérons par ailleurs que l'opérateur mobile i propose une gamme étagée de forfaits, linéairement progressive en fonction des volumes maximaux de trafic inclus dans les différents forfaits. Alors, la facture ϕ_i d'un i-représentant, qui émet q_i^j minutes de communication vers chacun des réseaux $j = 1, 2, \ldots, n$, peut être convenablement approchée par la fonction affine :

$$\phi_i = f_i + \sum_{j=1}^{n} p_i^j q_i^j = f_i + \mathbf{p}_i \cdot \mathbf{q}_i \ ,$$

où f_i désigne la composante fixe commune à tous les forfaits proposés par l'opérateur i et où p_i^j est le prix de la minute de i vers j.

Dans l'annexe 1, nous montrons qu'une telle tarification affine est strictement équivalente à une tarification forfaitaire, dans laquelle le multiplicateur de la contrainte du volume des communications incluses dans le forfait joue exactement le même rôle que le prix de la minute dans le tarif affine.

Par agrégation, les revenus de détail de l'opérateur i s'écrivent :

$$\Phi_i = M_i f_i + \sum_{j=1}^{n} p_i^j Q_i^j = M_i f_i + \mathbf{p}_i \cdot \mathbf{Q}_i \ .$$

Le surplus de consommation S_i que le trafic émis procure aux clients de i a pour expression :

$$\begin{aligned} S_i &= W_i - \Phi_i \\ &= M_i(u_i - f_i) + [v_i \mathbf{1}.\mathbf{M}_{./i} \cdot \mathbf{X}_i(a) - \mathbf{p}_i] \cdot \mathbf{Q}_i - \frac{v_i}{2\sigma_i M_i} \mathbf{Q}_i' \cdot \mathbf{X}_i(a) \cdot \mathbf{Q}_i \ . \end{aligned}$$

Le surplus S_i étant une fonction quadratique concave des volumes de communication émis Q_i^j (puisque la matrice $\mathbf{X}_i(a)$ est définie positive sur $\mathbb{R}^{+n}$), sa maximisation est assurée par les seules conditions du premier ordre (sous l'hypothèse que l'optimun est intérieur, *i.e.* n'est pas atteint en coin sur la frontière de $\mathbb{R}^{+n}$). Ces conditions du premier ordre conduisent au système inverse de demande, exprimant les prix en fonction des volumes :

$$\nabla_{\mathbf{Q}_i} S_i = \mathbf{0} \Rightarrow \mathbf{p}_i = \boldsymbol{\pi}_i(\mathbf{Q}_i) = v_i \left(\mathbf{1}.\mathbf{M}_{\cdot/i} - \frac{\mathbf{Q}_i'}{\sigma_i M_i} \right) \cdot \mathbf{X}_i(a) \ .$$

La résolution de ce système linéaire de n équations, par rapport aux n variables Q_i^j ($j = 1, 2, \dots, n$), permet de calculer les fonctions de demande directes, exprimant en fonction des prix les volumes de communication dans les différentes directions de trafic. On obtient ainsi :

$$\mathbf{Q}_i = \mathbf{D}_i(\mathbf{p}_i) = \sigma_i M_i \left(\mathbf{M}_{\cdot/i} \cdot \mathbf{1}' - \mathbf{A}_i(a) \cdot \mathbf{p}_i' \right) \Leftrightarrow$$
$$Q_i^j = \sigma_i M_i \left(M_{j/i} - M_{j/i}^{2a} \alpha_i^j p_i^j + \sum_{k \neq j} M_{j/i}^a M_{k/i}^a \beta_i^{j,k} p_i^k \right) \ ,$$

où l'on a introduit, par inversion de la matrice symétrique définie positive $\mathbf{X}_i(a)$, la matrice symétrique définie positive $\mathbf{A}_i(a)$:

$$\mathbf{A}_i = \mathbf{A}_i' = \frac{\mathbf{X}_i^{-1}}{v_i} = \begin{pmatrix} \alpha_i^1 & -\beta_i^{1,2} & \dots & -\beta_i^{1,n-1} & -\beta_i^{1,n} \\ -\beta_i^{2,1} & \alpha_i^1 & \dots & -\beta_i^{2,n-1} & -\beta_i^{2,n} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ -\beta_i^{n-1,1} & -\beta_i^{n-1,2} & \dots & \alpha_i^{n-1} & -\beta_i^{n-1,n} \\ -\beta_i^{n,1} & -\beta_i^{n,2} & \dots & -\beta_i^{n,n-1} & \alpha_i^n \end{pmatrix}$$
$$\mathbf{A}_i(a) = \mathbf{A}_i'(a) = \mathbf{M}_{\cdot/i}^a \cdot \mathbf{A}_i \cdot \mathbf{M}_{\cdot/i}^a = \frac{\mathbf{X}_i^{-1}(a)}{v_i} \ .$$

Les coefficients α_i^j et $\beta_i^{j,k}$ peuvent être calculés simplement en fonction des coefficients de couplage $\xi_i^{j,k}$ dans plusieurs cas particuliers.

(i) Par exemple, sous l'hypothèse que les coefficients de couplage $\xi_i^{j,k}$ sont petits devant l'unité, on a au premier ordre :

$$\forall j : \alpha_i^j = \frac{1}{v_i} > 0 \quad , \quad j \neq k : \beta_i^{j,k} = \beta_i^{k,j} = \frac{\xi_i^{j,k}}{v_i} \geq 0 \ .$$

(ii) Dans les cas $n = 2$ et $n = 3$ et sans faire l'hypothèse d'une faible amplitude des coefficients de couplage, les résultats sont les suivants.

Cas $n = 2$:

$$\alpha_i^1 = \alpha_i^2 = \frac{1}{v_i\left[1 - (\xi_i^{1,2})^2\right]} > 0, \quad j \neq k : \beta_i^{1,2} = \beta_i^{2,1} = \frac{\xi_i^{1,2}}{v_i\left[1 - (\xi_i^{1,2})^2\right]} \geq 0 \ .$$

Cas $n = 3$:

$$\begin{aligned} & j \neq k \neq l : \xi_i^{j,k} \geq \xi_i^{j,l}\xi_i^{k,l} \Rightarrow \\ & \alpha_i^j = \frac{1 - (\xi_i^{k,l})^2}{v_i\left[1 - (\xi_i^{1,2})^2 - (\xi_i^{1,3})^2 - (\xi_i^{2,3})^2 + 2\xi_i^{1,2}\xi_i^{1,3}\xi_i^{2,3}\right]} > 0, \\ & \beta_i^{j,k} = \beta_i^{k,j} = \frac{\xi_i^{j,k} - \xi_i^{j,l}\xi_i^{k,l}}{v_i\left[1 - (\xi_i^{1,2})^2 - (\xi_i^{1,3})^2 - (\xi_i^{2,3})^2 + 2\xi_i^{1,2}\xi_i^{1,3}\xi_i^{2,3}\right]} \geq 0 \ . \end{aligned}$$

(iii) Et, dans le cas d'un couplage "uniforme", avec un nombre quelconque n d'opérateurs, on obtient :

$$\begin{aligned} & \forall j, k : \xi_i^{j,k} = \xi_i \Rightarrow \\ & \alpha_i^j = \alpha_i = \frac{1 + (n-2)\xi_i}{v_i(1 - \xi_i)[1 + (n-1)\xi_i]} > 0, \\ & \beta_i^{j,k} = \beta_i = \frac{\xi_i}{v_i(1 - \xi_i)[1 + (n-1)\xi_i]} \geq 0 \ . \end{aligned}$$

Dans toute la suite, sans nous restreindre au cas d'un faible couplage ou à celui d'un couplage uniforme, ou encore à celui d'un petit nombre d'opérateurs, nous admettrons que les coefficients α_i^j, $\beta_i^{j,k}$ et $\tilde{\alpha}_i^j$ vérifient les conditions suivantes :

$$\forall i,j : \alpha_i^j > 0, \quad j \neq k : \beta_i^{j,k} = \beta_i^{k,j} \geq 0, \quad \forall i,j : \tilde{\alpha}_i^j = \alpha_i^j - \sum_{k\neq j} \left(\frac{M_{k/i}}{M_{j/i}}\right)^a \beta_i^{j,k} > 0 \; .$$

- $-M_{j/i}^{2a}\alpha_i^j < 0$ mesure la sensibilité propre de la demande de communication de i vers j à une variation du prix de la minute dans cette même direction de trafic ;
- $M_{j/i}^a M_{k/i}^a \beta_i^{j,k} > 0$ mesure la sensibilité croisée de la demande de communication de i vers j à une variation du prix de la minute dans la direction $k \neq j$;
- $-M_{j/i}^{2a}\tilde{\alpha}_i^j < 0$ mesure la sensibilité de la demande de communication de i vers j à une variation du prix de la minute dans toutes les directions de trafic (variation *all-net*) ;

Les coefficients de sensibilité $-M_{j/i}^{2a}\alpha_i^j$, $M_{j/i}^a M_{k/i}^a \beta_i^{j,k}$ et $-M_{j/i}^{2a}\tilde{\alpha}_i^j$, qui ont la dimension inverse de l'unité monétaire (€$^{-1}$), s'appliquent à des variations de prix absolues. Les fonctions de demande étant linéaires, les élasticités-prix, *i.e.* les coefficients sans dimension de sensibilité aux variations de prix relatives, sont proportionnelles aux prix et inversement proportionnelles aux volumes, selon les expressions :

$$\varepsilon_i^{j/j} = \frac{p_i^j}{Q_i^j}\frac{\partial Q_i^j}{\partial p_i^j} = -\frac{\alpha_i^j p_i^j}{M_{j/i}^{1-2a} - \alpha_i^j p_i^j + \sum_{l\neq j}(M_{l/i}/M_{j/i})^a \beta_i^{j,l} p_i^l} < 0,$$

$$k \neq j : \varepsilon_i^{j/k} = \frac{p_i^k}{Q_i^j}\frac{\partial Q_i^j}{\partial p_i^k} = \frac{(M_{k/i}/M_{j/i})^a \beta_i^{j,k} p_i^k}{M_{j/i}^{1-2a} - \alpha_i^j p_i^j + \sum_{l\neq j}(M_{l/i}/M_{j/i})^a \beta_i^{j,l} p_i^l} \geq 0 \; .$$

On constate que, de manière cohérente, les *élasticités propres* $\varepsilon_i^{j/j}$ sont négatives, tandis que les élasticités croisées $\varepsilon_i^{j/k}$ sont positives. Autrement dit, le trafic interne à un opérateur donné, d'une part, et chacun des trafics sortants vers les autres opérateurs, d'autre part, sont des biens substituts.

Lorsque les prix sont tous nuls, on obtient la matrice de trafic $\widehat{Q}_i^j$ de satiété, celle qui résulterait de la libre expression des communications inter-individuelles si celles-ci étaient gratuites, soit :

$$\widehat{Q}_i^j = \sigma_i M_i M_{j/i} = \sigma_i \omega_{j/i} M_i M_j \; .$$

Si tous les opérateurs présentaient le même profil de clientèle ($\forall i : \sigma_i = \sigma$) et en l'absence d'effets structurants de club ($\omega_{j/i} = 1$), alors la matrice de satiété serait à la fois symétrique et *gravitaire*, ses éléments étant proportionnels au produit de la masse M_i du réseau d'origine par celle M_j du réseau de destination.

1.2.2 Deux cas remarquables

1. Tarification all-net.

En l'absence de différenciation tarifaire selon les directions de trafic, désignons par p_i le tarif *all-net* de l'opérateur i. Le système de demande s'écrit alors simplement :

$$Q_i^j = \sigma_i M_i \left[M_{j/i} - M_{j/i}^{2a} \widetilde{\alpha}_i^j p_i \right] \ .$$

Les élasticités-prix pertinentes sont les élasticités-prix *all-net*, dont l'expression s'écrit :

$$\varepsilon_i^{j/\cdot} = \sum_{k=1}^{n} [\varepsilon_i^{j/k}]_{p_i^k = p_i} = \frac{p_i}{Q_i^j} \frac{dQ_i^j}{dp_i} = - \frac{\widetilde{\alpha}_i^j p_i}{M_{j/i}^{1-2a} - \widetilde{\alpha}_i^j p_i} < 0 \ .$$

En effectuant une somme pondérée sur toutes les directions de trafic, *on-net* et *off-net*, on obtient l'élasticité-prix *all-net* totale $\varepsilon_i^{\cdot/\cdot}$ pour chaque opérateur i, soit :

$$\varepsilon_i^{\cdot/\cdot} = \frac{p_i}{Q_i} \frac{dQ_i}{dp_i} = \sum_{j=1}^{n} \frac{Q_i^j}{Q_i} \varepsilon_i^{j/\cdot} = - \frac{\left(\sum_{j=1}^{n} M_{j/i}^{2a} \widetilde{\alpha}_i^j \right) p_i}{\sum_{j=1}^{n} M_{j/i} - \left(\sum_{j=1}^{n} M_{j/i}^{2a} \widetilde{\alpha}_i^j \right) p_i} < 0 \ .$$

2. Différenciation on-net/off-net.

Dans le cas d'une différenciation tarifaire binaire *on-net*/*off-net*, notant p_{+i} le tarif *on-net* et p_{-i} le tarif *off-net*, le système de demande prend la forme particulière :

$$\begin{aligned} Q_{+i} &= \sigma_i M_i M_{i/i}^{2a} \left[M_{i/i}^{1-2a} - \tilde{\alpha}_i^i p_{+i} + \left(\alpha_i^i - \tilde{\alpha}_i^i \right) (p_{-i} - p_{+i}) \right] \\ &= \sigma_i M_i M_{i/i}^{2a} \left[M_{i/i}^{1-2a} - \alpha_i^i p_{+i} + \left(\alpha_i^i - \tilde{\alpha}_i^i \right) p_{-i} \right], \end{aligned}$$

$$\begin{aligned} j \neq i : Q_i^j &= \sigma_i M_i M_{j/i}^{2a} \left[M_{j/i}^{1-2a} - \tilde{\alpha}_i^j p_{-i} + (M_{i/i}/M_{j/i})^a \beta_i^{i,j} (p_{+i} - p_{-i}) \right] \\ &= \sigma_i M_i M_{j/i}^{2a} \left[M_{j/i}^{1-2a} + (M_{i/i}/M_{j/i})^a \beta_i^{i,j} p_{+i} - [\tilde{\alpha}_i^j + (M_{i/i}/M_{j/i})^a \beta_i^{i,j}] p_{-i} \right] . \end{aligned}$$

On observe, par exemple, qu'une baisse du tarif *on-net* p_{+i} augmente la demande Q_{+i} de communications *on-net* sur le réseau i et qu'elle diminue, par effet de substitution, les demandes Q_i^j de communication *off-net* sortant de ce réseau.

Le système des élasticités-prix se résume alors aux élasticités $\varepsilon_i^{+/+}$, $\varepsilon_i^{+/-}$, $\varepsilon_i^{j/+}$, $\varepsilon_i^{j/-}$ du trafic dans chaque direction *on-net* ou *off-net*, respectivement au prix *on-net* et au prix *off-net*, soit :

$$\begin{aligned} \varepsilon_i^{+/+} &= -\frac{\alpha_i^i p_{+i}}{M_{i/i}^{1-2a} - \alpha_i^i p_{+i} + (\alpha_i^i - \tilde{\alpha}_i^i) p_{-i}} < 0, \\ \varepsilon_i^{+/-} &= \frac{(\alpha_i^i - \tilde{\alpha}_i^i) p_{-i}}{M_{i/i}^{1-2a} - \alpha_i^i p_{+i} + (\alpha_i^i - \tilde{\alpha}_i^i) p_{-i}} \geq 0, \\ \varepsilon_i^{j/+} &= \frac{(M_{i/i}/M_{j/i})^a \beta_i^{i,j} p_{+i}}{M_{j/i}^{1-2a} + (M_{i/i}/M_{j/i})^a \beta_i^{i,j} p_{+i} - [\tilde{\alpha}_i^j + (M_{i/i}/M_{j/i})^a \beta_i^{i,j}] p_{-i}} \geq 0, \\ \varepsilon_i^{j/-} &= -\frac{[\tilde{\alpha}_i^j + (M_{i/i}/M_{j/i})^a \beta_i^{i,j}] p_{-i}}{M_{j/i}^{1-2a} + (M_{i/i}/M_{j/i})^a \beta_i^{i,j} p_{+i} - [\tilde{\alpha}_i^j + (M_{i/i}/M_{j/i})^a \beta_i^{i,j}] p_{-i}} < 0 . \end{aligned}$$

Si l'on agrège les différentes directions de trafic *off-net*, le système de demande se réduit à :

$$Q_{+i} = \sigma_i M_i M_{i/i}^{2a} \left[M_{i/i}^{1-2a} - \alpha_i^i p_{+i} + \left(\alpha_i^i - \tilde{\alpha}_i^i \right) p_{-i} \right]$$

$$Q_{-i} = \sigma_i M_i \sum_{j \neq i} M_{j/i}^{2a} \left[M_{j/i}^{1-2a} + (M_{i/i}/M_{j/i})^a \beta_i^{i,j} p_{+i} - [\tilde{\alpha}_i^j + (M_{i/i}/M_{j/i})^a \beta_i^{i,j}] p_{-i} \right] .$$

On en déduit, pour chaque opérateur i, les élasticités-prix, propre et croisée, du trafic *off-net* aux tarifs *off-net* et *on-net*, soit :

$$\begin{aligned}
\varepsilon_i^{-/-} &= \frac{p_{-i}}{Q_{-i}}\frac{dQ_{-i}}{dp_{-i}} = \sum_{j\neq i}\frac{Q_i^j}{Q_{-i}}\varepsilon_i^{j/-} \\
&= -\frac{\left(\sum_{j\neq i}[\widetilde{\alpha}_i^j + (M_{i/i}/M_{j/i})^a\beta_i^{i,j}]\right)p_{-i}}{\sum_{j\neq i}M_{j/i}^{2a}\left[M_{j/i}^{1-2a} + (M_{i/i}/M_{j/i})^a\beta_i^{i,j}p_{+i} - [\widetilde{\alpha}_i^j + (M_{i/i}/M_{j/i})^a\beta_i^{i,j}]p_{-i}\right]} < 0, \\
\varepsilon_i^{-/+} &= \frac{p_{+i}}{Q_{-i}}\frac{dQ_{-i}}{dp_{+i}} = \sum_{j\neq i}\frac{Q_i^j}{Q_{-i}}\varepsilon_i^{j/+} \\
&= \frac{\left(\sum_{j\neq i}(M_{i/i}/M_{j/i})^a\beta_i^{i,j}\right)p_{+i}}{\sum_{j\neq i}M_{j/i}^{2a}\left[M_{j/i}^{1-2a} + (M_{i/i}/M_{j/i})^a\beta_i^{i,j}p_{+i} - [\widetilde{\alpha}_i^j + (M_{i/i}/M_{j/i})^a\beta_i^{i,j}]p_{-i}\right]} \geq 0\ .
\end{aligned}$$

2 Les états remarquables de marché

2.1 Optimum de court terme

2.1.1 Caractérisation de l'optimum de court terme

Désignons par c_i (*resp.* c^i) le coût marginal d'écouler une minute de communication mobile sortante (*resp.* entrante) sur le réseau de l'opérateur i. Le coût variable CV_i engendré par le cumul du trafic entrant, du trafic sortant et du trafic *on-net* circulant sur le réseau i, a pour expression :

$$CV_i = \sum_{j=1}^{n} (c_i Q_i^j + c^i Q_j^i) = \mathbf{1} \cdot (c_i \mathbf{Q}_i + c^i \mathbf{Q}^i) \ .$$

Tenant compte du coût par abonné g_i indépendant du trafic (coût moyen de couverture), le coût global "technique" supporté par l'opérateur i, hors versement de terminaisons d'appels, s'écrit :

$$C_i = M_i g_i + CV_i = M_i g_i + \mathbf{1} \cdot (c_i \mathbf{Q}_i + c^i \mathbf{Q}^i) \ .$$

On en déduit le surplus collectif Σ, soit :

$$\begin{aligned}\Sigma &= \sum_{i=1}^{n} (W_i + R^i - C_i) \\ &= \sum_{i=1}^{n} M_i(u_i - g_i) + \sum_{i=1}^{n} v_i \left[\mathbf{1} \cdot \mathbf{M}_{\cdot/i} - \frac{\mathbf{Q}_i'}{2\sigma_i M_i} \right] \cdot \mathbf{X}_i(a) \cdot \mathbf{Q}_i \\ &+ \mathbf{1} \cdot \sum_{i=1}^{n} \left[(\rho_i v_i \mathbf{M}_{\cdot/i}^{1-2a} - c^i) \cdot \mathbf{Q}^i - c_i \mathbf{Q}_i \right] \ .\end{aligned}$$

