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Par

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Ecosystem Strategies in the Shadow of Nonprofit Actors

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Abstract

My thesis focuses on issues related to value creation and value capture in business ecosystems. I explore how nonprofit and for-profit actors shape these ecosystems and their evolution through the design of relationships with key complements. The first chapter uses a formal model to study how a nonprofit actor, by strategically interacting with firms, can facilitate value creation in vertical supply chains. The second chapter studies the strategies that firms employ to shape the ecosystem they compete in and maximize value capture. Specifically, I look at firms’ decision regarding whether to make their product compatible with multiple complements or keep them exclusive for a specific complement in the context of anti-HIV drug market. I use a proprietary individual-level dataset on drug consumption obtained from the national French healthcare insurance and hand-collected data on clinical trials of anti-HIV drugs. The third chapter bridges the first two chapters and explores how nonprofit actors actively shape the ecosystem by comparing firm-sponsored and nonprofit-sponsored clinical trials on anti-HIV drugs. To conclude, I seek to understand how firms can maximize value creation and value capture in the contexts where complementary products are important. I strive to include nonprofit actors as an integral part of the ecosystem and understand how the actions of actors who do not seek to maximize profit affect the strategies of for-profit actors towards their complements.

Keywords: Ecosystem; complements; nonprofit; value creation; value capture; pharmaceutical
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1 French Summary

1.1 Introduction

Ma thèse porte sur les contextes dans lesquels la création de valeur dépend de produits complémentaires, appelés écosystèmes d’entreprise (Adner et Kapoor, 2010; Jacobides, Cennamo et Gawer, 2018). Je suis intéressé par les stratégies adoptées par les acteurs à but lucratif et non lucratif pour maximiser la création de valeur et la capture de valeur (Brandenburger et Stuart, 2007, 1996; Chatain et Zemsky, 2011; MacDonald et Ryall, 2004). En particulier, j’explore comment les entreprises et les acteurs à but non lucratif façonnent ces écosystèmes et leur évolution à travers la conception de relations avec des compléments clés. J’utilise des modèles formels et des méthodes empiriques pour étudier ces questions.

Ma thèse est composée de trois essais. Le premier essai examine comment un acteur à but non lucratif, en interagissant de manière stratégique avec une entreprise, peut faciliter la création de valeur en permettant une collaboration entre une entreprise et un fournisseur. Le second essai étudie les écosystèmes d’activités où l’établissement d’une compatibilité entre les compléments est coûteux. J’examine les stratégies utilisées par les entreprises pour façonner les écosystèmes et maximiser la capture de valeur, en particulier la décision de l’entreprise de rendre leur produit compatible avec de multiples compléments ou de le maintenir exclusif pour un complément spécifique en fonction de l’évolution de la valeur de ce complément. Enfin, le troisième essai jette un pont entre les deux premiers essais en explorant la manière dont les acteurs à but non lucratif affectent la compatibilité entre les compléments d’écosystèmes d’entreprise et ont donc un impact sur l’évolution des écosystèmes aux côtés des acteurs à but lucratif. Dans les premier et deuxième essais, j’utilise des modèles formels pour développer des propositions testables. Les deuxième et troisième essais utilisent des méthodes empiriques et s’inscrivent dans le contexte du traitement anti-VIH, qui est une combinaison de plusieurs médicaments produits par différentes entreprises. J’utilise un ensemble de données exclusif sur la consommation de médicaments au niveau individuel, obtenu auprès de l’assurance maladie nationale française, ainsi que des données collectées manuellement sur les essais cliniques de médicaments anti-VIH.
Dans le cadre de ma thèse, je cherche à contribuer à la littérature sur les écosystèmes et les compléments, ainsi qu’à la littérature sur les stratégies non marchandes.

Premièrement, je contribue à la littérature sur les écosystèmes d’entreprise en introduisant les compromis entre le besoin de maximiser la création de valeur par l’écosystème et le besoin de maximiser la capture de la valeur par un acteur individuel (Brandenburger et Nalebuff, 1997) en tant que moteur des stratégies des entreprises vers des compléments. L’intégration de ces compromis me permet d’élucider les mécanismes qui sous-tendent les décisions des entreprises d’être exclusivement compatibles avec certains compléments, ainsi que les décisions des entreprises de s’intégrer à des composants complémentaires pour bénéficier de cette exclusivité. Deuxièmement, j’endogenise la notion de complémentarité dans un écosystème en faisant de la disponibilité de compléments pour le produit focal le résultat de stratégies adoptées par les producteurs du produit focal et de compléments plutôt que de manière exogène. Troisièmement, je tiens compte des objectifs et des actions d’acteurs qui ne cherchent pas à maximiser leurs profits et qui peuvent lier des acteurs ou établir une compatibilité entre des produits que les entreprises ne feraient pas d’elles-mêmes en raison de préoccupations liées à la capture de valeur, ce qui contribue davantage à la compréhension des comment les complémentarités apparaissent dans un écosystème. Enfin, j’enrichis la perspective dynamique des écosystèmes en examinant les mutations de ce qui constitue un goulot d’étranglement dans un écosystème, à la fois par les stratégies des entreprises en matière de complémentarité et par les actions des acteurs à but non lucratif. En outre, cette thèse contribue à la recherche sur les interactions entre entreprises et organisations à but non lucratif en étudiant des contextes dans lesquels un acteur à but non lucratif dont les objectifs ne sont ni totalement antagonistes ni totalement alignés sur ceux des acteurs à but lucratif peut directement contribuer à la création de valeur économique.

Ensuite, je ferai un bref survol de la littérature consacrée aux écosystèmes et aux compléments et suggérerai comment l’inclusion des acteurs à but non lucratif en tant que partie intégrante d’un écosystème peut contribuer à faire avancer la recherche sur la création de valeur et la capture de valeur dans ces contextes. Je me concentrerai en particulier sur la décision des entreprises de
créer de la valeur avec des fournisseurs ou des producteurs de produits complémentaires et sur la manière dont les acteurs à but non lucratif, en ayant des objectifs différents de ceux de l’entreprise, affectent ces décisions.

1.2 Écosystèmes d’entreprises

L’écosystème d’entreprise est défini comme “la structure d’alignement de l’ensemble multilatéral de partenaires devant interagir pour qu’une proposition de valeur centrale se matérialise” (Adner, 2017), ou plus simplement comme “des groupes d’entreprises qui produisent des produits ou des services qui ensemble constituent une solution cohérente” (Hannah et Eisenhardt, 2018). Au cours des dernières années, le concept d’écosystème a suscité un intérêt croissant et un certain nombre de questions intéressantes se sont posées: qu’est-ce qui contribue à la création de valeur dans un écosystème? Comment la valeur est-elle capturée par des joueurs individuels? Quelles stratégies les entreprises peuvent-elles employer pour accroître la création de valeur du système et leur part dans cette valeur?

centre principalement sur la première question – comment créer de la valeur dans un écosystème – et suggère des stratégies pour garantir la disponibilité de compléments, par exemple, par le biais d’alliances avec des producteurs de produits complémentaires (Kapoor et Lee, 2013), ou du choix de la technologie (Kapoor et Furr, 2015).

Outre la littérature explicitement centrée sur les écosystèmes d’entreprises, il existe d’autres domaines de recherche qui examinent le rôle des interdépendances entre produits complémentaires et qui peuvent donc apporter des informations importantes pour comprendre comment la valeur est créée et capturée dans de tels contextes. La littérature technologique sur les systèmes complexes et la conception modulaire (Baldwin et Clark, 2000), fondée sur les travaux de Simon (1962), explore les incitations à innover dans les systèmes de produits complexes en fonction des interdépendances technologiques entre les modules (Ethiraj, 2007; Ethiraj et Posen, 2013; Mäkinen et Dedehayir, 2013). Bien que le jargon adopté dans cette littérature soit différent, les systèmes complexes sont essentiellement des écosystèmes, où les modules sont des produits complémentaires (Ethiraj et Posen, 2013). Ce volet de recherche met également l’accent sur l’aspect de la création de valeur de l’écosystème et moins sur les incitations des différents acteurs à accroître leur valeur.

D’autre part, la littérature sur l’architecture industrielle examine la répartition de la valeur entre les secteurs de l’industrie, ou modules, dans le langage de la littérature sur la conception modulaire (Baldwin et Clark, 2000; Jacobides, Knudsen et Augier, 2006). Cette littérature met l’accent sur le concept de goulot d’étranglement défini comme «la partie du système de l’entreprise ou de l’industrie la plus approvisionnée» (Jacobides et al., 2006). Dans la littérature sur les systèmes complexes, un goulot d’étranglement est considéré comme une contrainte pour la création de valeur par l’écosystème, car il limite les performances de l’ensemble du système (Ethiraj, 2007). En revanche, dans la littérature sur l’architecture industrielle, un goulot d’étranglement est considéré à la fois comme le point de création de valeur et de capture de valeur, et les entreprises qui se trouvent dans le goulot d’étranglement peuvent s’approprier une plus grande part de valeur (Baldwin, 2015; Jacobides et al., 2006). Ce courant de recherche étend également le cadre de Teece (1986) sur les bénéfices tirés de l’innovation, mais examine l’aspect capture de valeur et cherche à expliquer
la capacité des nouveaux entrants à tirer profit de l’innovation (Jacobides et al., 2006; Jacobides, Veloso et Wolter, 1999). 2013), modification de la répartition de la valeur entre les segments ou «migration de valeur» (Jacobides, MacDuffie et Tae, 2016) et maintien de la position de goulot d’étranglement (Jacobides et MacDuffie, 2013; Jacobides et Tae, 2015).

Il reste cependant trois problèmes importants à résoudre dans la littérature sur les écosystèmes d’entreprises. Premièrement, les entreprises de recherche existantes prennent des décisions et adoptent des stratégies dans un écosystème fondées soit sur des considérations de création de valeur (comme dans les flux de recherche sur les interdépendances des écosystèmes commerciaux et technologiques), soit sur des considérations de capture de valeur (comme dans le courant de recherche d’architecture industrielle), mais rarement sur les deux.1 Etant donné que les entreprises peuvent adopter des stratégies qui augmenteront leur capture de valeur individuelle, mais au détriment de la création de valeur globale, et inversement (Brandenburger and Nalebuff, 1997), dans ma thèse, je soutiens que ces deux considérations doivent être prises en compte dans la littérature sur les écosystèmes, car elles affectent les stratégies des entreprises en matière de complément dans un écosystème. À cette fin, j’utilise des modèles formels qui s’appuient sur le cadre stratégique fondé sur la valeur (Brandenburger et Stuart, 2007, 1996) et permettent d’incorporer à la fois la création de valeur par le groupe d’acteurs et la capture de valeur par des acteurs individuels.