Le surplus Σ est une fonction quadratique concave des volumes de trafic Q_i^j (puisque la matrice $\mathbf{X}_i(a)$ est définie positive sur $\mathbb{R}^{+n}$), si bien que l'optimum de court terme, à structure de marché invariante, est caractérisé par les conditions du premier ordre de la maximisation de Σ. Posant :

$$\mathbf{r}_i = [\rho_1 v_1 M_{i/1}^{1-2a}, \rho_2 v_2 M_{i/2}^{1-2a}, \ldots, \rho_n v_n M_{i/n}^{1-2a}], \quad \mathbf{c}^{\cdot} = [c^1, c^2, \ldots, c^n] \ ,$$

ces conditions s'écrivent :

$$\boldsymbol{\nabla}_{\mathbf{Q}_i}\Sigma = 0 \Leftrightarrow v_i \left(\mathbf{1} \cdot \mathbf{M}_{\cdot/i} - \frac{\mathbf{Q}_i'}{\sigma_i M_i} \right) \cdot \mathbf{X}_i(a) + \mathbf{r}_i = c_i \mathbf{1} + \mathbf{c}^{\cdot} \ .$$

D'où, compte tenu de l'expression des fonctions de demande inverse, l'expression des prix optimaux :

$$\begin{aligned} \mathbf{p}_i^* &= c_i \mathbf{1} + \mathbf{c}^{\cdot} - \mathbf{r}_i \Leftrightarrow \\ p_i^{j*} &= c_i + c^j - \rho_j v_j M_{i/j}^{1-2a} \ . \end{aligned}$$

Par substitution de ces prix dans l'expression des fonctions de demande agrégées, on obtient les trafics optimaux, soit :

$$\begin{aligned} \mathbf{Q}_i^* &= \sigma_i M_i \left(\mathbf{M}_{\cdot/i} \cdot \mathbf{1}' - \mathbf{A}_i(a) \cdot \mathbf{p}_i^{*\prime} \right) \Leftrightarrow \\ Q_i^{j*} &= \sigma_i M_i \left[M_{j/i} - M_{j/i}^{2a} \tilde{\alpha}_i^j c_i - M_{j/i}^{2a} \alpha_i^j (c^j - \rho_j v_j M_{i/j}^{1-2a}) + \sum_{k \neq j} M_{j/i}^a M_{k/i}^a \beta_i^{j,k} (c^k - \rho_k v_k M_{i/k}^{1-2a}) \right] \ . \end{aligned}$$

Enfin, l'écart entre le prix optimal *off-net* dans la direction j et le prix optimal *on-net* s'écrit :

$$j \neq i : p_i^{j*} - p_i^{i*} = c^j - c^i - (\rho_j v_j M_{i/j}^{1-2a} - \rho_i v_i M_{i/i}^{1-2a}) \ .$$

Propriété 1-a. *A l'optimum de court terme, le prix p_i^{j*} d'une minute de communication du réseau i vers le réseau j est égal au coût marginal correspondant $c_i + c^j$, minoré de l'externalité positive $\rho_j v_j M_{i/j}^{1-2a}$ procurée par la réception de cette minute.*

Propriété 1-b. *La différenciation off-net/on-net économiquement efficace traduit l'écart* *entre le coût marginal de terminaison sur le réseau destinataire et le coût marginal de terminaison sur le réseau propre, corrigé du différentiel d'utilité de réception d'une minute de communication selon que cette minute est off-net ou on-net. En l'absence de différentiels de coûts et d'externalités de réception d'appels, ou en présence de faibles différentiels, toute discrimination tarifaire significative entre trafics on-net et off-net est donc inefficace.*

2.1.2 Décentralisation de l'optimum de coourt terme

Le système des terminaisons d'appel, actuellement en vigueur sur les marchés mobiles européens, est un dispositif qui, accompagné d'une régulation des prix de détail, permet de décentraliser l'optimum.

Pour le montrer, notons τ^i le tarif de terminaison d'appel de l'opérateur i et soit γ_i^j le coût marginal que l'opérateur i supporte comptablement par minute de communication écoulée de i vers j :

$$\gamma_i^j = \begin{cases} c_i + c^i, & \text{si } j = i, \\ c_i + \tau^j, & \text{si } j \neq i. \end{cases}$$

Si les tarifs de détail étaient calés sur les coûts marginaux "sociaux" ($i.e.$ nets de l'externalité de réception d'appels) et si les tarifs de gros étaient calés sur les coûts marginaux, $i.e.$ si $p_i^j = \gamma_i^j - \rho_j v_j M_{i/j}^{1-2a}$ et $\tau^j = c^j$, on aurait :

$$p_i^j = c_i + c^j - \rho_j v_j M_{i/j}^{1-2a} = p_i^{j*} .$$

Propriété 1-c. *Si le régulateur fixait les tarifs de terminaison d'appel aux niveaux des coûts marginaux, et s'il était par ailleurs en mesure, sur le marché de détail, d'imposer une tarification au coût marginal "social", alors l'optimum de court terme serait ainsi décentralisé.*

Toutefois, soustraire l'externalité $\rho_j v_j M_{i/j}$ dans la fixation du tarif de détail p_i^j rend la minute de trafic sortante déficitaire ($p_i^{j*} < c_i + c^j$). On peut imaginer une compensation de ce déficit *via* une facturation de détail des appels reçus, c'est-à-dire *via* une internalisation de l'externalité dans les comptes. Si le prix de détail d'une minute entrante sur le réseau

j en provenance du réseau i était fixé égal à l'utilité marginale de cette minute, soit $\rho_j v_j M_{i/j}^{1-2a}$, alors les consommateurs seraient indifférents au volume des communications qu'ils reçoivent car leur "bilan" de la minute marginale reçue serait nul. Les fonctions de demande d'émission d'appels seraient inchangées, l'optimum serait préservé et l'opération d'internalisation se résumerait à un simple transfert : les consommateurs perdraient le surplus que leur procurait l'externalité de réception préalablement à son internalisation, tandis que les opérateurs incorporeraient ce surplus pour équilibrer leur bilan marginal de la minute de trafic sortante.

2.2 Equilibre de court terme

Les parts de marché des opérateurs en termes de nombres de clients étant exogènes à court terme, chaque opérateur i détient un monopole sur le sous-marché de détail des communications émises par ses clients depuis son réseau. Il en résulte que, dans le cadre de notre modèle, l'équilibre du marché global est de type "monopolistique". Cette référence correspond à un équilibre très peu concurrentiel parmi tous les équilibres de marché envisageables : en effet, dans la réalité, les parts de marché des opérateurs ne sont pas exogènes – mais endogènes – et ces derniers, qui craignent chacun une évasion de clientèle au bénéfice des autres, sont incités à tarifer la minute de communication en dessous du prix de monopole.

2.2.1 Equilibre de court terme non régulé

En l'absence de régulation des tarifs de terminaison d'appels, l'équilibre est celui d'un jeu dynamique en deux étapes, au cours duquel sont d'abord choisis les prix de gros, puis les prix de détail :

- à la première étape, en anticipant l'issue de la seconde, chaque opérateur i choisit le niveau de sa propre terminaison d'appel τ^i, celles des autres opérateurs étant fixées, en maximisant le profit d'interconnexion que le trafic entrant sur son réseau lui procure sur le marché de gros.
- à la seconde étape, chaque opérateur i choisit ses prix de détail p_i^j vers chacun des

réseaux destinataires ($j = 1, 2, \ldots, n$) en maximisant son profit de détail, à tarifs de terminaison d'appels données.

Ce jeu se résout par induction arrière, en "remontant" depuis le marché de détail vers le marché de gros.

1. Maximisation du profit à court terme sur le marché de détail.

Notons :

$$\boldsymbol{\gamma}_i = [\gamma_i^1, \gamma_i^2, \ldots, \gamma_i^n] \ ,$$

le vecteur des coûts "comptables", pour l'opérateur i, d'une minute de trafic sortante dans les différentes directions de trafic. Le profit engrangé par l'opérateur i sur le marché de détail s'écrit alors :

$$\begin{aligned}\Pi_i = \Phi_i - \gamma_i \cdot \mathbf{Q}_i &= M_i f_i + (\mathbf{p}_i - \boldsymbol{\gamma}_i) \cdot \mathbf{Q}_i \\ &= M_i f_i + v_i \left(\mathbf{1} \cdot \mathbf{M}_{./i} - \frac{\mathbf{Q}_i'}{\sigma_i M_i} \right) \cdot \mathbf{X}_i(a) \cdot \mathbf{Q}_i - \boldsymbol{\gamma}_i \cdot \mathbf{Q}_i \ .\end{aligned}$$

La maximisation de ce profit consiste à égaliser les recettes marginales aux coûts marginaux, ce qui conduit au système :

$$\boldsymbol{\nabla}_{\mathbf{Q}_i} \Pi_i = \mathbf{0} \Leftrightarrow \boldsymbol{\gamma}_i = \boldsymbol{\nabla}_{\mathbf{Q}_i} \Phi_i = v_i \left(\mathbf{1} \cdot \mathbf{M}_{./i} - \frac{2\mathbf{Q}_i'}{\sigma_i M_i} \right) \cdot \mathbf{X}_i(a) = 2\mathbf{p}_i - v_i \mathbf{1} \cdot \mathbf{M}_{./i} \cdot \mathbf{X}_i(a) \ .$$

On en déduit les prix d'équilibre, soit :

$$\begin{aligned}\overline{\mathbf{p}}_i &= \frac{1}{2} \left[\gamma_i + v_i \mathbf{1} \cdot \mathbf{M}_{./i} \cdot \mathbf{X}_i(a) \right] \\ &= \mathbf{p}_i^* + \frac{1}{2} \left[v_i \mathbf{1} \cdot \mathbf{M}_{./i} \cdot \mathbf{X}_i(a) - \boldsymbol{\gamma}_i \right] + (\boldsymbol{\gamma}_i - c_i \mathbf{1} - \mathbf{c}^{\cdot}) + \mathbf{r}_i \\ &\Leftrightarrow \overline{p}_i^j = \frac{1}{2} \left(\gamma_i^j + v_i \sum_{k=1}^{n} M_{j/i}^{-a} M_{k/i}^{1-a} \xi_i^{j,k} \right) \ .\end{aligned}$$

Par substitution de ces prix dans l'expression des fonctions de demande agrégées (et se rappelant que $\mathbf{A}_i(a) = \mathbf{X}_i^{-1}(a)/v_i$), on obtient la matrice de trafic d'équilibre, soit :

$$\overline{\mathbf{Q}}_i = \sigma_i M_i \left[\mathbf{M}_{\cdot/i} \cdot \mathbf{1}' - \mathbf{A}_i(a) \cdot \overline{\mathbf{p}}_i'\right] = \frac{\sigma_i M_i}{2} \left[\mathbf{M}_{\cdot/i} \cdot \mathbf{1}' - \mathbf{A}_i(a) \cdot \boldsymbol{\gamma}_i'\right] \Leftrightarrow$$
$$\overline{Q}_i^j = \frac{\sigma_i M_i}{2} \left[M_{j/i} - M_{j/i}^{2a} \alpha_i^j \gamma_i^j + \sum_{k \neq j} M_{j/i}^a M_{k/i}^a \beta_i^{j,k} \gamma_i^k\right] .$$

Enfin, l'écart entre le prix *off-net* dans la direction j et le prix *on-net* s'écrit :

$$j \neq i : \overline{p}_i^j - \overline{p}_i^i = \frac{1}{2}(\tau^j - c^i) + \frac{v_i}{2} \sum_{k \neq i,j}^{n} \left(M_{j/i}^{-a} \xi_i^{j,k} - M_{i/i}^{-a} \xi_i^{i,k}\right) M_{k/i}^{1-a} .$$

Propriété 2-a. *Les prix d'équilibre de court terme $\overline{p}_i^j$ sont supérieurs aux prix optimaux de court terme p_i^{j*} pour trois raisons cumulatives. D'abord, ils incorporent un mark-up au dessus du coût marginal associé γ_i^j ($v_i \mathbf{1} \cdot \mathbf{M}_{\cdot/i} \cdot \mathbf{X}_i(a) > \boldsymbol{\gamma}_i$). Ensuite, par effet de répercussion du marché de gros sur le marché de détail, les tarifs off-net sonts majorés des marges d'interconnexion que réalisent les opérateurs des réseaux destinataires ($\boldsymbol{\gamma}_i > c_i \mathbf{1} - \mathbf{c}^{\cdot}$). Enfin, les prix $\overline{p}_i^j$ ignorent l'externalité $\rho_j v_j M_{i/j}^{1-2a}$ de réception d'appels ($\mathbf{r}_i > \mathbf{0}$).*

Propriété 2-b. *L'équilibre de court terme induit une différenciation tarifaire off-net/on-net, par le cumul de deux effets. D'une part, l'écart entre la terminaison d'appel payée à chaque réseau destinataire et le coût de la minute on-net ($\tau^j - c^i > 0$) tend à grever les tarifs off-net. D'autre part, selon que la substituabilité off-net/off-net est plus intense ou moins intense que la substituabilité on-net/off-net (i.e. selon que $M_{j/i}^{-a} \xi_i^{j,k} >$ ou $< M_{i/i}^{-a} \xi_i^{i,k}$), le premier effet est majoré ou minoré.*

2. Maximisation du profit sur le marché de gros.

Pour l'opérateur i, le profit d'interconnexion entrante s'écrit :

$$\Psi^i = (\tau^i - c^i) \mathbf{1} \cdot \overline{\mathbf{Q}}^i$$
$$= \frac{1}{2}(\tau^i - c^i) \sum_{j \neq i} \sigma_j M_j \left[M_{i/j} - M_{j/i}^{2a} \widetilde{\alpha}_j^i c_j + \sum_{k \neq i} M_{j/i}^a M_{k/i}^a \beta_j^{i,k} \tau^k - M_{j/i}^{2a} \alpha_j^i \tau^i\right] .$$

La maximisation de Ψ^i par rapport à τ^i, tous les τ^k étant fixés pour $k \neq i$, donne la fonction de "meilleure réponse" $\tau^i(\boldsymbol{\tau}^{-i})$ de chaque opérateur i :

$$\tau^i(\boldsymbol{\tau}^{-i}) = \frac{\sum_{k\neq i}\left(\sum_{j\neq i}\sigma_j M_j (M_{i/k}/M_{i/j})^a M\beta_j^{i,k}\right)\tau^k + \sum_{j\neq i}\sigma_j M_j\left(M_{i/j}^{1-2a} + \alpha_j^i c^i - \tilde{\alpha}_j^i c_j\right)}{2\sum_{j\neq i}\sigma_j M_j \alpha_j^i} .$$

Dans le cas particulier uniforme, où les coûts de la minute sont identiques sur chacun des réseaux mobiles, où tous les opérateurs ont la même part de marché, ainsi que le même profil de clientèle, où les effets de club sont absents et où les effets de couplage sont uniformes, alors le tarif de terminaison d'appel est fixé par chacun des opérateurs à un même niveau $\overline{\tau}$, donné par l'équation précédente, soit :

$$c_i = c_. \ , \ c^i = c^. \ , \ M_i = M_{i/.} = \frac{M}{n} \ , \ \alpha_i^j = \alpha \ , \ \beta_i^{j,k} = \beta \ \Rightarrow$$
$$\overline{\tau}^i = \overline{\tau} = c^. + \frac{(M/n)^{1-2a} - [\alpha - (n-1)\beta](c^. + c_.)}{2\alpha - (n-1)\beta} .$$

Ou encore, en substituant les expressions de α et β en fonction de la valorisation psyvhologique v et du coefficient de couplage ξ dans le cas uniforme (cf. section 3) :

$$\overline{\tau} = c^. + \frac{v(M/n)^{1-2a}[1 + (n-1)\xi] - (c^. + c_.)}{2 + (n-1)\xi/(1-\xi)} .$$

Propriété 2-c. *Le comportement stratégique des opérateurs sur le marché de l'interconnexion conduit chacun d'eux à fixer son tarif de terminaison d'appels au-dessus du coût marginal. Puisque ce mark-up est répercuté sur les prix de détail off-net (cf. supra), il en résulte un phénomène de double marge en l'absence de régulation des tarifs de gros.*

2.2.2 Equilibre de court terme régulé

La différence, par rapport à l'équilibre non régulé, consiste en ce que le régulateur plafonne le *mark-up* incorporé dans les tarifs de terminaison d'appel en-dessous du niveau qui serait spontanément choisi par les opérateurs, soit :

$$\tau^i - c^i \leq \mu^i \ ,$$

où $c^i + \mu^i$ est le *price-cap* imposé à l'opérateur i sur le marché de gros.

Sous cette contrainte, chacun des opérateurs se cale sur le *price-cap*, d'où :

$$\begin{aligned} \boldsymbol{\gamma}_i &= c_i \mathbf{1} + \mathbf{c}^{\cdot} + \boldsymbol{\mu}^{\cdot} \Leftrightarrow \\ \gamma_i^j &= c_i + c^j + \mu^j \ . \end{aligned}$$

L'équilibre de court terme sur le marché de détail conduit alors au système de prix :

$$\begin{aligned} \overline{\mathbf{p}}_i &= \frac{1}{2}\left[c_i \mathbf{1} + \mathbf{c}^{\cdot} + \boldsymbol{\mu}^{\cdot} + v_i \mathbf{1} \cdot \mathbf{M}_{\cdot/i} \cdot \mathbf{X}_i(a)\right] \Leftrightarrow \\ \overline{p}_i^j &= \frac{1}{2}\left[c_i + c^j + \mu^j + v_i \left(\sum_{k=1}^{n} M_{j/i}^{-a} M_{k/i}^{1-a} \xi_i^{j,k}\right)\right] \ , \end{aligned}$$

d'où le différentiel entre les prix *off-net* et le prix *on-net* :

$$j \neq i : \overline{p}_i^j - \overline{p}_i^i = \frac{c^j - c^i}{2} + \frac{v_i}{2} \sum_{k=1}^{n} (M_{j/i}^{-a} \xi_i^{j,k} - M_{i/i}^{-a} \xi_i^{i,k}) M_{k/i}^{1-a} \ .$$

Propriété 2-d. *Via une répercussion du gros sur le détail, la régulation des tarifs de terminaison d'appels par plafonnement tarifaire incite transitoirement les opérateurs à majorer l'écart entre prix off-net et prix on-net, au-delà de ce que justifieraient le différentiel de coûts marginaux et le différentiel de parts de marché. Cette incitation tend cependant à disparaître au fur et à mesure que le plafonnement tarifaire converge vers le niveau des coûts marginaux (*$\boldsymbol{\mu}^{\cdot} \to \mathbf{0}$*).*

3 Impacts de changements tarifaires

Dans cette section, nous étudions l'incidence de court terme, à structure de marché invariante, de changements tarifaires décidés par les opérateurs mobiles actifs sur le marché. Ces variations interviennent à partir d'un certain état initial du marché caractérisé par les prix $(f_i, \mathbf{p}_i)$ et par les volumes de trafic $\mathbf{Q}_i$ correspondant aux demandes exprimées sous les prix de la minute $\mathbf{p}_i$. Autour de cet état de référence, nous ne considérerons que des changements tarifaires $(\Delta f_i, \Delta \mathbf{p}_i)$ *neutres*, c'est-à-dire ne modifiant pas les revenus de détail des opérateurs (ni donc les dépenses de leurs clients), soit :

$$\begin{aligned}
\Delta \Phi_i &= 0 \Leftrightarrow \\
\Delta f_i &= -\frac{1}{M_i} \Delta(\mathbf{p}_i \cdot \mathbf{Q}_i) \\
&= -\sigma_i \{\Delta \mathbf{p}_i \cdot [\mathbf{M}_{\cdot/i} \cdot \mathbf{1'} - \mathbf{A}_i(a) \cdot \mathbf{p}_i'] - \mathbf{p}_i \cdot \mathbf{A}_i(a) \cdot \Delta \mathbf{p}_i'\} \\
&- \sigma_i \Delta \mathbf{p}_i \cdot \mathbf{A}_i(a) \cdot \Delta \mathbf{p}_i' \\
\Delta f_i &= -\sigma_i \left[\mathbf{1} \cdot \mathbf{M}_{\cdot/i} - 2\mathbf{p}_i \cdot \mathbf{A}_i(a)\right] \cdot \Delta \mathbf{p}_i' - \sigma_i \Delta \mathbf{p}_i \cdot \mathbf{A}_i(a) \cdot \Delta \mathbf{p}_i' \,.
\end{aligned}$$

Au sein de "*l'orbite neutre*" de l'état de référence, *i.e.* l'ensemble de tous les changements tarifaires neutres pouvant être effectués à partir de cet état du marché, un changement particulier entrepris par l'opérateur i est entièrement spécifié par la donnée du vecteur $\Delta \mathbf{p}_i$ des variations des prix de la minute dans les différentes directions de trafic.