Deuxièmement, on suppose généralement que la disponibilité des compléments est donnée de manière exogène. On a tenté de l’endogénéiser, par exemple en recherchant des alliances avec les producteurs de compléments (Kapoor et Lee, 2013; Kapoor, Rahul, 2013) ou le choix de la technologie en fonction de la disponibilité des compléments (Kapoor et Furr, 2015). Cependant, les antécédents de la décision des producteurs de compléments de rendre les compléments disponibles pour le produit focal sont encore peu explorés. La littérature technologique propose une explication des interdépendances technologiques (Ethiraj et Posen, 2013). Toutefois, elle examine le contexte d’innovation continue dans un écosystème et la qualité des compléments correspondant à la qualité

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1J’exclus la recherche sur les plateformes à plusieurs côtés, qui représentent également un type spécifique d’écosystème, car dans la littérature sur les plateformes, le principal moteur est les effets de réseau directs et indirects et, dans ma thèse, j’ai choisi de me concentrer sur les contextes dans lesquels de tels effets sont faibles.
du produit focal plutôt que la disponibilité de compléments en tant que tels. Cette question revêt une importance particulière lorsque nous considérons que dans de nombreux cas, la compatibilité entre le complément et le produit focal peut être coûteuse ("complémentarités non génériques" dans Teece, 1986). En fait, Jacobides et ses coauteurs dans leur article de 2018 sur la théorie des écosystèmes déclarent que ce qui distingue les écosystèmes des marchés est l’existence de complémentarités non génériques. C’est pourquoi j’affirme que pour comprendre les stratégies des entreprises dans un écosystème, il est essentiel d’endogeniser la décision de complémentarité.

Troisièmement, la recherche en stratégie a largement adopté une perspective statique des écosystèmes et nous en savons moins sur leur émergence et leur évolution. Il est particulièrement intéressant de comprendre comment les goulots d’étranglement sont déplacés au sein d’un écosystème (Hannah et Eisenhardt, 2018). Bien que la littérature sur l’architecture industrielle offre des informations sur les modifications des goulots d’étranglement dans tous les secteurs (Jacobides, Mac-Duffie et Tae, 2016; Jacobides et Tae, 2015), elle adopte le secteur (ou module) comme secteur, au lieu de la entreprise individuelle. Dans cette thèse, je soutiens qu’une seule entreprise d’un secteur industriel peut atteindre une position de gout d’étranglement, et que cette entreprise peut s’approprier une valeur plus élevée au détriment d’autres entreprises du même secteur (de manière à ce que la documentation sur l’architecture de l’industrie soit moins bien équipée, analyser). En outre, l’évolution de l’écosystème peut entraîner un alignement différent des acteurs existants ou de nouveaux acteurs, ce qui n’est pas l’objet de la littérature sur l’architecture industrielle (Adner, 2017). En résumé, j’affirme qu’il est possible de mieux comprendre la façon dont la valeur créée et divisée dans un écosystème évolue au fil du temps et comment les stratégies des entreprises peuvent influer sur ces changements.

Ces trois questions sont également liées. S’attaquer au premier problème – intégrer les facteurs de création de valeur et de capture de la valeur en tant que facteurs de la prise de décision – permet d’élucider les compromis auxquels les entreprises sont confrontées et, partant, de résoudre le second problème, à savoir que la décision des producteurs de compléments soit compatible avec le produit focal. Cela permet à son tour de comprendre comment les acteurs réagiraient aux change-
ments d’un écosystème ou comment les actions des entreprises entraîneraient des changements dans la création et la valorisation de la valeur, abordant ainsi le troisième problème.

1.3 Écosystèmes commerciaux et acteurs à but non lucratif

Jusqu’à présent, la littérature sur les écosystèmes s’est principalement concentrée sur les acteurs à but lucratif en tant que constituants, tandis que d’autres acteurs peuvent également jouer un rôle important. En fait, la définition originale d’écosystème donnée par James Moore est beaucoup plus large, ce qui suggère qu’un écosystème d’entreprise est “une communauté économique soutenue par un ensemble d’organisations et d’individus en interaction – les organismes du monde des affaires ... Les organismes membres incluent également des fournisseurs, les producteurs principaux, les concurrents et d’autres parties prenantes ”(Moore, 1996: p.26). Par conséquent, alors que la recherche stratégique sur les écosystèmes a généralement désigné les entreprises comme leurs membres – “des groupes d’entreprises qui produisent des produits ou des services qui constituent ensemble une solution cohérente” (Hannah et Eisenhardt, 2018), ou “un groupe d’entreprises en interaction qui dépendent sur les activités de chacun ”(Jacobides et al., 2018) – il n’est pas nécessaire de contraindre les constituants de l’écosystème à des acteurs à but lucratif, en particulier lorsqu’ils peuvent affecter directement la manière dont la valeur est créée et capturée par les acteurs à but lucratif.

Plus spécifiquement, dans ma thèse, j’explore le rôle d’acteurs à but non lucratif qui ont des objectifs autres que la maximisation du profit et qui interagissent de plus en plus avec des acteurs à but lucratif (Cabrál et al., 2019; Dorobantu, Kaul et Zelner, 2017; Mahoney, McGahan et Pitelis, 2009). Des recherches récentes ont montré comment ces acteurs peuvent directement faciliter la création de valeur par les acteurs à but lucratif (Gatignon et Capron, 2016; Li et Garnsey, 2013; McDermott, Corredoira et Kruse, 2009). Dans ma thèse, je soutiens que l’extension des limites de l’écosystème pour inclure les acteurs à but non lucratif peut fournir des informations utiles pour approfondir notre compréhension des trois problèmes identifiés ci-dessus.

Comme les acteurs à but non lucratif, par définition, ne cherchent pas à maximiser leurs profits, leur inclusion peut fournir une dimension supplémentaire à la création de valeur et à des considéra-
tions de capture de valeur qui orientent les stratégies des entreprises dans un écosystème. D’une part, les acteurs à but non lucratif peuvent chercher à maximiser la création de valeur aux dépens de la capture de valeur. D’autre part, étant donné que la création de valeur dans le jargon de stratégie basée sur la valeur représente toujours une valeur monétaire, en particulier la différence entre le consentement à payer du client et le coût d’opportunité du fournisseur (Brandenburger et Stuart, 1996), les organisations sans but lucratif peuvent encore chercher à maximiser - utilité transférable (par exemple, la diffusion de pratiques durables, l’accès à un traitement médical) rendant les objectifs des organisations à but non lucratif orthogonaux à ceux des acteurs à but lucratif. Étant donné que les organisations à but non lucratif peuvent alors chercher à promouvoir différents types de complémentarité entre acteurs, il est essentiel de prendre en compte les incitations des acteurs à but non lucratif avec les considérations de création de valeur et de capture de valeur des entreprises afin de mieux comprendre les interactions au sein d’un écosystème.

Par conséquent, la comptabilisation des acteurs à but non lucratif peut aider à mettre en lumière l’émergence de complémentarités dans les écosystèmes, en particulier lorsque leur complémentarité entraîne un coût pour les acteurs à but lucratif. Les acteurs à but non lucratif peuvent faciliter les connexions entre les acteurs de l’écosystème (Li et Garnsey, 2013; McDermott, Corredoira et Kruse, 2009) même si ces acteurs n’auraient pas fait partie d’un écosystème. Cela peut arriver, par exemple, lorsque la capture de valeur n’incite pas suffisamment les entreprises à compenser le coût de la compatibilité, alors que les acteurs à but non lucratif peuvent tirer profit de la valeur créée par les entreprises susmentionnées.

Cette dernière implique qu’une organisation à but non lucratif peut contribuer à l’émergence d’un écosystème lui-même (Li et Garnsey, 2013), ce qui ne se serait pas produit autrement faute d’une capture de valeur suffisante. Cela implique également que les organisations à but non lucratif peuvent jouer un rôle important dans la manière dont les écosystèmes évoluent, car elles peuvent établir une complémentarité avec des compléments autres que ceux que choisiraient les entreprises à but lucratif, permettant ainsi de modifier ce qui constitue un goulot d’étranglement au sein d’un écosystème.
En résumé, dans ma thèse, je cherche à contribuer à la recherche sur les écosystèmes d’entreprise en abordant trois questions: apporter des compromis entre la création et la capture de valeur dans la littérature sur les écosystèmes, endogèner la décision de développer des compléments pour le produit focal, et examiner les facteurs de l’évolution de l’écosystème et des goulots d’étranglement. De plus, je soutiens que l’exploration du rôle des acteurs à but non lucratif susceptibles d’affecter les liens entre les acteurs à but lucratif au sein d’un écosystème peut améliorer notre compréhension de ces problèmes.

Je vais maintenant résumer brièvement les trois essais de la thèse. Chaque essai aborde un ou plusieurs problèmes décrits ci-dessus. Le premier essai examine comment un acteur à but non lucratif, intéressé par l’inclusion du fournisseur dans la chaîne de valeur de l’entreprise, peut faciliter la création de valeur entre une entreprise et un fournisseur. Étant donné que les objectifs de l’organisme à but non lucratif divergent, sans toutefois être antagonistes, pour celui de la société, l’organisme à but non lucratif est disposé à faire un effort pour permettre la création de valeur lorsque les acteurs à but lucratif ne la trouveraient pas rentable; toutefois, l’organisation à but non lucratif doit encore garantir la capture de valeur par ces derniers. Le deuxième essai porte sur les acteurs à but lucratif et sur la manière dont les considérations de création de valeur et de capture de valeur influent sur leur décision d’être compatibles avec des compléments uniques plutôt que multiples. Il explore l’impact de la modification des fonctionnalités de création de valeur des produits focaux sur la décision de compatibilité et, en définitive, explique comment ces décisions peuvent déplacer les goulots d’étranglement dans un écosystème. Le troisième essai compare les choix en termes de compléments faits par les acteurs à but lucratif et à but non lucratif, et comment ils affectent la création de valeur dans l’écosystème. En permettant des complémentarités entre des produits jusqu’alors non liés, les organisations à but non lucratif contribuent aux changements de détenteurs de goulots d’étranglement dans un écosystème.

1.3.1 Acteurs à but non lucratif et création de valeur
Les collaborations et les confrontations entre les acteurs à but non lucratif et les entreprises sont un élément clé de la stratégie moderne des entreprises et des marchés (Dorobantu, Kaul et Zel-
La littérature sur la politique privée (par exemple Baron, 2012) et les mouvements sociaux (par exemple, McDonnell et King, 2013) a principalement considéré les entreprises et les organismes sans but lucratif comme ayant des objectifs opposés, et s’est donc concentrée sur les stratégies de l’entreprise visant à anticiper ou à répondre aux demandes des organisations à but non lucratif. D’autres travaux ont considéré les organisations à but non lucratif comme des fournisseurs de biens sociaux, mais axées sur leur concurrence avec des acteurs à but lucratif (Kaul et Luo, 2018). Cependant, la recherche existante n’a que brièvement expliqué comment les organisations caritatives pouvaient favoriser la création de valeur économique, par exemple en améliorant les flux de connaissances entre les acteurs (McDermott, Corredoira et Kruse, 2009) ou en améliorant les capacités de ces derniers (Gatignon et Capron, 2016).