3.1 Impact sur les volumes de trafic

Supposons que les différents opérateurs $i = 1, 2, ..., n$ pratiquent des changements tarifaires neutres caractérisés par les variations $\Delta \mathbf{p}_i$ des prix de la minute vers les différentes directions de trafic. A court terme, chaque opérateur détenant un monopole sur les appels émis depuis son réseau, les volumes de trafic $\mathbf{Q}_i$ issus du réseau i ne sont sensibles qu'aux prix $\mathbf{p}_i$ fixés par l'opérateur i. D'après l'expression des fonctions de demande agrégée, on a :

$$\begin{aligned} \Delta \mathbf{Q}_i &= -\sigma_i M_i \mathbf{A}_i(a) \cdot \Delta \mathbf{p}_i' \Leftrightarrow \\ \Delta Q_i^j &= \sigma_i M_i \left[-M_{j/i}^{2a} \alpha_i^j \Delta p_i^j + \sum_{k \neq j} M_{j/i}^a M_{k/i}^a \beta_i^{k,j} \Delta p_i^k \right] , \end{aligned}$$

et l'impact sur le trafic total Q_i émis par les clients de l'opérateur i s'écrit :

$$\Delta Q_i = \mathbf{1} \cdot \Delta \mathbf{Q}_i = -\sigma_i M_i \sum_{j=1}^{n} M_{j/i}^{2a} \widetilde{\alpha}_i^j \Delta p_i^j \ .$$

A partir de ces expressions générales, on peut comparer les effets respectifs de baisses tarifaires *on-net*, soit $\Delta^{\text{on}} \mathbf{p}_i = \Delta p_{+i} \mathbf{1}_i$ ($\Delta p_{+i} < 0$) ou de baisses tarifaires *all-net*, soit $\Delta^{\text{all}} \mathbf{p}_i = \Delta p_i \mathbf{1}$ ($\Delta p_i < 0$).

Baisses on-net :

$$\begin{aligned} \Delta^{\text{on}} Q_{+i} &= -\sigma_i M_i M_{i/i}^{2a} \alpha_i^i \Delta p_{+i} > 0 \quad , \quad j \neq i : \Delta^{\text{on}} Q_i^j = \sigma_i M_i M_{i/i}^a M_{j/i}^a \beta_i^{i,j} \Delta p_{+i} \leq 0 \\ \Delta^{\text{on}} Q_i &= -\sigma_i M_i M_{i/i}^{2a} \widetilde{\alpha}_i^i \Delta p_{+i} > 0 \ . \end{aligned}$$

Baisses all-net :

$$\begin{aligned} \forall j : \Delta^{\text{all}} Q_i^j &= -\sigma_i M_i M_{j/i}^{2a} \widetilde{\alpha}_i^j \Delta p_i > 0 \\ \Delta^{\text{all}} Q_i &= -\sigma_i M_i \left(\sum_{j=1}^{n} M_{j/i}^{2a} \widetilde{\alpha}_i^j \right) \Delta p_i > 0 \ . \end{aligned}$$

Propriété 3-a. *Une baisse tarifaire on-net augmente le trafic on-net par effet d'élasticité propre, tandis qu'elle diminue le trafic off-net par effet d'élasticité croisée de substi-*

tution. Une baisse tarifaire all-net accroît les volumes de trafic dans toutes les directions, on-net et off-net. Qu'elle soit on-net ou all-net, une baisse tarifaire accroît le trafic total sortant de l'opérateur qui la décide. L'augmentation du trafic total sortant est plus forte (resp. plus faible) dans une baisse all-net que dans une baisse on-net si le ratio de la seconde baisse à la première n'excède pas (resp. excède) un certain seuil δ_i^Q, *dépendant des coefficients de substituabilité :*

$$\frac{\Delta^{\text{all}} Q_i}{\Delta^{\text{on}} Q_i} \gtreqless 1 \Leftrightarrow \frac{|\Delta p_{+i}|}{|\Delta p_i|} \lesseqgtr \delta_i^Q = 1 + \frac{1}{M_{i/i}^{2a} \widetilde{\alpha}_i^i} \sum_{j \neq i} M_{j/i}^{2a} \widetilde{\alpha}_i^j \ .$$

Lorsque $|\Delta p_{+i}| = \delta_i^Q \, |\Delta p_i|$, *la baisse on-net et la baisse all-net sont "trafic sortant équivalentes".*

3.2 Impact sur les consommateurs

La facture restant invariante sous un changement tarifaire neutre, la variation du surplus de consommation S_i de la clientèle de l'opérateur i, hors externalité de réception d'appels, coïncide avec la variation de l'utilité W_i du trafic émis. L'expression de cette dernière étant quadratique en fonction des volumes de trafic, et donc des prix de la minute, la variation ΔS_i s'écrit :

$$\Delta S_i = \Delta W_i = \boldsymbol{\nabla}_{\mathbf{Q}_i} W_i \cdot \Delta \mathbf{Q}_i + \frac{1}{2} \Delta \mathbf{Q}_i' \cdot \boldsymbol{\nabla}^2_{\mathbf{Q}_i^2} W_i \cdot \Delta \mathbf{Q}_i \ .$$

Or, on a :

$$\boldsymbol{\nabla}_{\mathbf{Q}_i} W_i = \mathbf{p}_i \quad , \quad \boldsymbol{\nabla}^2_{\mathbf{Q}_i^2} W_i = \boldsymbol{\nabla}_{\mathbf{Q_i}} \mathbf{p}_i = -\frac{v_i \mathbf{X}_i(a)}{\sigma_i M_i} = -\frac{\mathbf{A}_i^{-1}(a)}{\sigma_i M_i}$$

$$\Delta \mathbf{Q}_i = -\sigma_i M_i \mathbf{A}_i(a) \cdot \Delta \mathbf{p}_i' \ .$$

D'où :

$$\Delta S_i = -\sigma_i M_i \left(\mathbf{p}_i + \frac{\Delta \mathbf{p}_i}{2}\right) \cdot \mathbf{A}_i(a) \cdot \Delta \mathbf{p}'_i$$
$$= -\sigma_i M_i \sum_{j=1}^{n} \left(p_i^j + \frac{\Delta p_i^j}{2}\right) \left(M_{j/i}^{2a} \alpha_i^j \Delta p_i^j - \sum_{k\neq j} M_{j/i}^a M_{k/i}^a \beta_i^{j,k} \Delta p_i^k\right) .$$

On remarque que, au premier ordre, on a :

$$\Delta S_i \simeq \mathbf{p}_i \cdot \Delta \mathbf{Q}_i = -\sigma_i M_i \mathbf{p}_i \cdot \mathbf{A}_i(a) \cdot \Delta \mathbf{p}'_i .$$

Propriété 3-b. *Au premier ordre, l'impact sur le surplus de consommation d'un changement tarifaire neutre est égal à la variation virtuelle de facture à prix constants, i.e. égal à la sous-variation de facture imputable à la seule variation de trafic. L'impact sur le surplus est donc d'autant plus important que la demande est fortement élastique aux prix (coefficients de sensibilité-prix α_i^j élevés).*

Propriété 3-c. *Si tous les opérateurs décidaient simultanément des changements tarifaires neutres "équivalents", i.e. induisant une même variation virtuelle de facture ($j \neq i$: $\mathbf{p}_i \cdot \Delta \mathbf{Q}_i = \mathbf{p}_j \cdot \Delta \mathbf{Q}_j$) chez leurs clientèles respectives, alors ce mouvement tarifaire conjoint ne modifierait pas sensiblement la situation des consommateurs, ne susciterait pas des migrations de clientèle significatives et laisserait donc quasi-invariante la structure du marché.*

A la variation ΔS_i du surplus procuré par le trafic émis s'ajoute la variation ΔR^i du bénéfice externe des appels reçus, soit :

$$\Delta R^i = \rho_i v_i \mathbf{1} \cdot \mathbf{M}_{\cdot/i}^{1-2a} \cdot \Delta \mathbf{Q}^i = \rho_i v_i \sum_{j=1}^{n} M_{j/i}^{1-2a} \Delta Q_j^i$$
$$= -\rho_i v_i \mathbf{1}_i \cdot \sum_{j=1}^{n} \sigma_j M_j M_{j/i}^{1-2a} \mathbf{A}_j(a) \cdot \Delta \mathbf{p}'_j$$
$$= -\rho_i v_i \sum_{j=1}^{n} \sigma_j M_j M_{j/i}^{1-2a} \left(M_{i/j}^{2a} \alpha_j^i \Delta p_j^i - \sum_{k\neq i} M_{i/j}^a M_{k/j}^a \beta_j^{i,k} \Delta p_j^k\right) .$$

Comparons les effets de baisses simultanées *on-net* ou *all-net*.

Baisses on-net :

$$\Delta^{\text{on}} S_i = -\sigma_i M_i M_{i/i}^{2a} \left[\left(\alpha_i^i p_i^i - \sum_{j \neq i} (M_{j/i}/M_{i/i})^a \beta_i^{i,j} p_i^j \right) \Delta p_{+i} - \frac{\sigma_i \alpha_i^i}{2} (\Delta p_{+i})^2 \right]$$
$$\Delta^{\text{on}} R^i = -\rho_i v_i \sigma_i M_i M_{i/i} \alpha_i^i \Delta p_{+i} + \rho_i v_i \sum_{j \neq i} \sigma_j M_j M_{j/i}^{1-2a} M_{i/i}^a M_{j/j}^a \beta_j^{i,j} \Delta p_{+j} \ .$$

Baisses all-net :

$$\Delta^{\text{all}} S_i = -\sigma_i M_i \left(\sum_{j=1}^{n} M_{j/i}^{2a} \widetilde{\alpha}_i^j p_i^j \right) \Delta p_i - \frac{\sigma_i M_i}{2} \left(\sum_{j=1}^{n} M_{j/i}^{2a} \widetilde{\alpha}_i^j \right) (\Delta p_i)^2$$
$$\Delta^{\text{all}} R^i = -\rho_i v_i \sum_{j=1}^{n} \sigma_j M_j M_{j/i}^{1-2a} M_{i/j}^{2a} \widetilde{\alpha}_j^i \Delta p_j \ .$$

Propriété 3-d. *Au premier ordre, une baisse all-net procure davantage (resp. moins) de surplus de consommation qu'une baisse on-net si le ratio rapportant la seconde baisse n'excède pas (resp. excède) un certain seuil* δ_i^S *qui dépend des coefficients de substituabilité et des prix :*

$$\frac{\Delta^{\text{all}} S_i}{\Delta^{\text{on}} S_i} \gtreqless 1 \Leftrightarrow \frac{|\Delta p_{+i}|}{|\Delta p_i|} \lesseqgtr \delta_i^S = \frac{\sum_{j=1}^{n} M_{j/i}^{2a} \widetilde{\alpha}_i^j p_i^j}{M_{i/i}^{2a} \left(\alpha_i^i p_i^i - \sum_{j \neq i} (M_{j/i}/M_{i/i})^a \beta_i^{i,j} p_i^j \right)} \ .$$

Lorsque $|\Delta p_{+i}| = \delta_i^S \, |\Delta p_i|$, la *baisse on-net et la baisse off-net sont "surplus de consommation équivalentes".*

Propriété 3-e. *Une baisse tarifaire on-net augmente le bénéfice externe de réception d'appels pour les clients de l'opérateur qui pratique cette baisse et elle diminue ce bénéfice pour les clients d'un opérateur tiers. Une baisse tarifaire all-net accroît le bénéfice de réception d'appels pour tous les destinataires, que leur opérateur soit - ou non - celui qui pratique la baisse.*

3.3 Impact sur les opérateurs

Les revenus de détail restant invariants sous un changement tarifaire neutre, la variation de profit sur le marché de détail se résume à l'opposé de la variation du coût d'écoulement du trafic. Les variations respectives du profit de détail Π_i et du profit de gros Ψ^i de l'opérateur i s'écrivent :

$$\begin{aligned}\Delta\Pi_i &= -\gamma_i \cdot \Delta\mathbf{Q}_i = \sigma_i M_i \gamma_i \cdot \mathbf{A}_i(a) \cdot \Delta\mathbf{p}'_i \\ &= \sigma_i M_i \sum_{j=1}^{n} \gamma_i^j \left(M_{j/i}^{2a} \alpha_i^j \Delta p_i^j - \sum_{k\neq j} M_{j/i}^a M_{k/i}^a \beta_i^{j,k} \Delta p_i^k \right)\end{aligned}$$

$$\begin{aligned}\Delta\Psi^i &= (\tau^i - c^i) \sum_{j\neq i} \Delta Q_j^i = -(\tau^i - c^i) \mathbf{1}_i \cdot \sum_{j\neq i} \sigma_j M_j \mathbf{A}_j(a) \cdot \Delta\mathbf{p}'_j \\ &= -(\tau^i - c^i) \sum_{j\neq i} \sigma_j M_j \left(M_{j/i}^{2a} \alpha_j^i \Delta p_j^i - \sum_{k\neq i} M_{j/i}^a M_{k/i}^a \beta_j^{i,k} \Delta p_j^k \right) .\end{aligned}$$

Dans le cas de baisses simultanées *on-net* ou *all-net*, les impacts sur les profits prennent la forme suivante.

Baisses on-net :

$$\begin{aligned}\Delta^{\text{on}}\Pi_i &= \sigma_i M_i M_{i/i}^{2a} \left(\alpha_i^i \gamma_i^i - \sum_{j\neq i} (M_{j/i}/M_{i/i})^a \beta_i^{i,j} \gamma_i^j \right) \Delta p_{+i} < 0 \\ \Delta^{\text{on}}\Psi^i &= (\tau^i - c^i) \sum_{j\neq i} \sigma_j M_j M_{i/j}^a M_{j/j}^a \beta_j^{i,j} \Delta p_{+j} < 0 .\end{aligned}$$

Baisse tarifaire all-net équivalente :

$$\begin{aligned}\Delta^{\text{all}}\Pi_i &= \sigma_i M_i \left(\sum_{j=1}^{n} M_{j/i}^{2a} \tilde{\alpha}_i^j \gamma_i^j \right) \Delta p_i < 0 \\ \Delta^{\text{all}}\Psi^i &= -(\tau^i - c^i) \sum_{j\neq i} \sigma_j M_j M_{i/j}^{2a} \tilde{\alpha}_j^i \Delta p_j > 0 .\end{aligned}$$

Propriété 3-f. *Une baisse tarifaire neutre, on-net ou all-net, diminue le profit de détail* *de l'opérateur qui la décide.*

Propriété 3-g. *Une baisse all-net abaisse davantage (resp. moins) le profit de détail qu'une baisse on-net si le ratio rapportant la seconde baisse n'excède pas (resp. excède) un certain seuil δ_i^Π qui dépend des coefficients de substituabilité et des coûts :*

$$\frac{\left|\Delta^{\mathrm{all}}\Pi_i\right|}{\left|\Delta^{\mathrm{on}}\Pi_i\right|} \gtreqless 1 \Leftrightarrow \frac{|\Delta p_{+i}|}{|\Delta p_i|} \lesseqgtr \delta_i^\Pi = \frac{\sum_{j=1}^{n} M_{j/i}^{2a}\widetilde{\alpha}_i^j\gamma_i^j}{M_{i/i}^{2a}\left(\alpha_i^i\gamma_i^i - \sum_{j\neq i}(M_{j/i}/M_{i/i})^a\beta_i^{i,j}\gamma_i^j\right)} .$$

Lorsque $|\Delta p_{+i}| = \delta_i^\Pi\,|\Delta p_i|$, la *baisse on-net et la baisse off-net sont "profit de détail équivalentes".*

Propriété 3-h. *Une baisse tarifaire on-net (resp. all-net) consentie par un opérateur donné affecte négativement (resp. positivement) les profits que les opérateurs tiers engrangent au titre de l'interconnexion entrante, car elle diminue (resp. augmente) le trafic émis vers chacune des directions off-net.*

Il en résulte que, pour une même amplitude de réduction de profit sur le marché de détail, abaisser les tarifs en *all-net* plutôt que en *on-net*, confère un gain substantiel à chaque opérateur i, soit :

$$\Delta(\Delta\Psi^i) = -(\tau^i - c^i)\sum_{j\neq i}\sigma_j M_j M_{i/j}^{2a}\left[\widetilde{\alpha}_j^i\Delta p_j + (M_{j/j}/M_{i/j})^a\beta_j^{i,j}\Delta p_{+j}\right] > 0 .$$

Par conséquent, si des baisses tarifaires alternatives *on-net* et *all-net* étaient ajustées de telle façon qu'elles exercent le même impact sur le profit consolidé de chaque opérateur, et non pas sur leurs profits de détail comme on l'a supposé, alors pratiquer une baisse *all-net* plutôt que *on-net* conduirait à transférer un gain de surplus aux clients des différents opérateurs.

Propriété 3-i. *Entre deux jeux de baisses tarifaires produisant un même effet sur leurs profits consolidés, incluant les profits d'interconnexion entrante, les opérateurs cèdent davantage de surplus de consommation à leurs clients sous un jeu de baisses simultanées all-net que sous un jeu de baisses simultanées on-net.*

3.4 Impact économique global

En cumulant les impacts sur les surplus des différentes clientèles et les profits des différents opérateurs, on obtient l'impact sur le surplus collectif Σ, soit :

$$\begin{aligned}
\Delta\Sigma &= \sum_{i=1}^{n} \left(\Delta S_i + \Delta R^i + \Delta\Pi_i + \Delta\Psi^i\right) \\
&= \sum_{i=1}^{n} -\sigma_i M_i \left(\mathbf{p}_i + \frac{\Delta\mathbf{p}_i}{2}\right) \cdot \mathbf{A}_i(a) \cdot \Delta\mathbf{p}'_i - \sum_{i=1}^{n}\rho_i v_i \mathbf{1}_i \cdot \sum_{j=1}^{n}\sigma_j M_j M_{j/i}^{1-2a}\mathbf{A}_j(a)\cdot\Delta\mathbf{p}'_j \\
&+ \sum_{i=1}^{n}\sigma_i M_i \gamma_i \cdot \mathbf{A}_i(a)\cdot\Delta\mathbf{p}'_i - \sum_{i=1}^{n}(\tau^i - c^i)\mathbf{1}_i \cdot \sum_{j\neq i}\sigma_j M_j \mathbf{A}_j(a)\cdot\Delta\mathbf{p}'_j \;,
\end{aligned}$$

d'où, après recomposition des termes et introduction des prix optimaux $\mathbf{p}_i^*$:

$$\begin{aligned}
\Delta\Sigma &= \sum_{i=1}^{n}\sigma_i M_i(\mathbf{p}_i - \mathbf{p}_i^* - \frac{\Delta\mathbf{p}_i}{2})\cdot\mathbf{A}_i(a)\cdot\Delta\mathbf{p}'_i \\
&= \sum_{i=1}^{n}\sigma_i M_i \sum_{j=1}^{n}\left(p_i^j - p_i^{j*} - \frac{\Delta p_i^j}{2}\right)\left(M_{j/i}^{2a}\alpha_i^j\Delta p_i^j - \sum_{k\neq j}M_{j/i}^a M_{k/i}^a \beta_i^{j,k}\Delta p_i^k\right) \;.
\end{aligned}$$

On vérifie qu'au voisinage de l'optimum de premier rang ($\mathbf{p}_i = \mathbf{p}_i^*$), la variation du surplus collectif est nulle au premier ordre.