Dans l’essai “Les ONG et la création de valeur dans les chaînes d’approvisionnement”, je me suis concentré sur la perspective des organisations à but non lucratif qui cherchent à collaborer de manière stratégique avec des entreprises à but lucratif et à devenir des adjuvants à la création de valeur. Je modélise une interaction stratégique entre une organisation à but non lucratif et une entreprise dont l’objectif est d’accroître l’inclusion économique des fournisseurs potentiels d’une entreprise (par exemple, parce que l’association cherche à augmenter la consommation de certains produits, tels que les cultures biologiques, adoption de certaines pratiques chez les fournisseurs, par exemple la culture durable). Les objectifs de ces acteurs sont distincts mais ne sont pas totalement antagonistes, ce qui crée la possibilité de gains mutuels grâce à la collaboration. J’utilise les éléments du cadre de la politique privée (Baron et Diermeier, 2007) avec un modèle dans lequel l’entreprise et le fournisseur se soucient de la création de valeur et de la capture de la valeur (Brandenburger et Stuart, 2007, 1996). L’organisme à but non lucratif déploie des efforts coûteux pour améliorer les capacités de création de valeur du fournisseur afin de rendre son inclusion dans la chaîne de valeur de l’entreprise plus attrayante. L’organisme à but non lucratif choisit le niveau d’effort à déployer afin d’optimiser son utilité (qui est non transférable), mais il doit néanmoins assurer une capture de valeur suffisante pour que les acteurs à but lucratif puissent inciter ces derniers à collaborer.
Je montre que la nécessité de prendre en compte la contrainte de capture de valeur des acteurs à but lucratif aboutit à des résultats différents en termes d’effort de l’organisme à but non lucratif : aucun effort (lorsque le niveau d’effort requis pour répondre à la contrainte de capture de valeur est trop élevé pour l’acteur à but non lucratif), l’effort incitant à la participation (lorsque l’organisme à but lucratif fait un effort au-delà de ce qui est optimal pour répondre à la contrainte de capture de valeur), et l’effort optimal (le niveau d’effort optimal pour l’organisme à but non lucratif du fait des coûts-bénéfice). Je relie ces résultats au potentiel de création de valeur, aux capacités de l’organisation à but non lucratif et au pouvoir de négociation relatif entre une entreprise et un fournisseur.

Paradoxalement, l’effort de participation est plus élevé que le niveau optimal, mais dans le premier cas, l’entreprise ne peut réaliser qu’un bénéfice minime, alors que dans le dernier cas, elle réalise des bénéfices positifs. Pour cette raison, le régime d’efforts favorisant la participation est surnommé «la vallée de la frustration» - alors que l’acteur à but non lucratif fait de gros efforts, l’entreprise ne voit pas les avantages de la collaboration. C’est le cas lorsque le pouvoir de négociation de l’entreprise vis-à-vis du fournisseur et les capacités de l’organisme à but non lucratif se situent à un niveau moyen. De plus, je montre que dans de tels cas, l’OSBL sera disposée à accepter un compromis pour atteindre ses objectifs : l’OSBL préférera que l’entreprise augmente son pouvoir de négociation vis-à-vis du fournisseur afin de réduire la contrainte de participation de l’entreprise et rapprochez vos efforts de l’optimum.

De plus, j’examine la décision de l’entreprise lorsqu’elle a le choix d’intégraliser la fonction de l’acteur à but non lucratif (c’est-à-dire lorsque l’entreprise peut améliorer elle-même les capacités de création de valeur du fournisseur). L’entreprise doit ensuite faire un compromis entre la détermination du niveau d’effort qui optimise sa valeur et la redistribution du coût de l’amélioration des fournisseurs vers le secteur à but non lucratif. Je montre que lorsque l’entreprise dispose d’un pouvoir de négociation élevé vis-à-vis des fournisseurs et que ses capacités de développement sont comparables à celles des organisations à but non lucratif, elle choisira d’intégraliser ses efforts.

Enfin, je montre que, lorsqu’il y a concurrence entre entreprises et organisations à but non lu-
cratif pour la collaboration, les entreprises dotées d’un pouvoir de négociation plus élevé seront associées à des organisations à but non lucratif dotées de capacités de développement des fournisseurs renforcées dans le cadre d’un régime d’effort optimal, permettant aux organisations à but lucratif de maximiser leur utilité et aux entreprises de disposer de profits positifs. Cela laissera les entreprises disposant d’un pouvoir de négociation moins important que les entreprises les plus puissantes à même de s’associer à des organisations à but non lucratif dotées de capacités plus faibles dans la «vallée de la frustration» et ne réalisant que des bénéfices minimes.

Cet essai contribue à notre compréhension des interactions entre les acteurs à but lucratif et à but non lucratif. Il montre comment les acteurs à but non lucratif peuvent induire certains comportements des acteurs à but lucratif en affectant directement la création de valeur, par opposition aux tactiques préjudiciables aux entreprises telles que le lobbying ou les campagnes d’activistes (McDonnell, King et Soule, 2015). De plus, en expliquant explicitement les objectifs à but non lucratif, je mets en lumière les compromis qu’un acteur à but non lucratif est prêt à accepter pour maximiser son utilité (par exemple en permettant une appropriation de valeur supérieure par l’entreprise aux dépens des fournisseurs qui seraient autrement considérés en tant que composants naturels à but non lucratif). Enfin, le modèle suggère des explications sur certains modèles empiriques observables, soulignant l’importance de la prise en compte du processus d’appariement entre entreprises et organisations à but non lucratif afin de tirer des conclusions sur les éléments moteurs de tels partenariats.

1.3.2 Stratégies vers des compléments dans les écosystèmes d’entreprises

Un corpus de recherches en plein essor a émergé ces dernières années pour étudier les écosystèmes de composants complémentaires qui doivent être assemblés pour créer de la valeur pour le client final (par exemple, véhicules électriques, smartphones, thérapie combinée). Le compromis auquel les entreprises sont souvent confrontées dans de tels contextes réside entre la création de valeur par l’ensemble de l’écosystème et la capture de valeur par une entreprise individuelle. D’une part, un corpus de littérature s’est concentré sur l’aspect création de valeur des écosystèmes et a montré que les compléments sont essentiels à la création de valeur (Adner et Kapoor, 2010;
Ethiraj, 2007; Kapoor et Furr, 2015, par exemple). D’autre part, la littérature sur l’architecture industrielle a mis l’accent sur l’aspect de la capture de valeur et a montré que la valeur créée peut être inégalement répartie entre les composants de l’écosystème, comprenant les producteurs d’un type de produit similaire (par exemple, Jacobides, Knudsen et Augier, 2006; Jacobides et MacDuffie, 2013). Plus précisément, les entreprises qui se trouvent dans la composante “goulot d’étranglement” ou “la partie de leur système ou du système de l’industrie où l’offre est la plus rare” (Jacobides et al., 2006) peuvent capturer une part de valeur disproportionnée (Baldwin, 2015). Jusqu’à présent, la littérature a principalement choisi de se concentrer soit sur la création de valeur, soit sur la capture de valeur, en tant que moteur de la stratégie des entreprises, mais elle a rarement abordé la tension qui oppose ces deux considérations. En outre, nous en savons moins sur la manière dont la concurrence entre producteurs dans la composante focale affecte les incitations des complémenteurs à être compatibles avec le produit focal et la capture de valeur qui en découle des participants à l’écosystème.

Dans le deuxième essai intitulé “Concurrence sur des marchés avec des compléments: comment l’hétérogénéité entre des entreprises au sein d’un composant façonne les stratégies écosystémiques”, j’examine la décision de l’entreprise de rendre son produit compatible avec de multiples compléments ou de le garder exclusif pour un complément spécifique, et comment vertical et horizontal la différenciation entre les offres des entreprises affecte ces décisions. J’utilise le cadre stratégique basé sur la valeur (Brandenburger et Stuart, 2007, 1996) pour modéliser la concurrence entre les offres différenciées horizontalement du produit principal et la manière dont les producteurs de compléments et du produit principal réagissent aux changements inattendus dans les capacités de création de valeur de ces offres. Le modèle montre qu’il existe deux effets concurrents qui déterminent la décision de l’entreprise en ce qui concerne la compatibilité avec une offre exclusive plutôt que multiple. Le premier – l’effet sur la création de valeur – représente l’avantage net d’être compatible avec une offre focale supplémentaire lorsque le producteur d’un complément décide d’être compatible avec plusieurs offres focales. La seconde – l’effet sur la capture de valeur – représente une valeur supplémentaire qui peut être capturée par le bundle d’un produit focal et un
complément (qui aurait été capturé par le client) lorsque le producteur de ce complément choisit d’être compatible avec une seule offre focale privant le client d’un bundle de substitution viable. Lorsque l’effet de création de valeur prédomine, le producteur du complément choisit d’être compatible avec les offres multiples focales; lorsque l’effet de capture de valeur domine – le producteur du complément choisit d’être exclusif à une offre focale spécifique. Le modèle trace les décisions pour les producteurs de compléments uniquement et pour les producteurs des compléments et du produit focal en fonction de la différence de capacités de création de valeur des offres focales.

Je teste les prévisions du modèle dans le contexte du marché des médicaments anti-VIH. Elle convient particulièremment à cette recherche car un traitement standard représente une combinaison de plusieurs médicaments, qui peut être scindée en deux composants: un composant de base et un composant d’ajout. Il est important de noter que les entreprises biopharmaceutiques concentrent généralement leurs efforts sur une seule des parties du traitement, faisant de cette dernière les composantes semi-indépendantes de l’écosystème plutôt que sur deux gammes de produits différentes pour une même entreprise et créant des interdépendances entre les entreprises. La deuxième caractéristique importante de ce contexte est qu’un essai clinique est nécessaire pour assurer la compatibilité entre les médicaments complémentaires (c’est-à-dire qu’un médecin ne peut pas prescrire une combinaison qui n’a pas été testée au cours d’un essai clinique). Compte tenu du coût élevé des essais cliniques, la compatibilité est donc coûteuse à réaliser dans ce contexte. De plus, j’exploite un choc quasi-exogène sur la différenciation horizontale entre les médicaments du composant de base lorsqu’un essai clinique financé par un organisme à but non lucratif a révélé qu’un médicament de base était moins efficace chez une population de patients donnée, rendant l’autre médicament de base compatible avec une population de patients plus large et finalement un goulot d’étranglement pour le traitement.