Examinons maintenant les deux cas particuliers de baisses tarifaires simultanées *on-net* ou *all-net.*

Baisses on-net :

$$\begin{aligned}
\Delta^{\text{on}}\Sigma = -\sum_{i=1}^{n}\sigma_i M_i M_{i/i}^{2a}\left[\alpha_i^i(p_i^i - p_i^{i*}) - \sum_{j\neq i}(M_{j/i}/M_{I/i})^a\beta_i^{i,j}(p_i^j - p_i^{j*})\right]\Delta p_{+i} \\
-\frac{1}{2}\sum_{i=1}^{n}\sigma_i M_i M_{i/i}^{2a}\alpha_i^i\Delta^2 p_{+i} > 0 \;.
\end{aligned}$$

Baisses all-net :

$$\Delta^{\mathrm{all}}\Sigma = -\sum_{i=1}^{n}\sigma_i M_i\left[\sum_{j=1}^{n} M_{j/i}^{2a}\tilde{\alpha}_i^j(p_i^j - p_i^{j*})\right]\Delta p_i$$

$$+\frac{1}{2}\sum_{i=1}^{n}\sigma_i M_i\left[\sum_{j=1}^{n} M_{j/i}^{2a}\tilde{\alpha}_i^j\right]\Delta^2 p_i > 0\ .$$

Propriété 3-j. *Une baisse tarifaire, qu'elle soit all-net ou on-net, accroît le surplus collectif, augmente le surplus des consommateurs et diminue les profits de détail des opérateurs. Mais, de manière contrastée, une baisse all-net améliore le solde d'interconnexion des opérateurs tiers, tandis qu'une baisse on-net le dégrade. De même, une baisse all-net augmente le bénéfice externe des appels reçus par les clients des opérateurs tiers, tandis qu'une baisse on-net diminue ce bénéfice.*

4 Analyse numérique

L'objectif de cette section est d'illustrer les résultats de la précédente par une simulation numérique des effets comparés de différentes baisses tarifaires neutres, *on-net* ou *all-net*, pratiquées par les opérateurs à partir d'une situation initiale caractérisée par une tarification *all-net*.

4.1 Revue des approches à l'estimation de fonctions de la demande en télécommunications

Avant de procéder à la calibration de notre modèle, nous allons proposer une revue de la littérature empirique sur l'estimation de la demande sur le marché de télécommunications. Nous allons décrire les différentes approches de modélisation, les spécifications de modèles et les hypothèses qui peuvent être employées dans l'estimation. Les différents résultats de l'estimation du niveau d'élasticité prix et de la force d'externalités sont présentées dans la section suivante. Une variation de trafic sur un marché de téléphonie peut être décomposée en deux : une variation dans le nombre d'utilisateurs et une variation dans la consommation d'un utilisateur moyen. Dans notre modèle le nombre d'utilisateurs est donné de la manière exogène, c'est pourquoi nous allons nous intéresser à la deuxième composante, variation de consommation d'un abonné moyen ; la demande de traffic est une fonction de prix par minute. D'après notre connaissance, qucun travail empirique distingue les appels en fonction de l'opérateur de destination. Les appels peuvent être séparés uniquement en fonction de type – fixe ou mobile, ou en fonction de la distance.

L'élasticité de prix constante est une hypothèse couramment employée pour estimer la fonction de demande, elle est exprimée en forme log-linéaire :

$$\ln q = \alpha + \beta \ln p + \sum_j \gamma_j \ln p_j + \sum_k \delta_k x_k + \epsilon,$$

où q est la quantité de minutes du service étudié, p — son prix par minute, p_j — prix d'autres services téléphoniques et x_k — autres facteurs. β est l'élasicité propre et γ_j est l'élasticité croisée.

Cette regression peut être estimée en utilisant soit les données individuelles soit les données aggrégées. Ci-dessous nous allons considérer quelques exemples.

Dewenter et Haucap (2005) exploitent les données de panel agrégées au niveau des opérateurs pour estimer l'équation suivante de la demande de communications mobiles en Autriche :

$$\ln q_{it} = \alpha_{it} + \beta \ln p_{it} + \sum_k \delta_k x_{it,k} + \epsilon_{it},$$

où q_{it} est la quantité moyenne deamandée par un utilisateur pour le tarif i au moment de temps t, p_{it} est le prix moyen respectif, $x_{it,k}$ sont k variables explicatives additionnelles qui incluent la base d'abonnés, les variables indicatrices du temps et de l'opérateur.

Dans leur estimation de demande pour communications internationales en Grèce, Agiakloglou et Yannelis (2006) utilisent les séries chronologiques agrégées au niveau national :

$$lnQ_t = \alpha + \beta \ln p_t + \sum_k \delta_k x_{t,k} + \epsilon_t,$$

où Q_t est le trafic total international sortant mesuré en minutes d'appels et qui inclut les appels lancés sur les réseaux mobile et fixe, p_t est le prix réel par minute que l'opérateur OTE fait payer pour chaque destination. Les variables explicatives additionnelles $x_{t,k}$ incluent le PIB réel et le nombre de lignes fixes.

Pour estimer la demande de communications mobiles, Ingraham et Sidak (2004) utilisent des données au niveau des abonnés individuels à partir d'une enquête menée aux Etats-Unis. Ils estiment la demande de consommateurs pour les services mobiles comme une fonction de prix mobile et de prix de communications de longue distance pour prendre en compte l'effet de la substitution. L'élasticité propre et l'élasticité croisée sont constantes. La demande d'un consommateur i pour les services mobiles s'écrit

$$\ln q_i = \alpha + \beta \ln p_i + \gamma \ln p_{ld,i} + \delta_1 t_i + \sum_{k>1} \delta_k x_k + \epsilon_i,$$

où q_i est la consommation individuelle de minutes mobiles, p_i est le prix par minute de services mobiles, et p_{ld} est le prix par minute de service fixe de longue distance. x_k sont des variables demographiques.

Sur le marché de télécommunications qui évalue vite la valeur d'élasticité peut varier de l'année à l'autre. Les spécifications avec **élasticité-prix qui varie avec le temps** est utilisée plus rarement que les spécifications avec élasticité de prix constant. Elle peuvent être modélisées avec une fonction log-linéaire où le prix n'est pas en forme logarithmique :

$$\ln q = \alpha + \beta p + \sum_k \delta_k x_k + \epsilon.$$

Paramètre β détermine la rélation entre le prix et l'élasticité.

Par exemple, Agiakloglou et Yannelis (2006) dans une de leurs modèles utilisent une spécification avec élasticité qui varie avec le temps :

$$\ln Q_t = \alpha + \beta p_t + \sum_k \delta_k x_{t,k} + \epsilon_t,$$

où Q_t est la demande pour télécommunications internationales pour les appels faits vers les différents pays.

Une autre approche standard pour l'estimation de la demande est dérivée du modèle de Houthakker-Taylor qui prend en compte **la dépendance historique de consommation** (Houthakker et L.D. Taylor (1970)). Souvent les consommateurs ne réagissent pas immédiatement à une variation de prix et ne changent pas significativement leur consommation dans le court terme. Dewenter et Haucap (2005) et Karacuka, Haucap et Heimeshoff (2011) utilisent cette spécification dans l'analyse de données de panel. Ils emploient les données agrégées au niveau des opérateurs en Autriche et en Turquie respectivement.

L'équation pour la quantité demandée au moment de temps t pour le tarif i est de la forme :

$$\ln q_{it} = \alpha_i(\alpha_{it}) + \alpha_2 \ln q_{it-1} + \sum_j \gamma_j \ln p_{jt} + \sum_k \delta_k \ln x_{it,k} + \epsilon_{it}(\epsilon_t),$$

où la consommation d'un abonné i au moment de temps t depend de prix p_{jt} de l'opérateur j, de la consommation de la période précedente q_{it-1}, aussi que de k variables explicatives additionnelles $x_{it,k}$. Dewenter et Haucap (2005) inclut comme variables additionnelles la base des abonnés, les variables indicatrices de temps et d'opérateur. Karacuka, Haucap et Heimeshoff (2011) inclut dans la regression la population, le PIB par habitant et le trend de temps linéaire pour capturer le progrès technologique.

Les approches décrites ci-dessus sont des approches simples et purement statistiques. Ci-dessous nous allons considérer des différents travaux qui ont adopté une **approche structurelle** qui combine la théorie économique avec modèles statistiques. Ces travaux sont caractérisés par une grande diversité. Notre methode est plus proche à ce groupe de travaux.

Un modèle **logit imbriqué** est souvent utilisé pour caractériser le choix de consommateur de services de télécommunications. En première étape, le consommateur représentatif choisit les types de services dont il souhaite profiter, la mode de tarification ou l'opérateur. En deuxième étape, il définit son niveau de consommation.

Train, McFadden et Ben-Akiva (1987) spécifie un modèle logit imbriqué pour étudier la demande de la communication fixe. Chaque ménage fait deux choix :

- le choix de la mode de tarification avec une possibilité d'un payment fixe et de la variation de prix en fonction de la distance et de l'heure de jour,
- le choix du nombre et de la durée des appels pour chaque zone de distance et à chaque période de jour.

Les auteurs mettent dans le même groupe toutes les options avec le même portfolio mais avec les modes tarifaires différentes. La fonction d'utilité est spécifiée de la manière suivante : elle accroît avec la durée des appels selon la règle logarithmique. L'utilité de plusieurs appels est égale à l'utilité d'un seul appel multipliée par le nombre d'appels. L'utilité depend négativement du temps total des appels pour refléter les coût d'opportunité du temps dépensé en parlant. Le modèle est estimé en utilisant les données sur le nombre et la durée moyenne des appels locaux à chaque période de jour et pour chaque zone de distance pour un échantillon de consommateurs residentiels aux Etats-Unis. Comme le nombre de portfolios est trop grand, les auteurs utilisent un échantillon de portfolios.

De la même manière que Train, McFadden et Ben-Akiva (1987), Madden et Coble-Neal (2005) prennent pour la base la spécification logit et construisent un modèle discret-continu afin d'étudier la demande pour un groupe de services. Les utilisateurs doivent faire deux choix :

- le choix de portfolio qui peut inclure la téléphonie fixe, mobile et Internet ;
- la définition de leur niveau d'utilisation pour chaque service.

Les données sont basées sur une enquête téléphonique qui permet de générer un profil d'utilisation de services de télécommunications par les ménages australiens. Les interrogés ont fourni l'information sur les services auxquels ils sont inscrits, leurs dépenses, l'utilisation de téléphonie fixe et mobile et de services délivrés par Internet, aussi que sur leur revenu et les caractéristiques demographiques.

D.J. Kridel, P.N. Rappoport et L.D. Taylor (2002) construisent un modèle logit qui permet d'estimer simultanément le choix de l'opérateur et l'usage pour les appels fixe de longue distance aux Etats-Unis. Les utilisateurs font deux choix :

- le choix de l'opérateur qui dépend de l'élasticité croisée,
- le choix d'utilisation qui dépend de l'élasticité propre.

Les données consistent des factures téléphoniques residentielles, avec l'information detaillée sur les appels et les données démographiques sur les consommateurs.

Il était trouvé que les prix sont statistiquement significatifs, le revenu a peu d'impacte sur la consommation et les ménages plus agés utilisent moins les communications intra-LATA.[1] En plus, l'utilisation intra-LATA dépend positivement de conditions tarifaires du forfait, de concentration d'appels et du nombre de parties uniques appélées.

Dans les deux travaux suivants les modèles sont calibrés avec les **données agrégées**.

Huang (2008) étudie le service de téléphonie mobile en utilisant les données transversales agrégées au niveau des opérateurs à Taiwan. Les hypothèses suivantes sur l'utilité

[1] LATA-Local Access Transport Area.

d'appels était faites. L'utilité de consommateurs de différentes destinations d'appels est additive, l'utilité marginale d'une minute additionnelle decroît quand le trafic accroît (elle est proporionnelle à $(1-\log x)x$). L'utilité dépend aussi du type de ménage et de la qualité perçue du réseau. L'utilité des appels entrants est capturée par un terme fixe et idéntique pour tous les abonnés du même réseau. L'auteur déduit la fonction de demande à partir de la fonction d'utilité.

Les données utilisées incluent le nombre d'abonnés à chaque réseau, la distribution de dépenses de télécommunications dans les données transversales, la sensibilité des parts de marché des opérateurs et de l'option externe en réponse à la variation de prix, la variation du volume moyen de consommation par abonné d'un opérateur à l'autre et d'un moment du temps à l'autre.

Hausman (2012) étudie la consommation de trafic mobile vers mobile et mobile vers fixe. L'utilité d'un consommateur représentatif est quadratique, ce qui mène aux fonctions de demande linéaires. Les trafics mobile vers mobile et fixe vers mobile sont substituables. Le modèle est calibré à partir de données aggrégées en Australie. Les hypothèses principales suivantes ont été faites :

- L'élasticité est égale à 1,3.
- Quand les appels sont gratuits, le ratio entre les appels fixe vers mobile et mobile vers mobile est égal à 4 pour les abonnés mobile qui sont à la maison.
- L'élasticité croisée de la demande est égale à 0,5.

Pour calibrer le modèle, les auteurs ont fixé les valeurs pour le niveau de pénétration de téléphonie mobile, le prix par minute, le taux de terminaison. Le nombre total des appels par un abonné moyen est observé. Le prix des appels mobile vers mobile prend en compte la présence de forfaits avec les appels on-net gratuits. Pourtant, les auteurs ne distinguent pas entre les appels on-net et off-net parce que selon eux la partie qui fait l'appel connaît uniquement le prix moyen vers tous les opérateurs et ne connaît pas necessairement à quel réseau appartient la personne appelée.

4.2 Inputs et hypothèses de calibrage

Pour mener à bien la simulation envisagée, nous avons procédé à un calibrage du modèle, selon une procédure détaillée ci-dessous. Le marché de référence est le marché mobile français en 2003, année précédant l'introduction d'importantes réductions tarifaires *on-net.* Les données chiffrées publiquement disponibles pour 2003, ainsi que nos principales hypothèses, sont les suivantes.

1. En 2003, le parc mobile français compte environ $M = 40$ millions d'abonnés, se répartissant en $M_1 = 20$ millions pour l'opérateur historique France Télécom (Orange), $M_2 = 14$ milllions pour SFR et $M_3 = 6$ millions pour le dernier entrant, Bouygues Télécom ; soit des parts de marché respectives de 50%, 35% et 15%.

2. D'après les statistiques publiées par l'ARCEP, le volume de trafic mobile total s'élève à 41 170 Mmn (millions de minutes). En supposant que le trafic émis par tête est le même chez chaque opérateur, soit $q = Q/M = 1029$ mn, les trafics sortants valent respectivement à $Q_1 = 20\,585$ Mmn, $Q_2 = 14\,410$ Mmn et $Q_3 = 6\,176$ Mmn.

4. Un faisceau de données sur les revenus des opérateurs en 2003, ainsi que sur leurs gammes de forfaits, conduit à retenir comme valeurs réalistes $f_1 = f_2 = f_3 = 10$ €/client/mois, pour la composante fixe des tarifs, et $p_1 = p_2 = p_3 = 18$ c€, pour le prix *all-net* moyen de la minute.

5. Les statistiques de l'ARCEP donnent la part s de l'*on-net* dans le trafic total mobile vers mobile en 2003, soit $s = Q_+/Q = 0,63$.

6. Les coûts marginaux d'écoulement du trafic et les tarifs de terminaison d'appels sont également publiés par l'ARCEP. Pour l'année 2003 : $c_1 = c_2 = c_3 = 1,43$ c€ et $\tau^1 = 17,07$ c€, $\tau^2 = 17,07$ c€, $\tau^3 = 24,67$ c€.

7. Les études économétriques de la demande de télécommunications, essentiellement nord-américaines, fournissent un intervalle assez large pour les élasticités-prix, s'étendant typiquement de -1 à 0.

Les estimations d'élasticités-prix du trafic téléphonique diffèrent assez sensiblement selon les études, mais ces estimations sont très généralement situées à l'intérieur de l'intervalle $[-1, 0]$.

- S'agissant du marché de la téléphonie fixe longue distance aux Etats-Unis, Kridel, Rappoport et Taylor (2002) trouvent une élasticité-prix comprise entre $-0,44$ et $-0,55$. Rappoport et Taylor (1997) obtiennent $-0,44$ et Taylor (1996) entre $-0,44$ et $-0,2$.
- S'agissant du marché de la téléphonie mobile, la société Vodafone (2007) a publié une estimation de $-0,9$, établie à partir de données internes.
- Grzybowski (2004) fournit un panel de valeurs comprises entre $-0,96$ et $-0,19$ pour différents pays européens ; en particulier pour la France, où l'élasticité-prix du trafic mobile vaudrait $-0,45$ en 1998 et $-0,32$ en 2002 ; l'élasticité décroît en effet au cours du temps, au fil de la baisse du prix de la minute mobile.
- Rodini *et alii* (2002) obtiennent une valeur plus faible, soit $-0,17$, à partir de données portant sur le marché mobile aux Etats-Unis.
- Karacucka *et alii* (2002), conduisant une étude économétrique du marché mobile turc, obtiennent des élasticités-prix de court terme égales à $-0,36$ pour le sous-marché du post-payé et de $-0,2$ pour celui du pré-payé.

Dans l'évaluation de l'élasticité-prix, il convient de séparer deux effets distincs sur le trafic mobile d'une variation de prix de la minute : d'une part, le trafic individuel s'accroît ; d'autre part, le nombre des clients augmente. L'élasticité-prix globale du trafic est ainsi la somme de deux sous-élasticités : celle du trafic par tête au prix ; et celle de la masse de clientèle au prix. Dans notre modèle, où le parc d'abonnés est rigide à court terme, seule la première sous-élasticité est pertinente.

Ingraham et Sidak (2004) trouvent une élasticité-prix globale située entre $-1,12$ et $-1,29$. Par ailleurs, certaines études, comme celles de DotEcon et Frontier Economics citées dans le rapport annuel de l'Oftel (2003), avancent une élasticité-prix du parc d'abonnés comprise entre $-0,37$ et $-0,54$. Par différence entre les valeurs fournies par ces deux sources, l'élasticité prix du trafic à parc constant se situerait donc entre $-0,92$ et $-0,54$.

Or, dans notre modèle linéaire de demande, les élasticités sont également structurellement très variantes selon l'état du marché considéré : elles sont proches de zéro si les prix sont très bas et les volumes très élevés, comme typiquement au voisinage de l'optimum social ; elles sont au contraire fortes en valeur absolue si les prix sont élevés et les volumes bas, comme typiquement au voisinage de l'équilibre monopolistique. Nous fixerons ici la valeur absolue de l'élasticité du trafic total sortant au prix *all-net* en 2003 à un niveau "intermédiaire", le même pour chaque opérateur, soit $-0,5$. Ce choix engendre une grande variabilité des élasticités selon les états du marché, allant de $-0,04$ à l'optimum jusqu'à $-1,4$ à l'équilibre, qui reflète le large éventail des estimations économétriques.

8. Nous postulons que, sous l'impulsion des politiques commerciales actives des opérateurs, les correspondants proches d'un individu donné, ses "parents et amis", sont affiliés au même opérateur que lui, tandis que ses correspondants plus épisodiques sont répartis entre les opérateurs au *prorata* des masses de clientèle respectives.

9. Nous admettons que, pour chacun des opérateurs, la substituabilité entre directions de trafic est uniforme, *i.e.* la même pour chaque paire de directions de trafic. En l'absence d'information spécifique sur la structure de substituabilité cette hypothèse apparaît comme la plus neutre en comparaison de deux hypothèses alternatives : l'une, dans laquelle la substituabilité serait nulle entre la direction *on-net* et chacune des deux directions *off-net* ; l'autre, dans laquelle la substituabilité serait nulle entre les deux directions *off-net*. Nous avons retenu un coefficient de couplage uniforme $\xi_i^{j,k} = \xi = 0,1$, ce qui correspond à un ordre de grandeur raisonnable pour le ratio entre élasticité-prix propre et élasticité-prix croisée.

10. Nous retenons la valeur médiane $a = 0,5$ pour le cofficient d'appétence pour le nombre de correspondants. Ceci correspond à une valeur psychologique de la "première" minute de communication indépendante de la taille du réseau destinataire et donc de la direction de trafic.

11. Nous négligeons l'externalité de réception d'appels ($\rho_i = 0$), aucune étude économétrique n'ayant, à notre connaissance, permis d'estimer une valeur significativement non nulle de cette externalité.

Deux types d'externalités sont typiquement engendrées par un réseau de télécommunications : d'une part, la croissance du nombre des utilisateurs augmente pour chaque utilisateur déjà présent l'utilité de la minute de communication (externalité de club) ; d'autre part, recevoir des appels en provenance d'autres utilisateurs augmente l'utilité de chacun (externalité d'appels). Dans notre modèle, qui tient compte des effets de club mais où sont fixés les parcs d'abonnés des différents opérateurs, seule l'externalité d'appels est pertinente.

Les tentatives d'estimation de l'externalité de réception d'appels sont très peu nombreuses et, lorsqu'elles existent, elles sont le plus souvent appliquées au calcul des tarifs de terminaison d'appels optimaux sur le marché de gros de l'interconnexion entre opérateurs fixes ou mobiles.

- Sanbach et Van Hooft (2008) testent l'importance empirique de l'externalité de réception d'appels, à partir d'une base de données sur les prix de détail et les terminaisons d'appels dans les pays européens. Ces auteurs concluent que l'externalité est vraisemblablement très faible : en effet, même si, dans tous les modèles testés la valeur estimée est positive, elle n'est toutefois jamais significative, même au seuil de 10%.
- Frontier Economics (2010) cite une enquête réalisée par l'Ofcom en 2005, révélant que seulement 2% des répondants affirment prendre en considération le prix que leurs correspondants devront payer pour les appeler, au moment de choisir l'opérateur mobile auprès duquel ils vont s'abonner.
- Frontier Economics (2008) étudie l'impact économique du système des terminaisons d'appels. Ils introduisent dans leur analyse un paramètre d'externalité, défini comme le ratio rapportant le surplus de l'appelé à celui de l'appelant, dans le partage de l'utilité d'un appel. Les auteurs fixent normativement la valeur de ce paramètre et ils font varier cette valeur entre $0,1$, dans le scénario le plus bas, et $0,7$ dans le plus haut.

4.3 Procédure de calibrage

En complément des données portant sur le marché mobile français en 2003, précisées à la section 7.1, le calibrage du modèle repose sur des hypothèses concernant : d'une part, la matrice des coefficients de déformation ; d'autre part la structure de substituabilité entre directions de trafic.

4.3.1 Coefficients de déformation

Hypothèse. Un client d'un opérateur donné "perçoit" le parc de cet opérateur et ceux des autres opérateurs homothétiquement à la distribution de son club de sociabilité entre les différents opérateurs. En outre, le club de sociabilité d'un individu se répartit en deux sous-groupes : d'une part, un sous-groupe de correspondants privilégiés dont la proportion relative est la même pour tout individu, ces "parents et amis" étant supposés affiliés au même opérateur que celui de l'individu considéré ; d'autre part, un groupe de correspondants plus épisodiques, se répartissant de manière homogène entre les différents opérateurs, *i.e.* proportionnellement à leurs parcs d'abonnés.

Notons Z_i la taille du club de sociabilité du client-type de l'opérateur i ; $Z_{j/i}$, le nombre des correspondants de ce client-type qui sont affiliés à l'opérateur j ; et z, le ratio "parents et amis" rapportant le nombre des correspondants privilégiés au nombre total de correspondants. L'hypothèse précédente implique :

$$\forall j : \frac{M_{j/i}}{M} = \frac{Z_{j/i}}{Z_i}$$

$$\frac{Z_{i/i}}{Z_i} = z + (1-z)\frac{M_i}{M} \quad , \quad j \neq i : \frac{Z_{j/i}}{Z_i} = (1-z)\frac{M_j}{M} \; .$$

On en déduit la matrice $M_{j/i}$ des parcs perçus ainsi que la matrice de déformation $\omega_{j/i}$, soit en notant $M_{-i} = M - M_i$:

$$M_{i/i} = zM + (1-z)M_i = M_i + zM_{-i} \quad , \quad M_{j/i} = (1-z)M_j$$

$$\omega_{i/i} = 1 + z\frac{M_{-i}}{M_i} > 1 \quad , \quad \omega_{j/i} = 1 - z < 1 \; .$$

4.3.2 Trois scénarios de substituabilité

Trois scénarios alternatifs sont envisageables :

- un scénario de substituabilté “uniforme”, dans lequel, pour chaque opérateur, le coefficient de substituabilité est le même pour chacune des trois paires de directions de trafic ;
- un scénario de substituabilité *on-net/off-net*, dans lequel, pour chaque opérateur le coefficient de substituabilité est le même entre la direction *on-net* et chacune des deux directions *off-net*, tandis que le coefficient de substituabilité est nul entre les deux directions *off-net* ;
- un scénario de substituabilité *off-net/off-net*, dans lequel, pour chaque opérateur, le coefficient de substituabilité est nul entre la direction *on-net* et chacune des deux directions *off-net*.

1. Le *scénario uniforme* revient à considérer qu’une baisse de prix dans une direction quelconque, *on-net* ou *off-net*, induit une hausse du trafic dans cette direction et, par contre-coup une même baisse du trafic dans chacune des deux autres, soit :

$$k \neq j \neq i : \beta_i^{i,j} = \beta_i^{i,k} = \beta_i^{j,k} > 0 \ .$$

2. Le *scénario on-net/off-net* revient à considérer qu’un client d’un opérateur i donné, sous l’effet de variations de prix, substitue des minutes de communication entre la direction de trafic *on-net* et chacune des deux directions *off-net*, mais n’en substitue que de manière négligeable entre les deux directions *off-net*, soit :

$$k \neq j \neq i : \beta_i^{j,k} = 0 \ .$$

Autrement dit, si un prix *off-net* monte, un individu appelera moins ses correspondants *off-net* et il appellera par contre-coup davantage sa famille et ses amis proches, affiliés au même réseau que le sien ; en revanche, si le prix relatif des deux directions *off-net* évolue, alors le transfert d’appels d’une direction vers l’autre sera insignifiant. Par ailleurs, le scénario postule une symétrie entre les deux directions *off-net* en terme de substituabilité avec la direction *on-net*, soit :

$$k \neq j \neq i : \beta_i^{i,j} = \beta_i^{i,k} > 0 \ .$$

3. Le scénario *off-net/off-net* revient à considérer qu'un client d'un opérateur i donné, sous l'effet de variations de prix, substitue des minutes de communication entre les deux directions de trafic *off-net*, mais n'en substitue que de manière négligeable entre la direction *on-net* et les deux directions *off-net*, soit :

$$k \neq j \neq i : \beta_i^{i,j} = \beta_i^{i,k} = 0 \ .$$

Autrement dit, si un prix *off-net* monte, un individu appelera moins ses correspondants *off-net*, mais il ne modifiera en rien son comportement de communication avec sa famille et ses amis proches, affiliés au même réseau que le sien ; en revanche, si le prix relatif des deux directions *off-net* évolue, alors un certain transfert d'appels aura lieu d'une de ces directions vers l'autre soit :

$$k \neq j \neq i : \beta_i^{j,k} > 0 \ .$$

Ces trois scénarios sont respectivement associés aux trois structures suivantes de la matrice $\mathbf{X}_i$ des coefficients de couplage $\xi_i^{j,k}$ entre directions de trafic :

Scénario uniforme

$$k \neq j \neq i : \xi_i^{i,j} = \xi_i^{i,k} = \xi_i^{j,k} = \xi_i \ .$$

Scénario on-net/off-net

$$k \neq j \neq i : \xi_i^{i,j} = \xi_i^{i,k} = \xi_i' \quad , \quad \xi_i^{j,k} = (\xi_i')^2 \ .$$

Scénario off-net/off-net

$$k \neq j \neq i : \xi_i^{i,j} = \xi_i^{i,k} = 0 \quad , \quad \xi_i^{j,k} = \xi_i'' \ .$$

D'où, selon la relation d'inversion matricielle $\mathbf{A}_i = \mathbf{X}_i{}^{-1}/v_i$:

Scénario uniforme

$$\forall j : \alpha_i^j = \frac{1}{v_i}\frac{1+\xi_i}{(1-\xi_i)(1+2\xi_i)} \quad , \quad \beta_i^{i,j} = \beta_i^{i,k} = \beta_i^{j,k} = \frac{1}{v_i}\frac{\xi_i}{(1-\xi_i)(1+2\xi_i)}$$

Scénario on-net/off-net

$$\alpha_i^i = \frac{1}{v_i}\frac{1+(\xi_i')^2}{1-(\xi_i')^2} \quad , \quad j \neq i : \alpha_i^j = \frac{1}{v_i}\frac{1}{1-(\xi_i')^2}$$
$$j \neq i : \beta_i^{i,j} = \frac{1}{v_i}\frac{\xi_i'}{1-(\xi_i')^2} \quad , \quad k \neq j \neq i : \beta_i^{j,k} = 0 \ .$$

Scénario off-net/off-net

$$\alpha_i^i = \frac{1}{v_i} \quad , \quad j \neq i : \alpha_i^j = \frac{1}{v_i}\frac{1}{1-(\xi_i'')^2}$$
$$k \neq j \neq i : \beta_i^{i,j} = \beta_i^{i,k} = 0 \quad , \quad j \neq i : \beta_i^{j,k} = \frac{1}{v_i}\frac{\xi_i''}{1-(\xi_i'')^2} \ .$$

Dans la suite, nous privilégions le scénario uniforme car, en l'absence d'information spécifique sur la structure de substituabilité, c'est celui qui apparaît comme le plus “neutre”.

4.3.3 Réduction du système paramétrique

Puisqu'en 2003 la tarification était de type *all-net*, les fonctions de demande déduites de notre modèle s'écrivent :

$$\forall j : Q_i^j = \sigma_i M_i M_{j/i}^{2a}(M_{j/i}^{1-2a} - \widetilde{\alpha}_i^j p_i) \Rightarrow Q_i = \sigma_i M_i \left[M - \left(\sum_{j=1}^{3} M_{j/i}^{2a} \widetilde{\alpha}_i^j \right) p_i \right] \ ,$$

avec :

$$\widetilde{\alpha}_i^j = \frac{1}{v_i}\frac{(1+\xi_i) - \left[(M_{k/i}/M_{j/i})^a + (M_{l/i}/M_{j/i})^a \right] \xi_i}{(1-\xi_i)(1+2\xi_i)} \ .$$

La contrainte de compatibilité avec les valeurs données du volume du trafic total sortant

Q_i et de l'élasticité $\varepsilon_i^{\cdot/\cdot} = -e_i$ de ce trafic au prix *all-net* implique :

$$\sum_{j=1}^{3} M_{j/i}^{2a} \tilde{\alpha}_i^j = \frac{1}{v_i} \frac{(1+\xi_i)\sum_{k=1}^{3} M_{k/i}^{2a} - 2\xi_i \sum_{l<k} M_{k/i}^a M_{l/i}^a}{(1-\xi_i)(1+2\xi_i)}$$

$$e_i = \frac{\left[(1+\xi_i)\sum_{k=1}^{3} M_{k/i}^{2a} - 2\xi_i \sum_{l<k} M_{k/i}^a M_{l/i}^a\right] p_i}{M v_i (1-\xi_i)(1+2\xi_i) - \left[(1+\xi_i)\sum_{k=1}^{3} M_{k/i}^{2a} - 2\xi_i \sum_{l<k} M_{k/i}^a M_{l/i}^a\right] p_i} .$$

D'où les expressions des paramètres v_i et σ_i en fonction des observables M, M_i, Q_i, p_i ainsi que des deux paramètres e_i et ξ_i :

$$v_i = \frac{p_i}{M} \frac{1+e_i}{e_i} \frac{(1+\xi_i)\sum_{k=1}^{3} M_{k/i}^{2a} - 2\xi_i \sum_{l<k} M_{k/i}^a M_{l/i}^a}{(1-\xi_i)(1+2\xi_i)} \quad , \quad \sigma_i = \frac{(1+e_i) Q_i}{M M_i} .$$

Par substitution de ces différentes expressions dans les fonctions de demande, on obtient les coefficients de sensibilité aux prix ainsi que la matrice de trafic dans le scénario de substituabilité uniforme, soit :

$$\alpha_i^1 = \alpha_i^2 = \alpha_i^3 = \frac{M}{p_i}\frac{e_i}{1+e_i}\frac{1+\xi_i}{(1+\xi_i)\sum_{k=1}^{3} M_{j/i}^{2a} - 2\xi_i \sum_{l<k} M_{k/i}^a M_{l/i}^a}$$

$$\beta_i^{1,2} = \beta_i^{1,3} = \beta_i^{2,3} = \frac{M}{p_i}\frac{e_i}{1+e_i}\frac{\xi_i}{(1+\xi_i)\sum_{k=1}^{3} M_{j/i}^{2a} - 2\xi_i \sum_{l<k} M_{k/i}^a M_{l/i}^a}$$

$$\widetilde{\alpha}_i^j = \frac{M}{p_i}\frac{e_i}{1+e_i}\frac{1+\left[1-(M_{k/i}/M_{j/i})^a - (M_{l/i}/M_{j/i})^a\right]\xi_i}{(1+\xi_i)\sum_{k=1}^{3} M_{k/i}^{2a} - 2\xi_i \sum_{l<k} M_{k/i}^a M_{l/i}^a}$$

$$Q_i^j = Q_i \frac{M_{j/i}}{M}\left[1+e_i\left(1-\frac{M}{M_{j/i}^{1-a}}\frac{M_{j/i}^a + [M_{j/i}^a - M_{k/i}^a - M_{l/i}^a]\xi_i}{(1+\xi_i)\sum_{k=1}^{3} M_{k/i}^{2a} - 2\xi_i \sum_{l<k} M_{k/i}^a M_{l/i}^a}\right)\right] .$$

Par ailleurs, sous l'hypothèse d'une même élasticité-prix $e_i = e$ et d'un même coefficient de couplage $\xi_i = \xi$ pour chacun des opérateurs, le ratio s rapportant le trafic total *on-net* au trafic total sortant, vaut dans le scénario uniforme que nous privilégions (*cf.* section 7.1) :

$$s = \frac{1}{Q}\sum_{i=1}^{n} Q_{i/i} .$$

Cette relation, dans laquelle on substitue l'expression on de $Q_{i/i}$ obtenue supra en y remplaçant en outre $M_{i/i}$ par $M_i + zM_i$ et $M_{j/i}$ par $(1-z)M_j$, permet de calculer le ratio "famille et amis" z à partir du ratio observé s et des paramètres e et ξ.

4.3.4 Calculs numériques

Fixons $e = 0,5$ pour la valeur absolue de l'élasticité-prix *all-net*, valeur "raisonnable" au regard de la littérature économétrique (*cf.* annexe 3) et conduisant à une élasticité variable selon les états du marché, comprise entre $-0,10$ à l'optimum (prix très faibles) et $-1,4$ à l'équilibre (prix très élevés). Fixons par ailleurs le niveau réaliste $\xi = 0,1$ du coefficient de couplage uniforme entre les directions de trafic Fixons enfin à sa valeur médiane $a = 0,5$

le coefficient d'appétence pour le nombre de correspondants.

A l'aide des formules précédentes, on peut alors procéder à un calibrage numérique complet du modèle à partir des différentes observables :

- les parcs en millions d'abonnés, soit $M_1 = 20$, $M_2 = 14$, $M_3 = 6$;
- les trafics sortants en millions de minutes, soit $Q_1 = 20\,585$, $Q_2 = 14\,410$, $Q_3 = 6\,176$;
- les prix de la minute en centimes d'euros, soit $p_1 = p_2 = p_3 = 18$;
- le taux *on-net* dans le scénario *off-net/off-net*, soit $s = Q_+/Q = 0,63$.

Les résultats sont les suivants.

Taux "parents et amis".

$$z = 42\% \ .$$

Valeurs psychologiques de la minute (vers un parc d'effectif 1 *million).*

$$v_1 = 47,4\,\text{c€} \quad , \quad v_2 = 46,8\,\text{c€} \quad , \quad v_3 = 45,5\,\text{c€} \ .$$

Potentiels individuels de communication (vers un parc d'effectif 1 million*).*

$$\sigma_1 = \sigma_2 = \sigma_3 = 38,6\,\text{mn} \ .$$

Coefficients de déformation et parcs perçus.

$$\omega_{./.} = \left[\omega_{j/i}\right]_{i,j} = \begin{pmatrix} 1,42 & 0,58 & 0,58 \\ 0,58 & 1,79 & 0,58 \\ 0,58 & 0,58 & 3,40 \end{pmatrix}$$

$$\mathbf{M}_{./1} = \text{Diag}[28,46\,;\ 8,08\,;\ 3,46]\ (\text{Millions})$$
$$\mathbf{M}_{./2} = \text{Diag}[11,54\,;\ 25,00\,;\ 3,46]\ (\text{Millions})$$
$$\mathbf{M}_{./3} = \text{Diag}[11,54\,;\ 8,08\,,\ 20,38]\ (\text{Millions}) \ .$$

Matrices de sensibilité aux prix et matrice de trafic.

$$\mathbf{A}_1 = \begin{bmatrix} 2,149 & -0,195 & -0,195 \\ -0,195 & 2,149 & -0,195 \\ -0,195 & -0,195 & 2,149 \end{bmatrix} \quad , \quad \mathbf{A}_2 = \begin{bmatrix} 2,174 & -0,198 & -0,198 \\ -0,198 & 2,174 & -0,198 \\ -0,198 & -0,198 & 2,174 \end{bmatrix}$$

$$\mathbf{A}_3 = \begin{bmatrix} 2,24 & -0,20 & -0,20 \\ -0,20 & 2,24 & -0,20 \\ -0,20 & -0,20 & 2,24 \end{bmatrix} \quad (€^{-1})$$

$$\mathbf{Q} = \begin{bmatrix} 14\,153 & 4\,380 & 2\,052 \\ 4\,244 & 8\,726 & 1\,439 \\ 1\,809 & 1\,308 & 3\,058 \end{bmatrix} \quad (\text{Mmn}) \ .$$

4.4 Valeurs calibrées des paramètres

Sur la base des différentes données et hypothèses indiquées ci-dessus, la procédure de calibrage conduit aux valeurs suivantes des paramètres du modèle.

Valeurs psychologiques de la minute (vers un parc d'effectif 1 *million).*

$$v_1 = 47,4\,\text{c€} \quad , \quad v_2 = 46,8\,\text{c€} \quad , \quad v_3 = 45,5\,\text{c€} \ .$$

Potentiels individuels de communication (vers un parc d'effectif 1 million*).*

$$\sigma_1 = \sigma_2 = \sigma_3 = 38,6\,\text{mn} \ .$$

Coefficients de déformation et parcs perçus.

$$\omega_{\cdot/\cdot} = \left[\omega_{j/i}\right]_{i,j} = \begin{pmatrix} 1,42 & 0,58 & 0,58 \\ 0,58 & 1,79 & 0,58 \\ 0,58 & 0,58 & 3,40 \end{pmatrix}$$

$$\mathbf{M}_{\cdot/1} = \text{Diag}[28,46\,;\ 8,08\,;\ 3,46]\ (\text{Millions})$$

$$\mathbf{M}_{\cdot/2} = \text{Diag}[11,54\,;\ 25,00\,;\ 3,46]\ (\text{Millions})$$

$$\mathbf{M}_{\cdot/i} = \text{Diag}[11,54\,;\ 8,08\,,\ 20,38]\ (\text{Millions})\ .$$

Coefficients propres et croisés de sensibilité aux prix.

$$\mathbf{A}_1 = \begin{bmatrix} 2,149 & -0,195 & -0,195 \\ -0,195 & 2,149 & -0,195 \\ -0,195 & -0,195 & 2,149 \end{bmatrix} \quad , \quad \mathbf{A}_2 = \begin{bmatrix} 2,174 & -0,198 & -0,198 \\ -0,198 & 2,174 & -0,198 \\ -0,198 & -0,198 & 2,174 \end{bmatrix}$$

$$\mathbf{A}_3 = \begin{bmatrix} 2,24 & -0,20 & -0,20 \\ -0,20 & 2,24 & -0,20 \\ -0,20 & -0,20 & 2,24 \end{bmatrix} \quad (€^{-1})\ .$$

4.5 Etats remarquables du marché

Le modèle calibré permet de calculer les volumes de trafic, les prix, les revenus des opérateurs et les surplus des consommateurs dans quatre états de référence du marché :

- l'état du marché en 2003 ;
- l'état de satiété, sous des prix nuls ;
- l'état d'optimum social, sous des prix de détail et de gros tous calés sur les coûts marginaux techniques ;
- l'état d'équilibre monopolistique sous régulation des tarifs de terminaison d'appels.

Dans chacun de ces états, on norme la partie fixe de l'utilité en l'égalisant à la partie fixe du tarif affine, soit $u_i = f_i = 10$ €/mois.