L’essai combine deux ensembles de données différents: des données exclusives au niveau individuel sur la consommation de médicaments anti-VIH et des données collectées manuellement sur les essais cliniques de médicaments anti-VIH. Le premier ensemble de données provient de la base de données Echantillon Generaliste Beneficiaire fournie par l’assurance maladie française, qui con-
stitue un échantillon quasi aléatoire de 1/97ème de la population française retraçant l’ensemble de la consommation de soins de santé (y compris les achats de médicaments) remboursée au niveau individuel. Ces données me permettent de voir l’évolution de la valeur de différents médicaments et de confirmer les changements de différenciation horizontale et verticale des médicaments. J’utilise ensuite ces informations pour étudier les changements intervenus dans les stratégies de recherche et développement des entreprises en examinant les médicaments utilisés dans les essais cliniques. J’extrais les essais cliniques de stade avancé sur les médicaments anti-VIH de la base de données en ligne clinicaltrials.gov fournie par la US National Library of Medicine et je codais manuellement les principales caractéristiques de la conception de l’essai, y compris les combinaisons de médicaments testées. Je me concentre sur le choix des médicaments de base dans les essais cliniques sur les médicaments d’ajout, en examinant en particulier la décision de rendre les médicaments d’ajout compatibles avec un médicament de base unique par opposition à plusieurs médicaments à base, et en quoi cette décision change la valeur des médicaments de base.

Je trouve que, l’un des médicaments de base ayant été compatible avec une population de patients plus large, les producteurs des médicaments d’ajout ont cherché à former des combinaisons avec ce médicament, mais pas avec d’autres bases.

Le propriétaire de la base élargie a mis au point ses propres médicaments d’ajout, compatibles uniquement avec sa propre base; de plus, il ne les rend disponibles qu’en tant qu’intégrées avec sa base dans une seule pilule, mais pas en tant que pilule autonome. D’un côté, intégrer une base supplémentaire dans une seule pilule implique une création de valeur plus élevée en améliorant l’adhésion des patients au traitement. D’autre part, cette stratégie indique également la poursuite d’une capture de valeur plus élevée: des compléments exclusifs aident à renforcer le statut de goulot d’étranglement de la base plus élargie tandis que le propriétaire de la base concurrente est physiquement exclu de chercher la compatibilité avec des médicaments d’ajout. Inversement, le propriétaire de la base compatible avec une population de patients plus restreinte a mis au point des médicaments d’ajout compatibles avec sa propre base et la base concurrente, que j’interprète comme l’effet de création de valeur dominant celui de la capture de valeur pour cet acteur. Lorsque
cette stratégie a semblé échouer, elle a travaillé au développement de ses médicaments d’ajout en combinaison avec d’autres médicaments d’ajout, rendant ainsi le composant de base redondant et essayant de déplacer le goulot d’étranglement vers le composant d’ajout.

Ces résultats contribuent à la littérature sur les écosystèmes d’entreprises de plusieurs manières. En utilisant un modèle formel, je suis en mesure de mettre en lumière les compromis entre création de valeur et capture de valeur auxquels les entreprises sont confrontées lorsqu’elles choisissent d’être compatibles avec des compléments spécifiques. Cela permet de combler le fossé entre la littérature sur les écosystèmes d’entreprises (Adner et Kapoor, 2010) et la littérature d’architecture de l’industrie (Jacobides et al., 2006). Explorer l’impact de la concurrence intra-composante qui a été largement ignorée par les deux axes de recherche permet de mieux qualifier leurs prévisions en termes de stratégies que les entreprises adoptent pour se compléter. Plus précisément, je montre que la position différente dans la composante produits focaux amène les entreprises à faire des choix stratégiques différents en termes d’exclusion des tiers de l’accès à ces compléments. L’examen des différentes stratégies adoptées par le « gagnant » (intégration pour renforcer la position du goulot d’étranglement) et le « perdant » (s’appuyant sur l’écosystème et le déplacement du goulot d’étranglement) montre comment les entreprises tentent de façonner un écosystème et d’affecter l’emplacement du goulot d’étranglement, comme contribue au développement d’une perspective dynamique des écosystèmes (Hannah et Eisenhardt, 2018; Kapoor et Agarwal, 2017).

1.3.3 Acteurs à but non lucratif et choix de compléments

Bien qu’un nombre croissant de recherches se soit concentré sur les écosystèmes (Adner, 2017) et sur l’importance des compléments pour permettre la création de valeur avec le produit focal (Adner et Kapoor, 2010; Kapoor et Furr, 2015), la littérature s’est principalement concentrée sur les stratégies que les entreprises adoptent pour assurer la fourniture de compléments (Hannah et Eisenhardt, 2018; Kapoor et Lee, 2013), mais moins sur les actions des acteurs à but non lucratif qui peuvent influer sur ce résultat. D’autre part, des études récentes ont montré que les acteurs à but non lucratif peuvent contribuer à faciliter la création de valeur par les acteurs du marché (Dorobantu, Kaul et Zelner, 2017; Gatignon et Capron, 2016; McDermott, Corredoira et Kruse,
Dans l’essai intitulé “Comment les acteurs à but non lucratif façonnent les écosystèmes des
entreprises: essais cliniques à but non lucratif ou parrainés par l’industrie”, je m’appuie sur les
thèmes examinés dans les deux premiers essais et explore le rôle d’un acteur à but non lucratif
dans l’établissement de la compatibilité entre des compléments dans un écosystème. Cet essai
se situe également dans le contexte des médicaments anti-VIH, et j’utilise l’ensemble de données
codé manuellement des essais cliniques de stade avancé sur les médicaments anti-VIH du deux-
ième essai. Curieusement, une grande partie de ces essais sont parrainés par des acteurs à but non
lucratif, et leur portée et leur taille sont similaires à celles parrainées par les entreprises. Dans le
même temps, nous savons que les organisations à but non lucratif poursuivent des objectifs dif-
férents de ceux de la maximisation du profit: dans le contexte anti-VIH, les organisations à but non
lucratif peuvent chercher à accroître l’accès au traitement anti-VIH, à réduire le coût du traitement
et à trouver les combinaisons offrant l’efficacité et la sécurité optimales profil pour les patients.
Cela soulève la question de savoir si les organisations à but non lucratif choisissent d’établir le
même type de compatibilité entre les compléments que les acteurs à but lucratif. Par conséquent,
dans cet essai exploratoire, je compare les essais cliniques commandités par une entreprise et ceux
parrainés par une organisation à but non lucratif en termes de types et de caractéristiques des com-
binaisons de médicaments testées, ainsi que l’utilisation des connaissances antérieures par type
d’acteur.

Je conduis l’analyse au niveau de la combinaison-essai et j’utilise la comparaison des moyennes
sur une gamme de caractéristiques de l’essai et de la combinaison. Je trouve qu’il existe une
hétérogénéité significative entre les essais sponsorisés par une entreprise et ceux parrainés par une
organisation à but non lucratif, ainsi qu’une hétérogénéité entre les types d’essais. Plus précisé-
ment, j’aperçois que les essais portant sur des combinaisons multi-médicaments standard et des
essais sur des combinaisons non conformes à l’architecture existante (par exemple, des combi-
naisons ne comportant qu’un seul élément de l’écosystème) présentent des schémas très différents
en termes de rôles entreprise-acteurs sans but lucratif.
En ce qui concerne les combinaisons standard, je trouve une division subtile du travail entre entreprises et organisations à but non lucratif. Les entreprises prennent généralement la tête et testent les combinaisons avec les médicaments plus récents pour les pays développés, tandis que les organisations à but non lucratif semblent «combler les vides» laissés par les acteurs à but lucratif. Premièrement, les organismes à but non lucratif ont tendance à tester des médicaments plus anciens dans les pays en développement afin d’améliorer l’accès au traitement pour les patients dans des contextes aux ressources limitées. Deuxièmement, dans les pays développés, les organisations à but non lucratif conduisent des essais comparant et combinant plusieurs combinaisons afin de confirmer l’efficacité et l’innocuité de nouveaux médicaments et d’établir la compatibilité des nouveaux médicaments avec une gamme plus étendue de compléments. Les essais sans but lucratif peuvent permettre de produire des substituts complets ou partiels aux combinaisons testées par l’entreprise, en particulier en ce qui concerne les essais dans les pays développés. En outre, les essais standard présentent un schéma chronologique clair: les entreprises sont les premières à tester les nouveaux médicaments, mais sont beaucoup moins actives une fois que le médicament est approuvé, ce qui correspond au moment où les organisations à but non lucratif «entrent dans le jeu». Il est important de noter que les entreprises et les organisations à but non lucratif ont tendance à tirer parti de l’expérience acquise dans le même type d’acteur, et les entreprises sont particulièrement rares pour reproduire des combinaisons d’essais à but non lucratif.

Pour les essais portant sur des combinaisons non standard, je trouve un schéma complètement opposé. Il existe peu de différences dans les caractéristiques des essais entre les essais sponsorisés par une entreprise et les essais sponsorisés sans but lucratif. Il est important de noter que les organisations à but non lucratif sont plus actives que les entreprises menant de tels essais et, contrairement aux essais standard, les entreprises suivent souvent l’initiative en reproduisant, par exemple, les combinaisons testées précédemment par des organisations à but non lucratif. En particulier, les organisations à but non lucratif ont été très actives dans le test des combinaisons évitant l’un des composants essentiels du traitement anti-VIH, dans la mesure où elles correspondaient à leur objectif de réduction des coûts de traitement et d’amélioration du profil de sécurité des pa-
tients. Les entreprises, en revanche, ont été moins impliquées dans de tels essais, mais au cours des dernières années, l’entreprise avec un médicament plus faible dans la composante de base a également commencé à rechercher des associations non standard. Étant donné que de telles combinaisons représentent un défi majeur pour la position de goulot d’étranglement des médicaments de base performants, ces résultats démontrent que les acteurs à but non lucratif peuvent permettre et soutenir les changements dans les goulots d’étranglement au sein de l’écosystème.

Cet essai est conçu comme exploratoire et permet de mieux comprendre le rôle d’un acteur à but non lucratif dans un écosystème. En particulier, il montre que, conformément aux différences entre les incitations des acteurs, les organisations à but non lucratif interviennent souvent pour combler les vides laissés par les entreprises, facilitant ainsi les liens entre des compléments jusque-là non connectés ou modifiant les capacités de création de valeur des compléments promus par les entreprises. En outre, les résultats suggèrent que, bien que les entreprises soient plus incitées à agir au sein de l’architecture écosystémique existante et à maintenir ses goulots d’étranglement, les acteurs à but non lucratif sont plus disposés à les contester et, ce faisant, peuvent favoriser les remaniements des goulots d’étranglement (Jacobides, MacDuffie et Tae, 2016). Enfin, l’essai contribue à la littérature sur les interactions entre entreprises et organisations à but non lucratif en explorant la concurrence entre les organisations à but non lucratif et les entreprises pour la fourniture d’un bien non rival et non excluable (Kaul et Luo, 2018) (où le bien est une combinaison de médicaments), ce qui peut toutefois avoir des avantages directs pour l’entreprise.

Le tableau 1 fournit le résumé de la thèse, y compris la principale question de recherche, les méthodes, les principaux résultats et la contribution clé de chaque essai.