Etat du marché en 2003

$$\mathbf{p} = \begin{bmatrix} 18 & 18 & 18 \\ 18 & 18 & 18 \\ 18 & 18 & 18 \end{bmatrix} \quad (\text{c€})$$

$$\mathbf{Q} = \begin{bmatrix} 14\,153 & 4\,380 & 2\,052 \\ 4\,244 & 8\,726 & 1\,439 \\ 1\,809 & 1\,308 & 3\,058 \end{bmatrix} \quad (\text{Mmn})\ .$$

Les revenus des trois opérateurs s'établissent respectivement à 6 105 M€, 4 274 M€ et 1 832 M€, ce qui correspond à un ARPU (*Average Revenue per User*) mensuel d'environ 25 €, sensiblement inférieur à l'utilité par client et par mois qui s'élève à 41 €. Il en résulte donc, par différence, un surplus de consommation significatif, égal à 16 € par client et par mois. Les surplus des consommateurs par tête sont proches : 15,83, 15,75 et 15,54 €/mois/abonnée pour les opérateurs 1, 2 et 3 respectivement. Comme les surplus par tête diffèrent peu d'un opérateur à l'autre, ils incitent peu aux migrations inter-opérateurs.

Le solde d'interconnexion (*i.e.* le revenu de l'interconnexion entrante nette du paiement de l'interconnection sortante) est négatif pour les deux premiers opérateur (*resp.* −221 M€ et −109 M€) tandis qu'il est positif pour le troisième (+329 M€).

Etat de satiété

$$\widehat{\mathbf{p}} = \mathbf{0} \quad , \quad \widehat{\mathbf{Q}} = \begin{pmatrix} 21\,968 & 6\,237 & 2\,673 \\ 6\,237 & 13\,507 & 1\,871 \\ 2\,673 & 1\,871 & 4\,719 \end{pmatrix} \ (\text{Mmn})\ .$$

A satiété, c'est-à-dire si les consommateurs pouvaient communiquer gratuitement, les volumes de trafic sortant de chaque opérateur seraient supérieurs de 50% à leurs niveaux observés en 2003. Le surplus de consommation par client et par mois s'élèverait à 35 € pour chacun des opérateurs ; le gain relatif de surplus par rapport à l'état réel du marché en 2003 (16 € par client et par mois) serait ainsi supérieur à 100%.

Optimum social

$$\mathbf{p}^* = \begin{pmatrix} 2,86 & 2,86 & 2,86 \\ 2,86 & 2,86 & 2,86 \\ 2,86 & 2,86 & 2,86 \end{pmatrix} \text{ (c€)}$$
$$\mathbf{Q}^* = \begin{pmatrix} 20\,726 & 5\,942 & 2\,574 \\ 5\,920 & 12\,747 & 1\,802 \\ 2\,536 & 1\,782 & 4\,456 \end{pmatrix} \text{ (Mmn) .}$$

Les coûts marginaux du trafic étant faibles, les prix de détail le sont aussi. La matrice de trafic à l'optimum social est donc proche de la matrice de satiété et le surplus de consommation par client et par mois, soit $31,5$ €, est proche de celui obtenu dans l'état de satiété (35 €). Les tarifs de terminaison d'appel étant égaux aux coûts marginaux, les soldes d'interconnexion sont petits en valeur absolue, soit respectivement $-0,9$ M€, 0 M€ et $+0,9$ M€.

Equilibre monopolistique régulé

$$\overline{\mathbf{p}} = \begin{pmatrix} 27 & 39 & 47 \\ 37 & 27 & 47 \\ 37 & 38 & 27 \end{pmatrix} \text{ (c€)} \quad , \quad \overline{\mathbf{Q}} = \begin{pmatrix} 10\,716 & 2\,016 & 682 \\ 1\,978 & 6\,631 & 481 \\ 836 & 599 & 2\,331 \end{pmatrix} \text{ (Mmn) .}$$

Les prix d'équilibre sont élevés, surtout en *off-net*, car tirés vers le haut par les fortes valorisations psychologiques de la minute de trafic, ainsi que par le *mark-up* élevé des tarifs de terminaison d'appel au-dessus des coûts marginaux, particulièrement pour le troisième opérateur. Il en résulte que les volumes de trafic d'équilibre sont inférieurs à leurs niveaux observés en 2003 – d'environ un tiers – et que les trafics destinés au plus petit opérateur sont faibles.

Le marché réel de 2003 est donc plus “concurrentiel” qu'il ne le serait dans un équilibre hypothétique où les parts de marchés des opérateurs seraient “protégées” par une entente et/ou par un manque total de fluidité du marché. Dans la réalité, les parts de marché ne sont pas protégées mais “contestables” et chaque opérateur, craignant une évasion de clientèle au bénéfice de ses concurrents, pratique donc des prix sensiblement plus “vertueux” qu'à l'équilibre monopolistique. Dans un tel équilibre, le surplus de consommation par client et par mois serait de 6 €, soit près de trois fois plus faible que sur le marché réel (16 €).

Bien que régulés, les tarifs de terminaison d'appels de 2003 restent très supérieurs aux coûts marginaux, ce qui engendre à l'équilibre des soldes d'interconnexion d'amplitude non négligeable, soit respectivement −32 M€, −10 M€ et +42 M€. Sous une stricte orientation des tarifs de gros vers les coûts marginaux, ces soldes d'équilibre seraient considérablement réduits, soit respectivement $-0,4$ M€, $0,0$ M€ et $+0,4$ M€.

Le tableau ci-après récapitule les revenus, les surplus et les soldes d'interconnexion dans les quatre états du marché décrits ci-dessus.

	Utilité (€/client/mois)	Revenu (€/client/mois)	Surplus (€/client/mois)	Solde d'interco. (M€)
2003	41	25	16	−221 | −109 | 329
Satiété	45	10	35	–
Optimum	45	13,5	31,5	−0,9 | 0 | +0,9
Equilibre	33	27	6	−32 | −10 | 42

4.6 Trois transitions tarifaires alternatives

Comparons les effets de trois transitions tarifaires alternatives à partir de l'état initial correspondant au marché mobile français en 2003. Nous supposons que chacune de ces transitions est *neutre*, les revenus de détail des opérateurs et donc les dépenses de leurs clients y étant maintenu(e)s à un niveau constant, une augmentation de la partie fixe

f_i du tarif affine venant compenser la baisse des prix $\mathbf{p}_i$ de la minute. Par dualité entre tarification affine et tarification forfaitaire, cette hypothèse de neutralité reflète la pratique courante des opérateurs, consistant à desserrer la contrainte de volume des forfaits sans en changer le montant.

- la première transition (T_1) consiste en des baisses simultanées du prix de la minute *on-net* de 100%, soit un scénario d'introduction massive de l'on-net illimité par chacun des trois opérateurs ;
- la deuxième transition (T_2) consiste en des baisses simultanées du prix de la minute dans toutes les directions de trafic (baisses *all-net*), que les consommateurs jugent équivalentes aux baisses *on-net* de la transition (T_1), *i.e.* qui engendrent la même variation de surplus de consommation (et donc d'utilité, puisque la facture est invariante) ;
- la troisième transition (T_3) consiste, à l'instar de (T_2), en des baisses *all-net* simultanées, mais que cette fois les opérateurs – et non pas les consommateurs – jugent équivalentes aux baisses *on-net* de la transition (T_1), *i.e.* qui engendrent la même variation du profit consolidé de détail et de gros.

Transition (T_1) : gratuité on-net.

Sous l'effet de la gratuité de la minute *on-net*, les consommateurs augmentent fortement leur trafic individuel *on-net* (environ 30 mn mensuelles), ce qui leur procure par tête un gain d'utilité – et donc de surplus – atteignant respectivement 32, 1 €, 27, 5 € et 21, 3 €, selon l'opérateur auquel ils sont affiliés. D'où des accroissements de trafic *on-net* atteignant respectivement 8 496 Mmn, 5 286 Mmn et 1 900 Mmn, qui entraînent des gains de surplus de consommation s'élevant respectivement à 642 M€, 385 M€ et 128 M€.

Dans cette transition *on-net*, les flux de trafic *off-net* diminuent légèrement, par effet de substitution de l'*off-net* vers l'*on-net*. Les soldes d'interconnexion varient en conséquence, respectivement de +59 M€, +11 M€ et −70 M€. En raison du trafic supplémentaire à écouler sur les réseaux, les coûts techniques des opérateurs augmentent : ainsi, malgré l'invariance des revenus de détail, le profit de l'opérateur 1 s'abaisse de 168 M€ (8, 4 €/abonné), celui de l'opérateur 2 de 125 M€ (9 €/abonné) et celui de l'opérateur 3 de 114 M€ (19 €/abonné). Agrégeant variations de surplus et de profit, le gain net de surplus collectif, par rapport à la situation initiale, s'élève à 747 M€, se traduisant par un gain de 1 155 M€ pour les consommateurs, mais par une perte de 408 M€ pour les opérateurs. Rapportée à la taille du parc d'abonnés, cette perte est deux fois moins sévère pour les deux premiers entrants (1 et 2) que pour le troisième (3) ; l'introduction de l'*on-net* illimité porte par conséquent un préjudice relatif certain au dernier entrant, risquant même de l'évincer du marché, compte tenu d'une résilience face aux pertes moindre que celle de ses concurrents.

Transition (T_2) : baisses all-net "consommateurs équivalentes".

Pour les clients des différents opérateurs, cette transition *all-net* est, par construction, strictement équivalente à la transition *on-net* (T_1) ; mais, en contraste avec (T_1), les flux de trafic augmentent ici – non seulement dans la direction *on-net* – mais également dans les directions *off-net*.

La baisse absolue du prix de la minute *all-net* s'établit respectivement à -8 c€, -7 c€ et -5 c€ pour chacun des opérateurs, soit des taux de réduction de $-44,6\%$, $-36,3\%$ et $-26,5\%$. En résultent des accroissements respectifs de trafic total sortant s'élevant à 4 590 Mmn, 2 613 Mmn et 818 Mmn, environ deux fois inférieurs aux accroissements de trafic *on-net* produits par la transition (T_1). Ceci signifie que les consommateurs sont disposés à échanger "quantité" contre "variété" : un surcroît de trafic deux fois plus faible leur procure un même surcroît d'utilité lorsqu'il est réparti en *all-net* et non pas concentré en *on-net*.

Le plus gros opérateur 1 perd en solde d'interconnexion (-47 M€) au profit des deux plus petits 2 et 3 (*resp.* +5 M€ et +42 M€). Cet effet est en partie dû à l'asymétrie du tarif de terminaison d'appel en faveur de l'opérateur 3. Les variations de soldes d'interconnexion, auxquelles s'ajoutent les coûts d'écoulement du trafic supplémentaire, entraînent les variations respectives de profit total -176 M€ ($-8,8$ €/abonné), -71 M€ ($-5,1$ €/abonné) et +18 M€ (+3 €/abonné). La transition (T_2) est donc à peine plus défavorable plus gros opérateur 1 que la transition (T_1), puisqu'il n'encourt qu'une perte supplémentaire de 8 M€ ; cette transition est en revanche nettement plus favorable à l'opérateur intermédiaire 2, dont la perte est réduite de 54 M€ par rapport à (T_1), et elle est surtout extrêmement favorable au petit opérateur 3, dont le compte devient positif et qui gagne un différentiel de $+132,5$ M€.

Par rapport à la situation initiale, la transition (T_2) engendre un gain de surplus collectif s'élèvant à 926 M€, soit 179 M€ de plus que la transition (T_1), au bénéfice exclusif de la collectivité des opérateurs. Ce gain de 926 M€ se décompose en un gain d'utilité de 1 155 M€ pour les consommateurs, comme dans la transition (T_1), et par une perte de seulement 229 M€ pour les opérateurs, contre 407 M€ sous (T_1) ; avec, toutefois, une situation contrastée, dans laquelle le plus gros opérateur 1 est à peu près indifférent entre les transitions (T_1) et (T_2), l'opérateur intermédiaire 2 est légèrement gagnant sous (T_2), tandis que le plus petit 3 est quant à lui fortement gagnant et surtout échappe au risque d'éviction du marché auquel l'expose la transition tarifaire *on-net* (T_1) .

Transition (T_3) : baisses all-net "opérateurs équivalentes".

Pour chacun des opérateurs, cette transition *all-net* est, par construction, strictement équivalente à la transition *on-net* (T_1), en termes de pertes de profit total, soit respectivement −168 M€, −125 M€ et −114 M€ pour les opérateurs 1, 2 et 3.

En revanche, pour les consommateurs, le surcroît de gain d'utilité par rapport à (T_1) et (T_2) est très significatif : pour les clients de l'opérateur 1, le gain d'utilité vaut 825 M€ dans la transition (T_3) contre 642 M€ dans (T_1) ou (T_2), soit +28,5% ; pour ceux de l'opérateur 2, il vaut 566 M€ contre 385 M€, soit +47% ; et surtout, pour ceux du petit opérateur 3, il vaut 274 M€ contre 128 M€, soit +114%. Ces gains d'utilité proviennent d'un accroissement important du trafic sortant, soit *resp.* +6 885 Mmn, +4 633 Mmn et +2730 Mmn, permis par des réductions du prix de la minute *all-net* sensiblement plus fortes que dans la transition "consommateur équivalente" (T_2), soit respectivement −66, 9%, −64, 3% et −88, 4% contre −44, 6%, −36, 3% et −26, 5%.

Afin de comprendre l'origine des "performances" de la transition (T_3), il convient d'imaginer un glissement de la transition (T_2) vers la transition (T_3). Dans un tel glissement, tout se passe comme si le petit opérateur 3 utilisait sa "réserve" positive de profit, acquise en (T_2) grâce à l'interconnexion, pour atteindre en (T_3) deux objectifs au bénéfice de la collectivité : d'une part, abaisser beaucoup plus fortement que ses concurrents 1 et 2 son prix de la minute *all-net* ; d'autre part, réduire partiellement la perte de chacun de ces deux derniers (atténuée respectivement de 8 M€ et 54 M€ par rapport à la transition (T_2)), sans toutefois les avantager strictement par rapport la situation à laquelle les conduirait la transition (T_1), ce qui revient à conférer à ces deux gros opérateurs une réserve virtuelle, qu'ils utilisent pour abaisser, eux-aussi mais dans une moindre mesure, leur prix de la minute *all-net*.

Par rapport à la situation initiale, la transition (T_3) accroît le surplus collectif de 1 258 M€, les consommateurs gagnant 1 665 M€ et les opérateurs perdant $407,5$ M€. Cette transition Pareto-domine ainsi la transition (T_1) de 511 M€, les opérateurs étant indifférents entre (T_1) et (T_3) les consommateurs préfèrant fortement (T_3). Par ailleurs, comparée à (T_2), la transition (T_3) engendre une création nette de surplus collectif s'élevant à 332 M€, qui bénéficie entièrement aux consommateurs et s'ajoute à un transfert de 178 M€ en provenance des opérateurs.

Le tableau ci-après résume les caractéristiques des trois transitions alternatives.

	ΔProfit M€	ΔSurplus conso. M€	(€/tête)	ΔSurplus collectif M€
Transition (T_1)	−168	642	$(32,1)$	
	−126	385	$(27,5)$	747
	−114	128	$(21,3)$	
Transition (T_2)	−176	642	$(32,1)$	
	−71	385	$(27,5)$	926
	+18	128	$(21,3)$	
Transition (T_3)	−168	825	$(41,2)$	
	−126	566	$(40,4)$	1258
	−114	274	$(45,7)$	

Trois résultats notables se dégagent de cette étude chiffrée.

- Tout d'abord, pour une même augmentation du volume de leurs communications, les consommateurs gagnent d'avantage d'utilité si cette augmentation est répartie en *all-net* entre toutes les directions de trafic, plutôt que concentrée dans la seule direction *on-net*. Ainsi, une transition (T_4), qui consisterait en des baisses tarifaires *all-net* simultanées engendrant, pour chaque opérateur, les mêmes variations de trafic total sortant que la transition *on-net* (T_1), céderait aux consommateurs 1 666 M€ contre 1 155 M€ (+44%).

- Ensuite, le surplus collectif augmente moins sous des baisses *on-net* que sous des baisses *all-net* "équivalentes" et le sur-gain différentiel procuré par les baisses *all-net* est beaucoup plus important lorsque celles-ci bénéficient aux consommateurs en laissant les opérateurs indifférents (+68%) que lorsqu'elles bénéficient aux opérateurs en laissant les consommateurs indifférents (+24%).
- Enfin, le plus petit opérateur est à la fois le plus "exposé", *i.e.* celui qui subit la plus grosse perte par abonné sous des baisses *on-net*, et le plus "moteur", *i.e.* celui qui engendre les meilleures performances des baisses opérateurs-équivalentes par rapport aux baisses consommateurs-équivalentes. C'est lui en effet qui, en "renonçant" à l'amélioration de profit consolidé que lui procurerait son solde interconnexion positif sous une baisse consommateur équivalente, "finance" un fort accroissement de l'utilité de ses propres clients, ainsi qu'une amélioration de la situation de ses concurrents, permettant indirectement à ceux-ci d'améliorer également le sort de leurs propres clients.

4.7 Un scénario révélateur

La simulation qui suit s'inspire du contexte du marché mobile français en 2004, lorsque les deux opérateurs dominants ont sensiblement réduit les tarifs *on-net* en introduisant des offres comportant des appels *on-net* "illimités" et ont de ce fait instauré une différenciation tarifaire *on-net*/*off-net*, alors que le troisième opérateur a opté quant à lui pour une structure tarifaire *all-net*.

Supposons que, à partir de la situation initiale du marché de 2003, les trois opérateurs aient parallèlement envisagé la transition (T_1) consistant en trois baisses simultanées de 100% du prix de la minute *on-net* (baisses neutres, *i.e.* compensées à revenus de détail constants par des augmentations de la partie fixe du tarif). Cette transition (*cf. supra*) se traduit par des pertes de profit modérées, s'élevant à −168 M€, −126 M€ et −114 M€ pour les opérateurs 1, 2 et 3, ainsi que par des gains de surplus de consommation de

642 M€, 385 M€ et 128 M€ pour leurs clientèles respectives.

Par rapport à ce scénario hypothétique de référence, supposons que les deux opérateurs dominants décident effectivement de s'y conformer en consentant chacun une baisse on-net de 100%, mais que le troisième opérateur choisisse quant à lui de conserver une structure de tarification *all-net* et adopte ainsi la baisse *all-net* neutre qui concède à ses clients le même surcroît d'utilité qu'une baisse *on-net* de 100%. Par construction, ces changements tarifaires sont équivalents à la transition (T_1) du point de vue des consommateurs. En revanche, en raison d'un gain différentiel d'interconnexion entrante, les deux opérateurs dominants perdent un peu moins de profit que dans la transition (T_1) de référence, respectivement −112 M€ contre −168 M€ (+56 M€) et −85 M€ contre −126 M€ (+41 M€), tandis que le troisième opérateur en perd quant à lui davantage, soit −187 M€ contre −114 M€ (−73 M€).

Imaginons alors que, surpris par l'initiative du troisième opérateur, les deux premiers optent à leur tour pour une structure de tarification *all-net* et adoptent en conséquence les tarifs *all-net* qui préservent le niveau de dépense et d'utilité de leurs clients. Dans ce mouvement, par rapport au précédent, la situation de tous les consommateurs demeure inchangée. Le solde d'interconnexion des gros opérateurs 1 et 2 se dégrade tandis que celui du petit opérateur 3 s'améliore et les variations respectives de profit consolidé valent respectivement −64 M€, +14 M€ et +205 M€.

Dernier chapitre de ce scénario, les trois opérateurs décident d'ajuster leurs tarifications *all-net* respectives de manière à s'aligner sur les profits de référence que leur auraient procuré la transition non réalisée (T_1). Ce faisant, grâce à forte augmentation du surplus collectif (+332 M€), ils procurent à leurs clients respectifs les gains d'utilité +183 M€, +181 M€ et +146 M€, soit bien davantage que la restitution nette de 178 M€ de profit.

Les trois étapes de cet enchaînement de transitions tarifaires sont résumées dans le tableau ci-après où figurent les écarts entre chaque étape à la suivante.

	Δ Profits (M€)	Δ Surplus cons. (M€)	Δ Surplus col. (M€)
Scénario Réf. (T_1)	−168 | −126 | −114	642 | 385 | 128	747
Etape 1 / Réf.	+56 | +41 | −73	0 | 0 | 0	+24
Etape 2 / Etape1	−64 | +14 | 205	0 | 0 | 0	+155
Etape 3 / Etape 2	+8 | −54 | −133	+183 | +181 | +146	+331
Etape 3 / Réf	0 | 0 | 0	+183 | +181 | +146	+510

Cette simulation conforte la Pareto-supériorité des baisses tarifaires *all-net* sur les baisses *on-net* et elle révèle que si, sur le marché mobile français du début des années 2000, les trois opérateurs, et non pas seulement le dernier entrant, avaient pratiqué des baisses *all-net* plutôt que *on-net*, alors les consommateurs, notamment les clients du troisième opérateur auraient obtenus des gains de surplus sensiblement supérieurs : dans notre simulation, ils auraient globalement engrangé 1 665 M€ contre 1 155 M€, soit un supplément de 44% ; et, pour les seuls clients du dernier entrant, 374 M€ contre 128 M€, soit presqu'un triplement. Enfin, l'accroissement du surplus collectif serait de 1 257 M€ au terme de notre séquence vertueuse, contre seulement 747 M€ dans la transition (T_1), soit un supplément de 68%.

Conclusion

Dans cet article, nous avons analysé un marché national de téléphonie mobile en adoptant une architecture de modélisation dont la *généralité* est suffisante pour rendre compte, sans simplification excessive, des caractéristiques réelles du marché et dont la *maniabilité* permet de réaliser des simulations numériques. Le modèle tient compte de l'effet d'une variation de prix dans une "direction de trafic" donnée – *on-net* ou *off-net* – sur les quantités de trafic respectivement émises en *on-net* et en *off-net*. Il tient compte également des "effets de club" qui sont entretenus par chacun des opérateurs concurrents, à travers des stratégies tarifaires du type "*friends and family*".

A l'aide de ce modèle, nous avons dans un premier temps réétabli et précisé différents résultats issus de la littérature théorique existante, en caractérisant deux états remarquables du marché : d'une part, l'optimum collectif, qui correspond à une tarification au "coût marginal social", *i.e.* à un tarif de la minute de communication égal au coût de transmission de cette minute diminué du bénéfice procuré par la réception d'appels ; d'autre part, l'équilibre de marché, avec ou sans régulation des tarifs de terminaison d'appels sur le marché de gros.

Dans un second temps, nous avons mené une étude systématique de l'impact – sur le profit des opérateurs et sur le bien-être des consommateurs – d'une classe de changements tarifaires conforme à la pratique courante des opérateurs : les changements "neutres", qui laissent invariants le revenu de détail des opérateurs et donc la facture des usagers. Parmi les changements tarifaires neutres nous avons examiné en particulier : d'une part, le relâchement de la contrainte de volume de communication dans un forfait, à montant inchangé de ce forfait (baisse dite *all-net*) ; d'autre part, l'introduction de l'*on-net* illimité à montant du forfait également inchangé (baisse dite *on-net*). Il ressort principalement de notre étude que, contrairement à des baisses tarifaires *on-net*, des baisses *all-net* simultanément entreprises par tous les opérateurs présents sur le marché augmentent les profits d'interconnexion de ces derniers, constituant ainsi un "réservoir" permettant de réduire les profits de détail et donc d'accroître le surplus des consommateurs.

Dans un dernier temps, nous avons calibré numériquement le modèle à partir de données reflétant l'état du marché mobile français en 2003, puis utilisé ce calibrage afin de procéder à des simulations chiffrées des impacts de changements tarifaires. Nos principales conclusions sont les suivantes.

- Les consommateurs manifestent une forte "préférence pour la variété", en ce sens qu'un même accroissement de leur trafic émis leur procure environ deux fois plus de bien-être lorsque cet accroissement est *all-net*, *i.e.* réparti entre toutes les directions de trafic (*on-net* et *off-net*), que lorsqu'il est concentré dans la seule direction de trafic *on-net*.
- Des baisses tarifaires *on-net*, typiquement l'introduction simultanée de l'*on-net* illimité par tous les opérateurs, font subir à l'opérateur dernier entrant une perte de profit par abonné significativement supérieure à celles subies par les premiers entrants. Compte tenu de la moindre capacité financière du dernier entrant, celui-ci se trouve ainsi exposé à un risque d'éviction du marché.
- Des baisses tarifaires *all-net* simultanément réalisées par tous les opérateurs sont préférables à des baisses simultanées *on-net*, en ce sens que les baisses *all-net*, en comparaison des baisses *on-net*, augmentent davantage le bien-être des consommateurs pour une même perte de profit des opérateurs, ou encore réduisent la perte des opérateurs pour un même accroissement du bien-être des consommateurs.
- L'avantage relatif que procurent des baisses tarifaires simultanées *all-net*, relativement à des baisses simultanées *on-net*, s'avère très significativement supérieur lorsque les bénéficiaires de cet avantage sont les consommateurs plutôt que les opérateurs.
- Sur le marché français, où d'importantes baisses *on-net* ont été pratiquées en 2004 par les deux opérateurs premiers entrants, alors que le troisième opérateur avait adopté une structure tarifaire *all-net*, il eût été préférable pour l'ensemble des acteurs du marché, et tout particulièrement pour les clients du dernier entrant, que les opérateurs aient tous opté pour des baisses *all-net*. Le supplément ainsi engendré, en termes de gain différentiel de bien-être collectif (somme des profits des opérateurs et du bien-être des consommateurs), aurait avoisiné 70%.

Annexe

Equivalence entre tarif affine et forfait

Nous examinons ici les rapports entre tarification affine et tarification forfaitaire dans un contexte multi-produit. Par dualité, il apparaît qu'un tarif affine et un tarif forfaitaire sont équivalents du point de vue du consommateur si et seulement si : (i) ils engendrent la même facture et (ii) les prix unitaires du premier tarif sont proportionnels aux coefficients de la contrainte de volume du second, le facteur de proportionnalité étant égal au multiplicateur associé à cette contrainte dans la maximisation de l'utilité.

Notations mathématiques

Les vecteurs sont notés en caractères gras, afin de les distinguer des scalaires. La transposition est notée " $'$ " et le produit matriciel est noté " $\cdot$ ".

Soit $\mathbb{R}^{+n}$ l'orthant positif de l'espace vectoriel réel $\mathbb{R}^{+n}$. Si $S \subset N = \{1, 2, .., n\}$, on note :

$$E_S = \{\mathbf{x} \in \mathbb{R}^{+n} : x_j > 0 \text{ si } j \in S \text{ et } x_j = 0 \text{ si } j \in N - S\ \} .$$

Si $\mathbf{x} \in \mathbb{R}^{+n}$, on note $\mathbf{x}_S \in E_S$ la projection orthogonale de $\mathbf{x}$ sur E_S :

$$x_{S,j} = x_j \text{ si } j \in S \text{ et } x_{S,j} = 0 \text{ si } j \in N - S\ .$$

On note enfin $\mathbf{1} = (1, 1, ...1)$ et $\mathbf{1}_S$ la projection de $\mathbf{1}$ sur E_S.

Contexte de marché

Une entreprise offre sur le marché une collection $N = \{1, 2, ..., n\}$ de n variétés d'un même bien (places de cinéma dans différentes salles, minutes de communication téléphonique dans différentes directions de trafic, etc.).

Soit un client de cette entreprise dont le système individuel de préférences est représentable par la fonction d'utilité $w(\mathbf{q})$, où $\mathbf{q} = (q_1, q_2, ..., q_n) \geq \mathbf{0}$ est le vecteur des quantités consommées des différentes variétés. La fonction $w(\mathbf{q})$ est supposée croissante et concave sur un domaine $\mathcal{D}$ de $\mathbb{R}^{+n}$.

Le vecteur $\boldsymbol{\pi}(\mathbf{q})$ des fonctions de demande inverses s'écrit :

$$\forall \mathbf{q} \in \Delta : \boldsymbol{\pi}(\mathbf{q}) = \boldsymbol{\nabla} w(\mathbf{q}) \geq \mathbf{0} \ .$$

On note réciproquement $\mathbf{q} = \mathbf{d}(\mathbf{p})$ le vecteur des fonctions de demandes directes, obtenu par inversion du système $\boldsymbol{\pi}(\mathbf{q}) = \mathbf{p}$. Par convention, le vecteur $\mathbf{p}$ est un vecteur ligne et le vecteur $\mathbf{q}$, un vecteur colonne.

Modes de tarification

L'entreprise peut pratiquer deux modes alternatifs de tarification : la *tarification affine* ou la *tarification forfaitaire*.

Définition 1. *Si $S \subseteq N$, $f \geq 0$ et $p \in E_S$, on appelle tarif "S-affine", et on note (S, f, p), le système de tarification dans lequel l'accès à la consommation est tarifé f, les variétés du panier S sont tarifées à des prix unitaires strictement positifs ($p_j > 0$ si $j \in S$), et les variétés du panier complémentaire $N - S$ sont offertes gratuitement ($p_j = 0$ si $j \in N - S$). Dans le cas particulier où $p = p1_S$ ($p > 0$), le tarif est dit "affine homogène". Dans le cas particulier où $S = N$, le tarif est dit "affine complet".*

La fonction de facturation associée au tarif S-affine $(S, f, \mathbf{p})$ s'écrit :

$$\phi(\mathbf{q}) = f + \mathbf{p} \cdot \mathbf{q} \ .$$

Définition 2. *Si $S \subseteq N$, $\phi > 0$, $a \in E_S$ et $q^0 > 0$, on appelle "forfait S-limitant", et on note $(S, \phi, a/q^0)$ le système de tarification dans lequel le paiement du montant fixe*

ϕ ouvre droit : d'une part, à la consommation maximale de q^0 unités au sein du panier S avec conversion possible de a_j unités de la variété $k \in S$ contre a_k unités de la variété $j \in S$; d'autre part, à une consommation "illimitée" des biens du panier complémentaire $N - S$. Le vecteur a est dit "vecteur de conversion" et le vecteur $[\mathbf{a}, q^0] \in \mathbb{R}^{+(n+1)}$ n'est défini qu'à une homothétie près, d'où la notation a/q^0. Dans le cas particulier où $a = a 1_S$ ($a > 0$), le tarif est dit "forfait homogène". Dans le cas particulier où $S = N$, le tarif est dit "forfait globalement limitant" et dans le cas $S = \varnothing$, il est dit "forfait illimité".

La contrainte de consommation associée au forfait S-limitant $(S, \phi, \mathbf{a}/q^0)$ s'écrit :

$$\mathbf{a} \cdot \mathbf{q} \leq q^0 \ ,$$

où, par convention, $\mathbf{a} \in E_S$ est un vecteur ligne.

Réactions de la demande

1. Face au tarif S-affine $(S, f, \mathbf{p})$, la meilleure réponse du consommateur est le vecteur de demande $\mathbf{q} = \mathbf{d}(\mathbf{p})$, solution du système :

$$\boldsymbol{\pi}(\mathbf{q}) = \mathbf{p} \ .$$

En effet, par construction, ce vecteur de demande réalise la maximisation selon $\mathbf{q}$ du surplus de consommation $w(\mathbf{q}) - \mathbf{p} \cdot \mathbf{q} - f$.

2. Face au forfait S-limitant $(S, \phi, \mathbf{a}/q^0)$, maximiser le surplus de consommation revient à maximiser l'utilité, si bien que la meilleure réponse du consommateur est la solution du programme :

$$w_R\left(\mathbf{a}, q^0\right) = \max_{\mathbf{q} \in \mathbb{R}^{+n}} \left[w(\mathbf{q}) \mid \mathbf{a} \cdot \mathbf{q} \leq q^0\right] \ ,$$

où l'utilité maximisée $w_R\left(\mathbf{a}, q^0\right)$ est une fonction homogène de degré 0, décroissante selon $\mathbf{a}$ et croissante selon q^0 :

$$\lambda\left(\mathbf{a}, q^0\right) = \frac{\partial w_R}{\partial q_0}(\mathbf{a}, q^0) = -\frac{\mathbf{a}}{q^0} \cdot \boldsymbol{\nabla}'_{\mathbf{a}} w_R\left(\mathbf{a}, q^0\right) > 0 \ .$$

La contrainte de volume étant saturée en raison de la croissance de $w(\mathbf{q})$, les conditions du premier ordre de la maximisation s'écrivent :

$$\pi(\mathbf{q}) = \lambda\mathbf{a} \quad , \quad \mathbf{a}\cdot\mathbf{q} = q^0 \ .$$

La résolution de ce système de $n+1$ équations et $n+1$ inconnues permet de déterminer, en fonction du niveau q^0 de la contrainte, le multiplicateur $\lambda(\mathbf{a}, q^0)$, ainsi que le vecteur de consommation $\mathbf{q}(\mathbf{a}, q^0)$:

$$\begin{aligned}\pi(\mathbf{q}) = \lambda\mathbf{a} \Rightarrow \mathbf{q} = \mathbf{d}[\lambda\mathbf{a}] \Rightarrow \mathbf{a}\cdot\mathbf{d}[\lambda\mathbf{a}] = q^0 \Rightarrow \lambda(\mathbf{a}, q^0) \ ,\\ \Rightarrow \mathbf{q}(\mathbf{a}, q^0) = \mathbf{d}[\lambda(\mathbf{a}, q^0)\mathbf{a}] \ .\end{aligned}$$

La fonction de demande $\mathbf{d}[\cdot]$ étant décroissante, il résulte de l'identité $\mathbf{a}\cdot\mathbf{d}[\lambda\mathbf{a}] = q^0$ que la fonction $\lambda(\mathbf{a}, q^0)$ est décroissante selon q^0 :

$$\frac{\partial\lambda}{\partial q^0}(\mathbf{a}, q^0) < 0 \ .$$

Enfin, de manière que le forfait soit effectivement limitant, *i.e.* que la contrainte soit opérante, il convient que la consommation de satiété $\mathbf{d}(\mathbf{0})$ viole la contrainte, d'où la condition nécessaire suivante sur le vecteur de conversion $\mathbf{a}$ et le plafond q^0 de consommation incluse dans le forfait :

$$\mathbf{a}\cdot\mathbf{d}(\mathbf{0}) > q^0 \ .$$

Théorème d'équivalence

Théorème. *A tout tarif S-affine $(S, f, \mathbf{p})$ correspond un forfait S-limitant $(S, \phi, \mathbf{a}/q^0)$ "consommateur-équivalent", i.e. qui engendre les mêmes niveaux de consommation, de facturation et de surplus, soit :*

$$\phi = f + \mathbf{p}\cdot\mathbf{d}(\mathbf{p}) \quad , \quad \frac{\mathbf{a}}{q^0} = \frac{\mathbf{p}}{\mathbf{p}\cdot\mathbf{d}[\mathbf{p}]} \ .$$

Réciproquement, à tout forfait S-limitant $(S, \phi, \mathbf{a}/q^0)$ vérifiant la condition de cohé-

rence :

$$\phi \geq \lambda(\mathbf{a}, q^0)q^0 \ ,$$

où la fonction $\lambda(\mathbf{a}, q^0)$*, décroissante selon* q^0*, est la solution en* λ *de l'équation* $\mathbf{a} \cdot \mathbf{d}(\lambda \mathbf{a}) = q^0$*, correspond un tarif* S*-affine* $(S, f, \mathbf{p})$ *"consommateur-équivalent", soit :*

$$f = \phi - \lambda(\mathbf{a}, q^0)q^0 \quad , \quad \mathbf{p} = \lambda(\mathbf{a}, q^0)\mathbf{a} \ .$$

La démonstration de ce théorème résulte directement des considérations précédentes sur les réactions de la demande.

Tableau récaptitulatif.

	Tarif affine (S, f, p)	Forfait $(S, \phi, a/q^0)$
"Prix"	p	$\lambda(a, q^0)a$ où : $q^0 = a \cdot d[\lambda a] \Leftrightarrow \lambda = \lambda(a, q^0)$
Consommation	$d(p)$	$d[\lambda(a, q^0)a]$
Facturation	$f + p \cdot d(p)$	ϕ où : $\phi \geq \lambda(a, q^0)q^0$
Equivalence	$p = \lambda(a, q^0)a$ et $p \cdot d(p) = \phi - f$	

Deux transitions tarifaires particulières

Examinons les effets sur le tarif affine équivalent de deux modifications alternatives d'un tarif forfaitaire : (i) l'augmentation du volume des unités incluses dans un forfait globalement limitant (N-limitant) ; (ii) le passage d'un forfait globalement limitant à un forfait S-limitant $(S \subset N)$.

1. *Relaxation de la contrainte de volume dans un forfait* N*-limitant.*

Si un forfait globalement limitant $(N, \phi, \mathbf{a}/q^0)$ est transformé "à la baisse" en le forfait $(N, \phi, \mathbf{a}/\tilde{q}^0)$ par une augmentation $\tilde{q}^0 - q^0 > 0$ du nombre des unités incluses à montant ϕ du forfait inchangé, ceci revient à la transformation du tarif affine complet équivalent

$(N, f, \mathbf{p})$ en le tarif affine complet $(N, \tilde{f}, \tilde{\mathbf{p}})$:

$$f = \phi - \lambda(\mathbf{a}, q^0)q^0 \quad , \quad \mathbf{p} = \lambda(\mathbf{a}, q^0)\mathbf{a}$$
$$\tilde{f} = \phi - \lambda(\mathbf{a}, \tilde{q}^0)\tilde{q}^0 \quad , \quad \tilde{\mathbf{p}} = \lambda(\mathbf{a}, \tilde{q}^0)\mathbf{a} < \mathbf{p} \ .$$

Ainsi, les prix du tarif affine complet équivalent s'abaissent et on peut affirmer que la partie fixe de ce tarif augmente (*resp.* diminue), lorsque les forfaits initial et final sont tous deux faiblement (*resp.* fortement) limitants, *i.e.* lorsque les volumes contraints q^0 et $\tilde{q}^0$ se situent dans le domaine de décroissance (*resp.* de croissance) de la fonction $\lambda(\mathbf{a}, q)q$ (supposant cette dernière croissante puis décroissante selon q) :

$$\lambda(\mathbf{a}, \tilde{q}^0)\tilde{q}^0 \lesseqgtr \lambda(\mathbf{a}, \tilde{q}^0)\tilde{q}^0 \Leftrightarrow \tilde{f} \gtreqless f \ .$$

2. *Passage d'un forfait N-limitant à un forfait S-limitant ($S \subset N$).*

Si un forfait globalement limitant $(N, \phi, \mathbf{a}/q^0)$ est changé en un forfait S-limitant $(S, \phi, \mathbf{a}_S/\tilde{q}^0)$, à montant ϕ du forfait inchangé, à coefficients de conversion invariants ($\mathbf{a}_S$ est la projection de $\mathbf{a}$ sur E_S), et à utilité marginale constante d'une relaxation de la contrainte de volume, soit :

$$\frac{\partial w_R}{\partial \tilde{q}^0}(\mathbf{a}_S, \tilde{q}^0) = \frac{\partial w_R}{\partial \tilde{q}^0}(\mathbf{a}, q^0) = \lambda \ ,$$

alors ce changement équivaut à la transition depuis le tarif affine complet $(N, f, \mathbf{p})$:

$$f = \phi - \lambda q^0 \quad , \quad \mathbf{p} = \lambda \mathbf{a} \ ,$$

vers le tarif S-affine $(S, \tilde{f}, \tilde{\mathbf{p}})$ caractérisé par :

$$\tilde{f} = \phi - \lambda \tilde{q}^0 \quad , \quad \tilde{\mathbf{p}} = \lambda \mathbf{a}_S \ .$$

Dans cette transition, les prix des variétés demeurant limitées en volume sont invariants ($\tilde{\mathbf{p}} - \mathbf{p}_S = \mathbf{0}$), les prix des variétés devenues "illimitées" passent de $\lambda \mathbf{a}_{N-S}$ à $\mathbf{0}$ (réduction de 100%). La consommation des variétés du panier S ne peut que rester stable ou diminuer par effet de substitution vers les variétés $N - S$ (dont le prix s'annule), si bien que $\tilde{q}^0 < q^0$.

Il en résulte que la partie fixe du tarif affine augmente de manière à maintenir la facture constante : $\tilde{f} - f = \lambda(q^0 - \tilde{q}^0) > 0$.