1.4 Conclusions
Dans ma thèse, j’ai exploré des stratégies visant à compléter les stratégies adoptées par les acteurs à but lucratif et non lucratif pour maximiser la création de valeur et la capture de valeur dans les contextes où une coalition d’entreprises est nécessaire pour créer de la valeur pour le client final (Adner, 2017; Adner et Kapoor, 2010; Jacobides et al., 2018). Je me suis concentré sur les cas où former de telles coalitions nécessite un investissement initial. Dans le premier essai, j’ai montré
Table 1: Dissertation summary

<table>
<thead>
<tr>
<th>Essay 1</th>
<th>Essai 2</th>
<th>Essai 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Les ONG et la création de valeur dans les chaînes d’approvisionnement</strong></td>
<td><strong>Concurrence sur des marchés avec des compléments: comment l’hétérogénéité entre des entreprises au sein d’un composant façonne les stratégies écosystémiques</strong></td>
<td><strong>Comment les acteurs à but non lucratif façonnent les écosystèmes des entreprises: essais cliniques à but non lucratif ou parrainés par l’industrie</strong></td>
</tr>
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</table>

**Question**

- Comment et quand un acteur à but non lucratif peut-il faciliter la création de valeur entre une entreprise et un fournisseur en améliorant la capacité de création de valeur du fournisseur?
- Comment un changement dans la valeur du produit focal affecte-t-il la décision des entreprises de rendre le complément compatible avec plusieurs produits contre un seul produit?
- Quel est le rôle des acteurs à but non lucratif dans l’établissement de la compatibilité parmi les compléments dans un écosystème?

**Méthode**

- Modèle formel
- Modèle formel
- Méthodes empiriques (médicaments anti-VIH)

**Principales constatations**

- Nécessité de prendre en compte les contraintes des acteurs à but lucratif conduit à différents résultats des partenariats entreprise-organismes à but non lucratif (OBNL), y compris une “vallée de frustration” où malgré un effort important de la part d’OBNL, l’entreprise ne voit que des retours minimes
- Entreprises avec un plus grand pouvoir de négociation vis-à-vis des fournisseurs peut préférer internaliser des fonctions d’OBNL
- Les entreprises avec un pouvoir de négociation plus élevé seront associées aux OBNL avec des capacités plus fortes laissant moins d’entreprises de pouvoir et moins capables OBNL dans la “vallée de la frustration”
- Le propriétaire du produit focal avec une clientèle plus large développe des compléments exclusifs, ce qui entraîne une capture de valeur plus élevée et contribue à maintenir le statut de goulot d’étranglement.
- Le propriétaire du produit focal dont la clientèle est plus restreinte élabore des compléments pour atténuer une pénurie d’approvisionnement en complément, tout en les maintenant ouverts.
- Il cherche également à déplacer le goulot d’étranglement dans l’écosystème en essayant de rendre le produit principal inutile

- Les différences entre entreprises et organisations à but non lucratif (OBNL) varient selon que les essais maintiennent ou remettent en cause les goulots d’étranglement existants de l’écosystème
- Dans les essais qui soutiennent les entreprises prennent les devants, et il existe une division du travail: les entreprises se concentrent sur les nouveaux médicaments pour les pays développés alors que les OBNL testent les médicaments plus anciens pour maximiser l’accès au traitement pour les pays en développement ou comparant les combinaisons pour trouver le traitement optimal
- Dans les essais qui contestent (en évitant la composante goulot d’étranglement) les OBNL prennent les devants et les entreprises emboîtent le pas

**Contributions**

- Montre comment une OBNL peut induire un comportement d’acteur à but lucratif en affectant directement la création de valeur économique, par opposition aux tactiques antagonistes
- Elucider le compromis que l’OBNL est prêt à faire pour atteindre ses objectifs
- Suggère des explications sur les modèles empiriques (endogénéité, processus de sélection)
- Introduit le compromis entre création de valeur et capture de valeur dans la littérature sur les écosystèmes pour expliquer la décision de l’entreprise d’être compatible avec certains compléments
- Explorer l’impact de la concurrence intra-composant sur les stratégies des entreprises vers les compléments
- Développer une perspective dynamique sur les écosystèmes en explorant comment les acteurs de l’écosystème réagissent aux changements dans la valeur des compléments

- Conceptualiser les OBNL en tant que partie intégrante du écosystème
- Explorer comment les OBNL affectent l’émergence des complémentarités et l’évolution d’un écosystème
- Etudier le contexte dans lequel entreprises et OBNL sont en concurrence avec des biens sociaux qui, toutefois, se traduisent directement en valeur économique pour les entreprises

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que les acteurs à but non lucratif peuvent prendre des mesures pour permettre la création de valeur entre acteurs à but lucratif, et a examiné en quoi les résultats de ces collaborations dépendent des caractéristiques des entreprises et des organisations à but non lucratif. Dans le deuxième essai, j’ai montré que les entreprises faisaient des choix stratégiques en matière d’intégration dans la composante complémentaire et de développement de compléments exclusifs, et que ces choix façonnent l’évolution des goulots d’étranglement dans un écosystème. Enfin, dans le troisième essai, j’ai montré que les acteurs à but non lucratif, en établissant une compatibilité entre des compléments autres que ceux priorisés par les entreprises, peuvent provoquer des changements dans les goulots d’étranglement de l’écosystème.

Dans l’ensemble, ma thèse suggère que les complémentarités observées dans les écosystèmes résultent des décisions stratégiques des entreprises et que ces décisions ont une incidence sur l’évolution de ce qui constitue un goulot d’étranglement dans un écosystème. En outre, cela suggère que les acteurs à but non lucratif peuvent stimuler ces changements en s’engageant activement dans la formation des complémentarités susmentionnées.

**Contribution**

Dans cette thèse, j’ai cherché à aborder les trois lacunes que j’ai identifiées comme insuffisamment explorées dans la littérature sur les écosystèmes et les compléments: intégrer les considérations de création de valeur et de capture de valeur en tant que moteurs de la prise de décision, endogénéiser la complémentarité et examiner les changements de goulot d’étranglement dans les écosystèmes. De plus, j’ai cherché à inclure les acteurs à but non lucratif en tant que partie intégrante d’un écosystème et à examiner l’effet de ces acteurs sur les problèmes mentionnés ci-dessus. Pour combler ces lacunes, je m’efforce de contribuer à la littérature sur les écosystèmes et les compléments, ainsi qu’à la littérature étudiant les interactions entre entreprises et acteurs non marchands.

En intégrant à la fois la création de valeur et la capture de valeur en tant que moteurs des stratégies des entreprises pour compléter, je jette un pont entre les deux courants de littérature: la littérature sur les écosystèmes d’entreprises qui traite de la création de valeur et effectue des
analyses au niveau d’une entreprise (Adner et Kapoor, 2010; Kapoor et Furr, 2015; Kapoor et Lee, 2013) et la littérature sur l’architecture industrielle qui met l’accent sur la capture de valeur, mais examine le niveau d’une composante plutôt que celui d’une entreprise individuelle (Jacobides et al., 2006; Jacobides et al., 2016; Jacobides et Tae, 2015). Le fait de réunir les deux littératures qui traitent de compléments, mais développés indépendamment les uns des autres, permet de qualifier leurs idées. Par exemple, le deuxième essai a montré que, pour des raisons de capture de la valeur, les entreprises choisissaient parfois d’intégrer des composants complémentaires même lorsque des compléments étaient déjà disponibles, alors que la littérature sur les écosystèmes d’entreprises suggère que les entreprises ne le feraient qu’en l’absence de compléments (Kapoor et Furr, 2015): l’intégration permet aux entreprises de développer des compléments exclusifs à leur produit principal et ainsi de capter une valeur supérieure aux dépens du client. Il a également montré que, outre l’hétérogénéité entre les composants, comme dans la littérature sur l’architecture industrielle, l’hétérogénéité au sein des composants est importante: les entreprises adopteront des stratégies différentes en fonction de la position de leur produit dans un composant de l’écosystème.

L’implication importante est que la disponibilité de compléments pour le produit focal (Adner et Kapoor, 2010; Kapoor et Furr, 2015) n’est plus supposée exogène, mais constitue une décision stratégique du producteur de compléments. Le deuxième essai a montré que les entreprises peuvent choisir de rechercher la compatibilité avec un complément spécifique plutôt que de multiples, et cette décision est dictée, d’une part, par le compromis entre la création de valeur et la capture de valeur, et, d’autre part, par des capacités du produit focal pour la création de valeur.

Cette thèse offre également des informations sur la façon dont les écosystèmes évoluent au fil du temps, en particulier sur les goulots d’étroitesse qui apparaissent, persistent et changent (Baldwin, 2015; Jacobides, MacDuffie et Tae, 2016). Alors que la littérature sur l’architecture industrielle porte principalement sur les changements de goulots d’étroitesse entre composants (Jacobides, et al., 2016; Jacobides et Tae, 2015), je montre qu’un seul produit dans un composant peut devenir un goulot d’étroitesse. En outre, les entreprises de cette composante adopteront différentes stratégies qui affecteront l’évolution d’un écosystème: le propriétaire du
goulot d’étranglement s’intégrera dans la composante complémentaire et cherchera effectivement à transformer l’écosystème en une chaîne d’approvisionnement verticale, tandis que l’entreprise au produit plus faible cherchera à déplacer le goulot d’étranglement vers un autre composant, mais continuera à compter sur d’autres participants de l’écosystème pour créer de la valeur. Ces résultats contribuent aux recherches sur la perspective dynamique des écosystèmes (Hannah et Eisenhardt, 2018; Kapoor et Agarwal, 2017).

De plus, en intégrant un acteur à but non lucratif à un écosystème, cette thèse offre de nouvelles informations sur la manière dont les complémentarités apparaissent dans un écosystème (Adner, 2017) et sur leur évolution. Les premier et troisième essais ont montré que, dans la mesure où les acteurs à but non lucratif ne cherchent pas à maximiser leurs profits, ils peuvent permettre la création de coalitions d’entreprises ou de produits générant de la valeur lorsque les acteurs à but lucratif seraient dissuadés par une capture insuffisante de la valeur. Les deux essais ont également souligné l’importance de la comptabilisation des objectifs des organisations à but non lucratif afin de comprendre les résultats des interactions entre entreprises et organisations à but non lucratif. Fait important, le troisième essai a montré que les organisations à but non lucratif peuvent non seulement intervenir pour combler les vides laissés par les entreprises à but lucratif au sein de l’architecture écosystémique existante, mais aussi contester cette architecture en favorisant les combinaisons évitant le composant contenant des goulots d’étranglement. Ces résultats soulignent l’importance de la comptabilisation des acteurs à but non lucratif dans la recherche sur les écosystèmes d’entreprises, ces derniers pouvant jouer un rôle déterminant dans la promotion des complémentarités et la formation de l’évolution des écosystèmes.

Enfin, cette thèse contribue également à la littérature sur les stratégies non marchandes et l’engagement des parties prenantes. Cela témoigne du flot croissant de recherches sur l’interaction entre les acteurs publics et privés et la création de valeur (Cabral et al., 2019; Kivleniece et Quélin, 2012). En examinant le comportement d’un acteur à but non lucratif qui contribue directement à la création de valeur économique, je fais avancer la recherche sur l’interaction entreprise-organisme à but non lucratif à travers un objectif collaboratif (Dorobantu et Odziemkowska, 2017; Gatignon
et Capron, 2016; McDermott, Corredoira et Kruse, 2009) opposé à la confrontation (par exemple, Baron et Diermeier, 2007; McDonnell, King et Soule, 2015). Dans la lignée de cette recherche, les premier et troisième essais ont montré comment une organisation à but non lucratif peut faciliter la création de valeur économique entre acteurs à but lucratif. Le premier essai a également précisé les conditions dans lesquelles les organisations à but non lucratif et les entreprises sont capables de créer de la valeur, en particulier les contraintes que le besoin de capture de valeur par des acteurs à but lucratif impose aux organisations à but non lucratif.

En même temps, cela est pertinent pour la recherche sur la concurrence entreprise-organisation à but non lucratif qui est généralement limitée au domaine des biens sociaux (par exemple, Cabral et al., 2013; Chau et Huysentruyt, 2006; Kaul et Luo, 2018; Luo et Kaul, 2018). Je l’étends ici dans le contexte où la concurrence concerne soit la fourniture de valeur économique (internalisation de l’effort des entreprises par rapport au non-profit dans le premier essai), soit du bien social qui, néanmoins, se traduit directement par une valeur économique pour les entreprises (concurrence sur la fourniture de combinaisons de compléments dans le troisième essai).

**Limites**

Naturellement, cette thèse a un certain nombre de limites. Premièrement, il met l’accent sur le choix de la stratégie en tant que variable dépendante, mais pas sur les résultats de ces stratégies, ce qui m’empêche d’avoir des implications normatives. Une autre limite est l’absence d’informations sur la qualité des combinaisons - résultats des essais cliniques - dans les deuxième et troisième essais. Inclure cette information dans le deuxième essai aiderait à expliquer le rôle de la valeur médicale des médicaments par opposition aux considérations stratégiques de l’entreprise dans le choix des compléments. Dans le troisième essai, les informations sur les résultats des essais seraient importantes pour mieux comprendre les schémas de réplication des essais antérieurs: que se passera-t-il lorsque les résultats des essais seront négatifs? La réplication est-elle principalement motivée par le fait que la combinaison fonctionne bien dans un essai?

Tout en mettant l’accent sur les choix des entreprises actives dans la composante focale, la thèse ne tient pas compte de la concurrence qui en résulte entre ces entreprises qui s’intègrent
dans la composante complémentaire et les entreprises initialement actives dans la composante complémentaire. La stratégie d’exclusivité poursuivie par le propriétaire d’un produit focal plus fort inciterait-elle les producteurs d’origine de compléments à travailler avec le propriétaire du produit focal plus faible? Quelles seraient les implications pour la création de valeur et la capture de valeur par le propriétaire du produit le plus puissant?

Enfin, le contexte empirique est limité à une industrie spécifique - le marché des médicaments anti-VIH - qui peut limiter la généralisabilité à d’autres contextes. En particulier, dans ce contexte, les produits des composants focaux et complémentaires requièrent des capacités similaires, ce qui facilite relativement l’intégration des entreprises du segment focal dans les composants complémentaires. Des recherches ultérieures pourraient vérifier si les résultats sont valables au fur et à mesure que les obstacles à l’entrée dans la composante complémentaire deviennent plus importants.

**La recherche future**

En ce qui concerne les recherches futures, je compte poursuivre les travaux sur l’intégration des acteurs non marchands dans le cadre de l’écosystème. Les orientations possibles incluent la résolution de certaines des limitations que j’ai identifiées. Une façon d’avancer serait de collecter des données sur les résultats des essais cliniques, ce qui fournirait une variation quasi-exogène de la qualité des combinaisons. Cela permettrait également de répondre aux questions concernant la structure temporelle de l’innovation: les entreprises s’arrêtent-elles lorsque la combinaison des intérêts est réussie? Les produits initialement présentés comme non aboutis sont-ils ensuite essayés selon différentes combinaisons, et existe-t-il des différences à cet égard entre entreprises et organisations à but non lucratif? Ces derniers pourraient être particulièrement intéressants pour mieux comprendre comment les entreprises et les organismes à but non lucratif s’appuient sur les connaissances de chacun. Cela pourrait également indiquer comment un produit moins performant peut encore survivre dans un écosystème.

Une autre direction intéressante que je compte poursuivre consiste à examiner l’impact des stratégies des entreprises et des organisations à but non lucratif sur la performance des médica-
ments et des associations sur le marché. En utilisant l’ensemble de données sur la consommation individuelle de médicaments anti-VIH, je peux explorer la manière dont les résultats des essais cliniques se traduisent par la consommation de médicaments. Cela permettrait d’examiner l’impact des stratégies des organisations à but non lucratif sur la performance des entreprises et de déterminer si celles-ci peuvent utiliser leurs efforts sans rien céder. Il serait également particulièrement intéressant d’examiner s’il existe une hétérogénéité dans l’impact des actions à but lucratif et non lucratif.

En conclusion, cette thèse permet de faire avancer la recherche sur les écosystèmes d’entreprise en développant une meilleure compréhension des stratégies des entreprises en matière de complémentarité et en rendant compte du rôle des acteurs à but non lucratif dans la formation de ces écosystèmes. Il contribue également à la recherche sur les interactions entre entreprises et acteurs non marchands en approfondissant les recherches sur le rôle des acteurs non marchands dans la création de valeur économique.
2 Introduction

My dissertation focuses on the contexts where value creation depends on complementary products, known as business ecosystems (Adner and Kapoor, 2010; Jacobides, Cennamo, and Gawer, 2018). I am interested in strategies that for-profit and nonprofit actors adopt to maximize value creation and value capture (Brandenburger and Stuart, 2007, 1996; Chatain and Zemsky, 2011; MacDonald and Ryall, 2004) in such contexts. In particular, I explore how firms and nonprofit actors shape these ecosystems and their evolution through the design of relationships with key complements. I use formal models and empirical methods to study these questions.

My dissertation is composed of three essays. The first essay examines how a nonprofit actor, by strategically interacting with a firm, can facilitate value creation by enabling a collaboration between a firm and a supplier. The second essay studies business ecosystems where establishing compatibility among complements is costly. I look at the strategies that firms employ to shape ecosystems and maximize value capture, particularly the firm’s decision to make their product compatible with multiple complements or to keep them exclusive for a specific complement as a function of changes in that complement’s value. Finally, the third essay bridges the first two essays by exploring how nonprofit actors affect compatibility among complements in business ecosystems and hence impact the evolution of ecosystems alongside for-profit actors. In the first and the second essays I use formal models to develop testable propositions. The second and the third essays use empirical methods and are set in the context of anti-HIV treatment, which is a combination of multiple drugs produced by different firms. I use a proprietary individual-level dataset on drug consumption obtained from the national French healthcare insurance and hand-collected data on clinical trials of anti-HIV drugs.

With my dissertation I seek to contribute to the literature on ecosystems and complements, as well as the literature on non-market strategies. First, I contribute to the literature on business ecosystems by introducing the trade-offs between the need to maximize value creation by the ecosystem and the need to maximize value capture by an individual actor (Brandenburger and Nalebuff, 1997) as driving the firms’ strategies towards complements. Incorporating these trade-offs
allows me to elucidate the mechanisms that underlie firms’ decisions to be exclusively compatible with certain complements as well as the firms’ decisions to integrate into complementary components to benefit from this exclusivity. Second, I endogenize the notion of complementarity in an ecosystem by making the availability of complements for the focal product an outcome of strategies adopted by the producers of the focal product and those of complements rather than exogenously given. Third, I account for the goals and the actions of actors who do not seek to maximize profits and who may connect actors or establish compatibility among products that firms would not do on their own due to value capture concerns, which further contributes to the understanding of how complementarities emerge in an ecosystem. Finally, I enrich the dynamic perspective on ecosystems by examining the shifts in what constitutes a bottleneck in an ecosystem as a result of both the firm’s strategies towards complements as well as the actions of nonprofit actors. Furthermore, this dissertation contributes to research on firm-nonprofit interactions by studying contexts where a nonprofit actor whose goals are neither fully antagonistic, nor fully aligned with those of for-profit actors can directly contribute to the economic value creation.

Next I will provide a brief review of literature studying ecosystems and complements, and suggest how the inclusion of nonprofit actors as an integral part of an ecosystem can help advance research on value creation and value capture in these contexts. I will focus in particular on the firms’ decision to create value with suppliers or producers of complementary products, and how nonprofit actors, by having the goals that are different from those of the firm, affect these decisions.

**Business ecosystems**

Business ecosystem is defined as “the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize” (Adner, 2017), or, more simply, as “groups of firms that produce products or services that together comprise a coherent solution” (Hannah and Eisenhardt, 2018). In recent years there has been a growing interest in the concept of ecosystems, and a number of interesting questions have arisen: What contributes to value creation in an ecosystem? How is value captured by individual players? What are the strategies that firms can employ to increase value creation by the system and their share of this
Recent strategy research has sought to answer some of these questions by extending the seminal contribution of Teece (1986) on the importance of complementary assets to the contexts featuring complementary products necessary for the innovation adoption. Starting with Adner (2006), and Adner and Kapoor (2010) this research stream has put the spotlight on complements, in particular how accounting for complements can help explain industry evolution. The work in this stream explored the impact of complements availability on new technology adoption (Adner, 2006; Kapoor and Furr, 2015), substitution of an old technology by a new one (Adner and Kapoor, 2016), performance of innovators (Adner and Kapoor, 2010), and technology choices by new entrants (Kapoor and Furr, 2015). The availability of complements for the given technology affects value creation that can be achieved with it. Thus, this literature argues, through extending value creation opportunities with the old technology (Adner and Kapoor, 2016), or enabling value creation with a new technology (Adner and Kapoor, 2010), the availability of complements affects innovators’ and incumbents’ performance. This research stream focuses mainly on the first question – how value is created in an ecosystem – and suggests strategies to ensure the availability of complements, for instance, through alliances with producers of complementary products (Kapoor and Lee, 2013), or the choice of technology (Kapoor and Furr, 2015).