Application au modèle on-net/off-net

Le client-type de l'opérateur mobile i consomme le vecteur de flux communication $\mathbf{q}_i = \{q_i^1, q_i^2, ...q_i^n\}$ dans les différentes directions de trafic $j = 1, 2, ..., n$. Sa fonction d'utilité s'écrit :

$$w_i(\mathbf{q}_i) = u_i + v_i \left(\mathbf{1} \cdot \mathbf{M}_{./i} - \frac{\mathbf{q}_i'}{2\sigma_i} \right) \cdot \mathbf{X}_i(a) \cdot \mathbf{q}_i \ ,$$

d'où l'on déduit les fonctions de demande inverses :

$$\mathbf{p}_i = \boldsymbol{\pi}_i(\mathbf{q}_i) = v_i \left(\mathbf{1} \cdot \mathbf{M}_{./i} - \frac{\mathbf{q}_i'}{\sigma_i} \right) \cdot \mathbf{X}_i(a) \ ,$$

puis, en posant $\mathbf{A}_i(a) = \mathbf{X}_i^{-1}(a)/v_i$, les fonctions de demande directes :

$$\mathbf{q}_i = \mathbf{d}_i(\mathbf{p}_i) = \sigma_i[\mathbf{M}_{./i} \cdot \mathbf{1}' - \mathbf{A}_i(a) \cdot \mathbf{p}_i'] \ .$$

1. *Situation de référence.*

Dans cette situation, les prix des différents opérateurs sont supposés *all-net*, ce qui correspond à des tarifs affines complets $(N, f_i, p_i\mathbf{1})$. Ces tarifs affines sont équivalents aux forfaits globalement limitants $(N, \phi_i, \mathbf{1}/q_i^0)$, avec :

$$q_i^0 = q_i = \sigma_i \mathbf{1} \cdot [\mathbf{M}_{./i} - p_i \mathbf{A}_i(a)] \cdot \mathbf{1}'$$
$$\phi_i = f_i + p_i q_i = f_i + \sigma_i p_i \mathbf{1} \cdot [\mathbf{M}_{./i} - p_i \mathbf{A}_i(a)] \cdot \mathbf{1}' = f_i + \frac{[\sigma_i \mathbf{1} \cdot \mathbf{M}_{./i} \cdot \mathbf{1}' - q_i] q_i}{\sigma_i \mathbf{1} \cdot \mathbf{A}_i(a) \cdot \mathbf{1}'} \ .$$

2. *Transition all-net : augmentation des volumes de communication inclus dans les forfaits.*

A partir de la situation de référence, un changement tarifaire *all-net* consiste à augmenter de $\Delta q_i^0 > 0$ le volume de communication inclus dans le forfait-type $(N, \phi_i, \mathbf{1}/q_i^0)$, sans modifier le montant ϕ_i de ce forfait $(\Delta\phi_i = 0)$. Ceci équivaut à une baisse $\Delta p_i < 0$

du prix *all-net* équivalent, soit :

$$\Delta p_i = -\frac{\Delta q_i^0}{\sigma_i \mathbf{1} \cdot \mathbf{A}_i(a) \cdot \mathbf{1}'} = -\frac{\Delta q_i^0}{\sigma_i \left(\sum_{j=1}^{n} M_{j/i}^{2a} \widetilde{\alpha}_i^j \right)} \ ,$$

accompagnée d'une variation Δf_i de la partie fixe du tarif affine, soit :

$$\Delta f_i = -\frac{\Delta[(\sigma_i \mathbf{1} \cdot \mathbf{M}_{\cdot/i} \cdot \mathbf{1}' - q_i^0) q_i^0]}{\sigma_i \mathbf{1} \cdot \mathbf{A}_i(a) \cdot \mathbf{1}'} = -\frac{\Delta \left[\left(\sigma_i \sum_{j=1}^{n} M_{j/i} - q_i^0 \right) q_i^0 \right]}{\sigma_i \left(\sum_{j=1}^{n} M_{j/i}^{2a} \widetilde{\alpha}_i^j \right)} \ .$$

Compte tenu du volume de trafic dans la situation de référence correspondant à l'état du marché en 2003 (*cf.* annexe 2), on a :

$$q_i^0 = q_i > \frac{\sigma_i}{2} \sum_{j=1}^{n} M_{j/i} \Rightarrow \Delta f_i > 0 \ .$$

3. *Transition on-net : introduction de l'on-net illimité.*

L'opérateur i propose à son client-type un forfait $(N - i, \phi_i, \mathbf{1}_{-i}/q_0^{-i})$ offrant l'*on-net* en illimité, de même montant ϕ_i que le forfait initial $(N, \phi_i, \mathbf{1}/q_i^0)$ et se traduisant par la même utilité marginale d'un desserrement de la contrainte de volume $(\partial w_R / \partial q_{-i}^0 = \partial w_R / \partial q_i^0)$.Le tarif affine *off-net* $(N - i, \widetilde{f}_i, \widetilde{p}_{-i})$ équivalent au forfait $(N - i, \phi_i, \mathbf{1}_{-i}/q_{-i}^0)$ a pour caractéristiques :

$$\widetilde{p}_{-i} = \frac{\sigma_i \mathbf{1}_{N-i} \cdot \mathbf{M}_{\cdot/i} \cdot \mathbf{1}'_{N-i} - q_{-i}^0}{\sigma_i \mathbf{1}_{N-i} \cdot \mathbf{A}_i(a) \cdot \mathbf{1}'_{N-i}} = \frac{\sigma_i \mathbf{1} \cdot \mathbf{M}_{\cdot/i} \cdot \mathbf{1}' - q_i^0}{\sigma_i \mathbf{1} \cdot \mathbf{A}_i(a) \cdot \mathbf{1}'} = p_i$$

$$\Rightarrow \widetilde{p}_{-i} = p_i = \frac{\sigma_i \sum_{j=1}^{n} M_{j/i} - q_i^0}{\sigma_i \sum_{j=1}^{n} \left(M_{j/i}^{2a} \alpha_i^j - \sum_{k \neq i,j} M_{j/i}^a M_{k/i}^a \beta_i^{j,k} \right)} \quad , \quad \widetilde{p}_{+i} = 0$$

$$\widetilde{f}_i = \phi_i - p_i q_{-i}^0 \ .$$

Dans cette transition, le prix de l'*on-net* passe de $p_{+i} = p_i$ à $\widetilde{p}_{+i} = 0$ tandis que celui de l'*off-net* ne change pas ($\widetilde{p}_{-i} = p_i$). La partie fixe du tarif affine équivalent augmente quant à elle de $\widetilde{f}_i - f_i = p_i(q_i^0 - q_{-i}^0) > 0$.

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Conclusion

La thèse a permis d'analyser certains aspects de la régulation économique des communications électroniques et de mettre en lumière la nécessité de prendre en compte les caractéristiques particulières de ce secteur pour être efficace. Trois thèmes ont été successivement abordés : la question du déploiement optimal de la boucle locale fixe de nouvelle génération, l'appréhension du marché des services sur Internet à travers la théorie des marchés bifaces et la différenciation tarifaire sur le marché des communications mobiles.

Le premier chapitre a été dédié au déploiement du réseau de téléphonie fixe de nouvelle génération en fibre optique et à la stratégie de régulation qui doit l'accompagner. Deux mécanismes principaux peuvent être utilisés pour promouvoir la concurrence sur le marché des télécommunications fixes : la concurrence basée sur les infrastructures, lorsque chaque opérateur est en possession de son propre réseau, et la concurrence basée sur les services, lorsque les opérateurs ont accès à un réseau commun via un marché de gros.

Afin de comparer les effets de ces deux types de régulation, un modèle technico-économique a été construit qui permet d'estimer le coût d'une boucle locale fibre en France (coût de la fibre optique elle-même et coût du génie civil). L'utilisation de ce modèle en faisant varier le nombre d'opérateurs du réseau a notamment permis de comparer deux scénarios particuliers :

- un déploiement de la fibre réalisé par un monopole ;
- un déploiement réalisé par plusieurs opérateurs en zones urbaines et par un seul opérateur dans les zones rurales (scénario actuel).

Le calibrage du modèle avec les données françaises a montré que l'investissement nécessaire pour déployer un réseau de nouvelle génération en France était égal à environ 37 milliards € en monopole et à 41 milliards € selon le schéma actuel. Le prix de l'accès a été ensuite estimé à 15,3€ par mois et par ligne en monopole tandis qu'il s'élève à 21,0€ avec le schéma actuel. Le déploiement de la fibre par un monopole permettrait donc de réduire les coûts de 20 à 30% par rapport à la politique actuelle, notamment grâce à la non-duplication des infrastructures et la réduction de la prime de risque.

Les résultats du modèle, analyse de l'expérience internationale et de la littérature économique ont permis d'établir une approche qui permette à la fois d'accélérer le déploiement de la fibre et de favoriser la concurrence. Cette approche s'appuie sur les dispositions suivantes :

- délivrer une licence unique pour la construction du réseau fibre ;
- imposer au bénéficiaire de la licence une obligation de fournir en gros l'accès au réseau fibre aux autres opérateurs,
- fixer un prix unique national de l'accès orienté vers les coûts ;
- si nécessaire, introduire un mécanisme de financement de zones moins denses par les zones plus denses ;
- arrêter l'exploitation du réseau cuivre au moment de lancement du réseau fibre.

Dans le cadre de futures recherches sur ce thème, il serait intéressant d'étudier dans quelles mesures la réglementation optimale que nous avons définie pourrait être appliquée à d'autres pays. En particulier, on pourrait tester la sensibilité des résultats du modèle à d'autres caractéristiques nationales (exigences techniques, paramètres géographiques et démographiques de chaque pays, état de l'infrastructure, nombre d'opérateurs en place et intensité concurrentielle sur le marché). On pourrait par ailleurs étudier les mécanismes optimaux d'attribution de la licence permettant d'opérer le réseau : enchères et *beauty contest*, puisque le choix du mécanisme a une importante influence sur les incitations à l'investissement.

Le deuxième chapitre a proposé une application du concept de « marché biface » à l'analyse des communications électroniques. Une plateforme biface fournit un service aux deux versants d'un marché, les utilisateurs sur un versant ayant besoin d'interagir avec les utilisateurs de l'autre versant. Il s'agit-là d'une configuration typique pour les services en ligne, les deux versants représentant par exemple des vendeurs et des acheteurs, des annonceurs et des internautes, etc.

Dans la première partie de ce chapitre, nous avons étudié la manière dont les règles du droit de la concurrence devaient être adaptées pour prendre en compte les spécificités des marchés bifaces, notamment l'existence d'externalités entre les deux versants, qui a un impact notable sur la fixation des tarifs optimaux et le calcul de marges de profit. Cette analyse est basée sur une synthèse des résultats théoriques existants à ce sujet, ainsi que sur quelques exemples concrets de marchés bifaces.

Dans la deuxième partie, les impacts potentiels d'un système de tarification asymétrique et de la gratuité des services sur une face ont été étudiés à l'aide de l'exemple d'un contentieux sur le marché de la transmission de déclarations fiscales en ligne. Une plateforme permettait ainsi aux experts-comptables, constituant la première face du marché, d'envoyer ces déclarations vers les organismes de gestion agréés, constituant la deuxième face du marché. Les organismes de gestion agrées ont porté plainte contre cette plateforme pour avoir établi une tarification asymétrique, les services fournis aux experts-comptables étant « subventionnés » par les services aux organismes de gestion. Nous avons proposé un modèle simple permettant d'analyser l'impact de cette structure tarifaire sur le surplus des différentes parties, en fonction des valeurs absolues et de la dispersion des économies faits par les acteurs grâce à l'utilisation de format numérique. Sous certaines hypothèses, ce modèle a permis de prouver qu'une tarification asymétrique pouvait se révéler bénéfique pour les utilisateurs de chaque face du marché dans la mesure où elle permettait de mieux internaliser les externalités de réseau.

Dans la troisième partie de ce chapitre, les pratiques de discrimination tarifaire sur des marchés bifaces a été étudiée. Un modèle a été proposé pour analyser la discrimination entre deux types d'utilisateurs sur l'une des deux faces. Son utilisation a permis de montrer que les effets de la discrimination sur le bien-être et sur le surplus des consommateurs dépendent de certaines caractéristiques du marché : l'intensité concurrentielle qui y prévaut, sa maturité, l'existence d'externalités positives ou négatives, l'existence de coûts fixes dans la fonction de production et la possibilité pour les plateformes de distribuer gratuitement leurs services.

- Dans un premier temps, nous avons considéré le cas d'une plateforme en monopole. L'étude d'un modèle a permis de prouver que l'impact positif ou négatif de la discrimination tarifaire dépendait significativement de la phase de développement du marché. Sur un marché émergent, avec une base d'utilisateurs très faible, la discrimination peut ainsi s'avérer préférable pour la société et pour les utilisateurs. A l'inverse, sur un marché mature, la discrimination sert principalement à extraire le surplus des consommateurs. Cet effet s'explique par le problème de « la poule et de l'oeuf ». Sur un marché émergent, une plateforme peut en effet atteindre un seuil critique d'utilisateurs sur une des deux faces en proposant un service gratuit, subventionnés par les utilisateurs de l'autre face.
- Dans un seconde temps, nous avons considéré la situation de deux plateformes en concurrence. Dans ces circonstances, l'objectif de chaque plateforme est d'éviter la migration de ses clients vers l'autre plateforme. L'équilibre concurrentiel dépend de la position historique des plateformes sur le marché. Quand les utilisateurs peuvent se coordonner sur leur choix d'une plateforme et les deux plateformes *a priori* sy-

métriques, il n'existe qu'une seule plateforme active à l'équilibre car cela permet de maximiser la valeur totale des externalités. La pression concurrentielle et la coordination des utilisateurs permet cependant de transfert l'intégralité de surplus aux consommateurs : le profit supplémentaire obtenu par la plateforme grâce à la discrimination sur une face du marché est transféré aux utilisateurs de l'autre face en forme de prix plus bas. Quand les utilisateurs ne peuvent pas se coordonner sur leur choix d'une plateforme, ils ont une préférence pour la plateforme historique. Dans ce cas, la plateforme-nouvelle entrant peut entrer sur le marché uniquement si elle est plus efficace en termes de coûts ; la discrimination facilite l'entrée sur le marché.

Dans le cadre de futures recherches il serait intéressant de tester les résultats de notre modèle théorique en réalisant une étude empirique sur un service en ligne pour analyser l'évolution de sa stratégie de tarification dans le temps en fonction de la taille de sa base de clients et de l'apparition de plateformes alternatives.

Dans **le troisième chapitre**, nous avons analysé le fonctionnement d'un marché national de téléphonie mobile en adoptant une architecture de modélisation dont la généralité est suffisante pour rendre compte, sans simplification excessive, des caractéristiques réelles du marché et dont la maniabilité permet de réaliser des simulations numériques. Le modèle permet de simuler l'effet d'une différentiation tarifaire entre les appels *on-net* ou *off-net* sur les quantités de trafic respectivement émis en *on-net* et en *off-net*. Il tient également compte des « effets de club » qui sont entretenus par chaque opérateur concurrent, grâce aux stratégies tarifaires du type « friends and family ».

A l'aide de ce modèle, nous avons dans un premier temps ré-établi et précisé différents résultats issus de la littérature théorique existante, en caractérisant deux états remarquables du marché :

- d'une part, l'optimum collectif, qui correspond à une tarification au « coût marginal social », i.e. à un tarif de la minute de communication égal au coût de transmission de cette minute diminué du bénéfice procuré par la réception d'appels ;
- d'autre part, l'équilibre de marché, avec ou sans régulation des tarifs de terminaison d'appels sur le marché de gros.

Dans un second temps, nous avons mené une étude systématique de l'impact – sur le profit des opérateurs et sur le bien-être des consommateurs – d'une classe de changements tarifaires conforme à la pratique courante des opérateurs : les changements « neutres », qui laissent invariants le revenu de détail des opérateurs et donc la facture des usagers. Parmi les changements tarifaires neutres nous avons examiné en particulier d'une part, le relâchement de la contrainte de volume de communication dans un forfait, à montant inchangé de ce forfait (baisse dite *all-net*) ; d'autre part, l'introduction de *l'on-net* illimité à montant du forfait également inchangé (baisse dite *on-net*). Il ressort principalement de notre étude que, contrairement à des baisses tarifaires *on-net*, des baisses *all-net* simultanément entreprises par tous les opérateurs présents sur le marché augmentent les profits d'interconnexion de ces derniers, constituant ainsi un « réservoir » permettant de réduire les profits de détail et donc d'accroître le surplus des consommateurs.

Nous avons enfin calibré numériquement le modèle à partir de données reflétant l'état du marché mobile français en 2003, puis utilisé ce calibrage afin de procéder à des simulations chiffrées des impacts de changements tarifaires. Nos principales conclusions sont les suivantes :

- Les consommateurs manifestent une forte « préférence pour la variété », en ce sens qu'un même accroissement de leur trafic émis leur procure environ deux fois plus de bien-être lorsque cet accroissement est *all-net*, i.e. réparti entre toutes les directions de trafic (*on-net* et *off-net*), que lorsqu'il est concentré dans la seule direction de trafic *on-net*.
- Des baisses tarifaires *on-net*, typiquement l'introduction simultanée de *l'on-net* illimité par tous les opérateurs, font subir à l'opérateur dernier entrant une perte de profit par abonné significativement supérieure à celles subies par les premiers entrants. Compte tenu de la moindre capacité financière du dernier entrant, celui-ci se trouve ainsi exposé à un risque d'éviction du marché.
- Des baisses tarifaires *all-net* simultanément réalisées par tous les opérateurs sont préférables à des baisses simultanées *on-net*, en ce sens que les baisses *all-net*, en comparaison des baisses *on-net*, augmentent davantage le bien-être des consommateurs pour une même perte de profit des opérateurs, ou encore réduisent la perte des opérateurs pour un même accroissement du bien-être des consommateurs.
- L'avantage relatif que procurent des baisses tarifaires simultanées *all-net*, relativement à des baisses simultanées *on-net*, s'avère très significativement supérieur lorsque les bénéficiaires de cet avantage sont les consommateurs plutôt que les opérateurs.
- Sur le marché français, où d'importantes baisses *on-net* ont été pratiquées en 2004 par

les deux opérateurs premiers entrants, alors que le troisième opérateur avait adopté une structure tarifaire *all-net*, il eût été préférable pour l'ensemble des acteurs du marché, et tout particulièrement pour les clients du dernier entrant, que les opérateurs aient tous opté pour des baisses *all-net*. Le supplément ainsi engendré, en termes de gain différentiel de bien-être collectif (somme des profits des opérateurs et du bien-être des consommateurs), aurait avoisiné 70%.

Dans une perspective de prolongement le modèle proposé pourrait être calibré pour d'autres marchés nationaux et pour un autre nombre d'opérateurs, afin d'évaluer l'impact de la tarification choisie par les opérateurs dans d'autres pays que la France et à d'autres périodes.

Monopole naturel, marchés bifaces, différenciation tarifaire : trois essais sur la régulation de télécommunications

Résumé : La thèse s'intéresse à l'économie de l'industrie des télécommunications et à sa régulation. *La première partie* est dédiée au déploiement du réseau fixe de fibre optique. L'étude de différentes méthodes de régulation permet de comparer les approches en termes de vitesse et d'efficacité du déploiement ainsi que de bien-être de consommateurs. Un modèle technico-économique est construit afin d'estimer les coûts du réseau d'accès de fibre en France et de comparer les résultats des différentes approches de régulation en termes quantitatifs. *La deuxième partie* applique la théorie de marchés bifaces au domaine des communications électroniques. Elle aborde le sujet de la régulation concurrentielle de marchés bifaces et montre en quoi leur traitement doit être spécifique, en s'appuyant sur des résultats théoriques et études de cas. Un modèle de la discrimination par les prix sur des marchés bifaces est proposé qui révèle les facteurs qui déterminent le caractère favorable ou défavorable de l'impact de la discrimination. *La troisième partie* étudie la question de l'impact de la différenciation tarifaire en fonction de la destination d'appel sur le marché des communications mobiles. Un modèle théorique est construit et ensuite calibré sur la base de l'exemple du marché français en 2003. Il est montré que des baisses all-net des tarifs vers tous les réseaux simultanément entreprises par tous les opérateurs sont plus avantageux pour les consommateurs que des baisses on-net du tarif intra-réseau.

Descripteurs : télécommunications, régulation, politique de concurrence, marchés bifaces.

Natural monopoly, two-sided markets, price differentiation: three essays on the regulation of telecommunications

Abstract: The thesis focuses on the economics of the telecommunications industry and on its regulation. *The first part* is dedicated to the deployment of the fixed network of the optical fibre. The study of different regulation methods allows to compare the approaches in terms of the speed and efficiency of deployment as well as the consumers' welfare. We construct a technico-economic model of the fibre access network in France in order to compare the results of different regulation approaches in quantitative terms. *The second part* applies the theory of two-sided markets to the field of electronic communications. It deals with the issue of competition regulation on two-sided markets and shows in what way their treatment should be specific, based on theoretic results and case studies. A model of price discrimination on two-sided markets is proposed that reveals the factors determining favourable or unfavourable impact of discrimination. *The third part* studies the impact of the price differentiation depending on the call destination on the mobile communications market. A theoretic model is constructed and then calibrated based on the example of the French market in 2003. It is shown that the all-net reduction of the tariffs towards all the networks and by all the operators is more beneficial for consumers than the on-net reduction of the intra-network tariffs.

Keywords: telecommunications, regulation, competition policy, two-sided markets.