Besides the literature explicitly focusing on business ecosystems there are other research streams that examine the role of interdependencies among complementary products, and that can therefore bring important insights to our understanding of how value is created and captured in such contexts. Technology literature on complex systems and modular design (Baldwin and Clark, 2000), grounded in the work of Simon (1962), explores incentives to innovate in complex product systems as a function of technological interdependencies among modules (Ethiraj, 2007; Ethiraj and Posen, 2013; Mäkinen and Dedehayir, 2013). While the jargon adopted in this literature is different, complex systems are, essentially, ecosystems, where modules are complementary products (Ethiraj and Posen, 2013). This research stream also focuses predominantly on the value creating aspect of the ecosystem and less on the incentives of the individual actors to increase their value capture.
On the other hand, the industry architecture literature explores the distribution of value across industry sectors, or modules, in the parlance of the modular design literature, (Baldwin and Clark, 2000; Jacobides, Knudsen, and Augier, 2006). This literature focuses on the concept of a bottleneck which is defined as “the part of the firms’ or the industry’s system that is in most scarce supply” (Jacobides et al., 2006). In the literature on complex systems a bottleneck is viewed as a constraint on value creation by the ecosystem as it limits the performance of the entire system (Ethiraj, 2007). By contrast, in the industry architecture literature a bottleneck is viewed as both the point of value creation and value capture, and firms who find themselves in the industry sector that is a bottleneck are able to appropriate a higher share of value (Baldwin, 2015; Jacobides et al., 2006). This stream of research also extends Teece’s (1986) framework about profiting from innovation, but examines the value capture aspect and seeks to explain the ability of new entrants to profit from innovation (Jacobides et al., 2006; Jacobides, Veloso, and Wolter, 2013), change of value distribution across segments, or “value migration” (Jacobides, MacDuffie, and Tae, 2016), and sustaining the position of a bottleneck (Jacobides and MacDuffie, 2013; Jacobides and Tae, 2015).

Yet, there are three important issues that remain to be tackled in the literature on business ecosystems. First, in the extant research firms are making decisions and adopting strategies in an ecosystem based either on value creation considerations (as in the business ecosystem and technological interdependencies research streams) or on value capture considerations (as in the industry architecture research stream), but rarely on both. Given that firms may adopt strategies that will increase their individual value capture, but at the expense of the overall value creation, and vice versa (Brandenburger and Nalebuff, 1997), in my dissertation I argue that both considerations should be incorporated in the ecosystems literature as they both affect firm’s strategies towards complements. To this end I use formal models that rely on the value-based strategy framework (Brandenburger and Stuart, 2007, 1996) and allow to incorporate both value creation by the group.

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2 I exclude the research on multi-sided platforms, which also represent a specific kind of an ecosystem, because in platform literature the main driver is the direct and indirect network effects, and in my dissertation I chose to focus on the contexts where such effects are weak.
of actors and value capture by individual actors as incentives.

Second, the availability of complements is generally assumed to be exogenously given. There have been attempts to endogenize it, for instance, by looking at alliances with the complements’ producers (Kapoor and Lee, 2013; Kapoor, Rahul, 2013) or at choice of technology given complements availability (Kapoor and Furr, 2015). However the antecedents of the complements’ producers decision to make the complements available for the focal product are still little explored. The technology literature offers technological interdependencies as an explanation (Ethiraj and Posen, 2013), however it looks at the context of continuous innovation in an ecosystem and the quality of complements matching the quality of the focal product rather than the availability of complements per se. This issue gains particular importance when we consider that in many instances compatibility between the complement and the focal product can be costly (“nongeneric complementarities” in Teece, 1986). In fact, Jacobides and coauthors in their 2018 paper on the theory of ecosystems state that what distinguishes ecosystems from markets is the existence of nongeneric complementarities. Hence I argue that in order to understand the firms’ strategies in an ecosystem it is crucial to endogenize the complementarity decision.

Third, strategy research has largely adopted a static perspective of ecosystems, and we know less about the their emergence and evolution. Of particular interest is the understanding of how bottlenecks are shifted within an ecosystem (Hannah and Eisenhardt, 2018). While the industry architecture literature offers some insights on bottleneck changes across industry sectors (Jacobides, MacDuffie, and Tae, 2016; Jacobides and Tae, 2015), it adopts the industry sector (or module) as its level of analysis, not that of the individual firm. In this dissertation I argue that a bottleneck position can be attained by a single firm within an industry sector, and such firm can appropriate higher value at the expense of other firms in the same sector (in a way that the industry architecture literature is less equipped to analyze). Furthermore, ecosystem evolution may result in a different alignment of the existing actors, or the alignment of new actors, which is not the focus of the industry architecture literature (Adner, 2017). In sum, I contend that there is an opportunity to delve into how the way the value is created and split in an ecosystem changes over time, and how firms’
strategies can affect these changes.

These three issues are also interrelated. Tackling the first issue – incorporating both value creation and value capture considerations as factors in the decision-making – helps elucidate the trade-offs that firms face and, hence, address the second issue, the decision of the producers of complements to be compatible with the focal product. This, in turn, allows to understand how the actors would react to changes in an ecosystem, or how firms’ actions would lead to changes in how value is created and captured, thereby addressing the third issue.

**Business ecosystems and nonprofit actors**

So far the ecosystem literature has predominantly focused on for-profit actors as its constituents, while other actors can also play an important role. In fact, the original definition of ecosystem by James Moore is much broader, suggesting that a business ecosystem is “an economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world ... The member organisms also include suppliers, lead producers, competitors, and other stakeholders” (Moore, 1996: p.26). Therefore, while strategy research on ecosystems has generally referred to firms as the ecosystem members – “groups of firms that produce products or services that together comprise a coherent solution” (Hannah and Eisenhardt, 2018), or “a group of interacting firms that depend on each other’s activities” (Jacobides et al., 2018) – we do not have to constrain ecosystem constituents to for-profit actors only, in particular when they can directly affect how value is created and captured by the for-profit actors.

More specifically, in my dissertation I explore the role of nonprofit actors who have goals other than profit maximization and who are increasingly interacting with for-profit actors (Cabral et al., 2019; Dorobantu, Kaul, and Zelner, 2017; Mahoney, McGahan, and Pitelis, 2009). Recent research has shed light on how such actors can directly facilitate value creation by the for-profit actors (Gatignon and Capron, 2016; Li and Garnsey, 2013; McDermott, Corredoira, and Kruse, 2009). In my dissertation I argue that extending ecosystem boundaries to include nonprofit actors can provide useful insights to further our understanding of the three issues identified above.

Because nonprofit actors, by definition, do not seek to maximize profit, their inclusion can pro-
vide an additional dimension to value creation and value capture considerations that drive firm’s strategies in an ecosystem. On the one hand, nonprofit actors may seek to maximize value creation at the expense of value capture. On the other hand, because value creation in the value-based strategy parlance still represents monetary value, specifically, the difference between the customer’s willingness to pay and the supplier’s opportunity cost (Brandenburger and Stuart, 1996), nonprofits may yet seek to maximize non-transferable utility (e.g., the spread of sustainable practices, the access to medical treatment) making nonprofits’ goals orthogonal to those of for-profit actors. Because nonprofits may then seek to promote different types of complementarities among actors it is essential to consider the incentives of nonprofit actors in concert with firms’ considerations of value creation and value capture to gain a better understanding of the interactions within an ecosystem.

Consequently, accounting for nonprofit actors can help shed light on the emergence of complementarities in ecosystems, especially when being complements entails a cost for the for-profit actors. Nonprofit actors can facilitate connections among ecosystem actors (Li and Garnsey, 2013; McDermott, Corredoira, and Kruse, 2009) even when these actors would have not been a part of an ecosystem otherwise. This can happen, for instance, when value capture does not provide enough inducement for the firms to compensate for the cost of being compatible, yet nonprofit actors may derive utility from having value created by the aforementioned firms.

The latter implies that a nonprofit may contribute to the emergence of an ecosystem itself (Li and Garnsey, 2013) which otherwise would not have happened due to the lack of sufficient value capture. It also implies that nonprofits may play an important role in how ecosystems evolve as they may establish complementarity with complements other than what for-profit firms would choose and thus enable changes in what constitutes a bottleneck within an ecosystem.

To sum up, in my dissertation I seek to contribute to the research on business ecosystems by addressing three issues: bringing value creation and value capture trade-offs into the literature on ecosystems, endogenizing the decision to develop complements for the focal product, and examining the drivers of the ecosystem evolution and bottleneck shifts. Furthermore, I contend that exploring the role of nonprofit actors who may affect the connections among for-profit actors
within an ecosystem can further our understanding of these issues.

I will now briefly summarize the three essays of the dissertation. Each essay addresses one or more issues outlined above. The first essay examines how a nonprofit actor, who is interested in the supplier’s inclusion in the firm’s value chain, can facilitate value creation between a firm and a supplier. Because nonprofit’s goals are divergent, but not antagonistic, to those of the firm, the nonprofit is willing to make an effort to enable value creation when for-profit actors would not find it profitable; however, the nonprofit still has to ensure value capture by the latter. The second essay focuses on for-profit actors and how value creation and value capture considerations shape their decision to be compatible with a unique versus multiple complements. It explores the impact of the change in the focal product value creating capabilities on the compatibility decision and, ultimately, traces how these decisions can shift bottlenecks in an ecosystem. The third essay compares the choices in terms of complements made by for-profit and nonprofit actors, and how they affect value creation in the ecosystem. By enabling complementarities between hitherto unconnected products nonprofits contribute to the changes in who holds the bottleneck position in an ecosystem.

**Nonprofit actors and value creation in supply chains**

Collaborations and confrontations between nonprofit actors and business firms are a key feature of modern corporate and non-market strategy (Dorobantu, Kaul, and Zelner, 2017). The literature on private politics (e.g. Baron, 2012) and social movements (e.g., McDonnell and King, 2013) has predominantly considered the firms and the nonprofits as having opposing goals, and thus focused on the firm’s strategies to pre-empt or respond to the nonprofits’ demands. Other works have considered nonprofits as providers of social goods, but focused on their competition with for-profit actors (Kaul and Luo, 2018). However, extant research has only briefly accounted for how nonprofits can foster economic value creation, for instance by improving knowledge flows among the actors (McDermott, Corredoir, and Kruse, 2009) or improving the latter’s capabilities (Gatignon and Capron, 2016).

In the essay “NGOs and the Creation of Value in Supply Chains” I focus on the perspective of nonprofits that seek to strategically collaborate with for-profit firms and become adjuvants to
the creation of value. I model a strategic interaction between a nonprofit and a firm where the nonprofit’s goal is to increase the economic inclusion of the potential suppliers of a firm (for instance, because the nonprofit seeks to increase the consumption of certain products, e.g. organic crops, or the adoption of certain practices among suppliers, e.g. sustainable crop growing). The goals of these players are distinct but are not fully antagonistic, creating the possibility of mutual gains thanks to collaboration. I use the elements from the private politics framework (Baron and Diermeier, 2007) with model where the firm and the supplier care about value creation and value capture (Brandenburger and Stuart, 2007, 1996). The nonprofit makes a costly effort to improve the value creating capabilities of the supplier to make its inclusion in the firm’s value chain more attractive. The nonprofit selects the level of effort to exert in order to maximize its utility (which is non-transferable), yet it needs to ensure sufficient value capture for the for-profit actors for the latter to be induced to collaborate.

I show that the need to accommodate the value capture constraint of the for-profit actors results in different outcomes in terms of the nonprofit’s effort: no effort (when the level of effort required to meet the value capture constraint is too high for the nonprofit to make), the participation-inducing effort (when the nonprofit makes an effort that is above and beyond that is optimal to meet the value capture constraint), and the optimal effort (the level of effort that is optimal for the nonprofit from the cost-benefit perspective). I link these outcomes to the the potential for value creation, the nonprofit’s capabilities, and the relative bargaining power between a firm and a supplier.

Paradoxically, the participation-inducing effort is higher than the optimal level of effort, yet in the former case the firm can only make a minimal profit while in the latter case the firm enjoys positive profits. For this reason the participation-inducing effort regime is dubbed “the valley of frustration” – while the nonprofit makes a high effort the firm does not see the benefits of collaboration. This is the case when firm’s bargaining power vis-à-vis the supplier and the nonprofit’s capabilities are at the medium level. Moreover, I show that in such cases the nonprofit will be willing to accept a trade-off in order to achieve its goals: the nonprofit will prefer the firm to increase
its bargaining power \textit{vis-à-vis} the supplier to reduce the firm’s participation constraint and get the nonprofit’s effort closer to the optimum.

Furthermore, I examine the firm’s decision when it has an option of internalizing the nonprofit function (i.e., when the firm can improve the supplier’s value creating capabilities by itself). The firm then faces a trade-off between setting the level of effort that maximizes its value capture and shifting the cost of supplier’s improvement to the nonprofit. I show that when the firm has high bargaining power \textit{vis-à-vis} the supplier and supplier development capabilities comparable to those of the nonprofit the firm will choose to internalize the effort.

Finally, I show that when there is a competition among firms and nonprofits for the collaboration firms with higher bargaining power will match with nonprofits with stronger capabilities for supplier development under the optimal effort regime, enabling the nonprofits to maximize their utility and the firms to have positive profits. This will leave firms with lesser bargaining power outcompeted by the more powerful firms to be matched with nonprofits with weaker capabilities in the “valley of frustration” and enjoying only minimal profit.

This essay contributes to our understanding of the interactions between for-profit and nonprofit actors. It shows how nonprofit actors can induce a certain behavior by the for-profit actors by directly affecting value creation as opposed to tactics that are harmful to the firms such as lobbying or activists campaigns (McDonnell, King, and Soule, 2015). Furthermore, by explicitly accounting for the nonprofit goals I bring to light the trade-offs that a nonprofit actor is willing to accept to maximize its utility (for instance allowing higher value appropriation by the firm at the expense of the suppliers who would otherwise be considered as nonprofit’s natural constituents). Finally, the model suggests explanations for some empirical patterns that we can observe, highlighting the importance of accounting for the matching process among firms and nonprofits to draw conclusions about the drivers of such partnerships.

\textbf{Strategies towards complements in business ecosystems}

A burgeoning body of research has emerged in recent years to study ecosystems of complementary components that have to be assembled into a bundle to create value for the final customer
(for instance, electric vehicles, smartphones, combination therapy). The trade-off often faced by firms in such contexts is between value creation by the whole ecosystem and value capture by an individual firm. On the one hand, a body of literature has focused on the value creation aspect of ecosystems and showed that complements are crucial to value creation (e.g., Adner and Kapoor, 2010; Ethiraj, 2007; Kapoor and Furr, 2015). On the other hand, the industry architecture literature has focused on the value capture aspect and showed that the value created may be unequally distributed among ecosystem components, which comprise producers of a similar type of product (e.g., Jacobides, Knudsen, and Augier, 2006; Jacobides and MacDuffie, 2013). Specifically, firms that find themselves in the “bottleneck” component, or “the part of the firms’ or the industry’s system that is in most scarce supply” (Jacobides et al., 2006) are able to capture a disproportionate share of value (Baldwin, 2015). So far, the literature has predominantly chosen to focus on either value creation or value capture as the driver of the firms’ strategy, but has rarely dealt with the tension between these two considerations. Furthermore, we know less about how competition among producers in the focal component affects the incentives of complementors to be compatible with the focal product and the ensuing value capture of the ecosystem participants.

In the second essay “Competition in Markets with Complements: How Within-Component Firm Heterogeneity Shapes Ecosystem Strategies” I examine the firm’s decision regarding whether to make their product compatible with multiple complements or keep them exclusive for a specific complement, and how vertical and horizontal differentiation among firms’ offerings affects these decisions. I use the value-based strategy framework (Brandenburger and Stuart, 2007, 1996) to model competition between horizontally differentiated offerings of the focal product and how the producers of complements and of the focal product react to the unexpected changes in the value creating capabilities of these offerings. The model shows that there are two competing effects that shape the firm’s decision regarding compatibility with an exclusive vs. multiple focal offerings. The first one – the effect on value creation – represents the net benefit from being compatible with an extra focal offering when the producer of a complement decides to be compatible with more than one focal offering. The second one – the effect on value capture – represents an extra value
that can be captured by the bundle of a focal product and a complement (which would have otherwise been captured by the customer) when the complement’s producer chooses to be compatible with only one focal offering depriving the customer from a viable substitute bundle. When value creation effect dominates, the complement’s producer chooses to be compatible with multiple focal offerings; when value capture effect dominates – the complement’s producer chooses to be exclusive to a specific focal offering. The model maps the decisions for producers of complements only and for producers of both complements and the focal product as a function of the difference in value creating capabilities of the focal offerings.

I test the model’s predictions in the context of anti-HIV drug market. It is particularly amenable to this research because a standard treatment represents a multi-drug combination, which can be split in two components: a base component, and an add-on component. Importantly, biopharmaceutical firms generally concentrated their efforts in only one of the treatment parts making the latter the semi-independent components of the ecosystem rather than two different product lines for a single firm, and creating interdependences among the firms. The second important feature of this context is that a clinical trial is needed to ensure compatibility between complementary drugs (i.e., a doctor cannot prescribe a combination that has not been tested in a clinical trial). Given a high cost of clinical trials the implication is that compatibility is costly to achieve in this context. Furthermore, I exploit a quasi-exogenous shock to the horizontal differentiation among drugs in the base component when a nonprofit-sponsored trial found that one base drug was less effective in a certain patient population, making the other base drug compatible with a broader patient population and eventually a bottleneck for the treatment.

The essay combines two different datasets: an individual-level proprietary data on anti-HIV drug consumption and the hand-collected firm-level data on clinical trials of anti-HIV drugs. The first dataset comes from the *Echantillon Generaliste Beneficiaire* database provided by the main French healthcare insurance payer, which is a quasi-random sample of 1/97th of the French population tracking all healthcare consumption (including drug purchases) reimbursed at the individual level. This data allows me to see the evolution in the value of different drugs, and to confirm the
shifts in horizontal and vertical differentiation of the drugs. I then use these insights to study the changes in firms’ R&D strategies by looking at the drugs used in clinical trials. I extract the late-stage clinical trials on anti-HIV drugs from the online database clinicaltrials.gov provided by the US National Library of Medicine and I manually code the key features of the trial design, including the drug combinations tested. I focus on the choice of base drugs in the clinical trials on add-on drugs, specifically examining the decision to make add-on drugs compatible with a unique base drug as opposed to multiple base drugs, and how this decision changes following the shock to the base drugs’ value.

I find that as one of the base drugs emerged compatible with a broader patient population producers of the add-on complements sought to form bundles with that drug, but not with other bases. The owner of the broader base developed its own add-on drugs as compatible only with its own base; furthermore, it made them available only as integrated with its base into a single pill, but not as a standalone pill. On the one hand, integrating an add-on and a base into a single pill entails higher value creation by improving patients’ adherence to treatment, on the other hand, this strategy also indicates pursuing higher value capture: exclusive complements help reinforce the bottleneck status of the broader base while the owner of the competing base is physically precluded from seeking compatibility with those add-ons. Conversely, the owner of the base compatible with a narrower patient population developed add-on drugs as compatible with both its own base and the rival base, which I interpret as value creation effect dominating value capture effect for this actor. When this strategy appeared to fail, it worked to develop its add-on drugs in combination with other add-on drugs, thereby making the base component redundant and attempting to shift the bottleneck to the add-on component.

These findings contribute to the literature on the business ecosystems in several ways. By using a formal model I am able to bring to light the trade-offs between value creation and value capture that firms face when choosing to be compatible with specific complements. This allows to bridge the gap between the business ecosystems literature (Adner and Kapoor, 2010) and the industry architecture literature (Jacobides et al., 2006). Exploring the impact of within-component
competition that has been largely ignored by both research streams allows to further qualify their predictions in terms of strategies that firms adopt towards complements. Specifically, I show that different position in the focal product component leads to different strategic choices by the firms in terms of excluding others from the access to these complements. Examining different strategies adopted by the “winner” (integration to reinforce the bottleneck position) and the “loser” (relying on the ecosystem and shifting the bottleneck) firms sheds light on how firms try to shape an ecosystem and affect the bottleneck location, as well as contributes to the developing a dynamic perspective on ecosystems (Hannah and Eisenhardt, 2018; Kapoor and Agarwal, 2017).

**Nonprofit actors and choice of complements**

While a growing body of research has focused on ecosystems (Adner, 2017) and the importance of complements to enable value creation with the focal product (Adner and Kapoor, 2010; Kapoor and Furr, 2015), the literature has predominantly focused on the strategies that firms adopt to ensure the supply of complements (Hannah and Eisenhardt, 2018; Kapoor and Lee, 2013), but less so on the actions of nonprofit actors that can affect this outcome. On the other hand, recent studies have shown that nonprofit actors can be instrumental in facilitating value creation by market actors (Dorobantu, Kaul, and Zelner, 2017; Gatignon and Capron, 2016; McDermott, Corredoira, and Kruse, 2009).

In the essay “How Nonprofit Actors Shape Business Ecosystems: Nonprofit vs. Industry-Sponsored Clinical Trials” I build on the themes examined in the first two essays and explore the role of a nonprofit actor in establishing compatibility among complements in an ecosystem. This essay is also set in the context of anti-HIV drugs, and I use the the manually coded dataset of late-stage clinical trials on anti-HIV drugs from the second essay. Curiously, a large share of these trials is sponsored by nonprofit actors, and these trials are similar in scope and size to those sponsored by the firms. At the same time we know that nonprofits pursue goals different from the profit maximization: in the anti-HIV context nonprofits may seek to increase the access to the anti-HIV treatment, reduce the treatment cost and find the combinations offering the optimal efficacy-safety profile for the patients. This begs the question of whether nonprofits choose to es-
Establish the same kinds of compatibility among complements as the for-profit actors. Therefore, in this exploratory essay I compare firm-sponsored and nonprofit-sponsored clinical trials in terms of types and characteristics of the drug combinations tested, as well as the use of prior knowledge by the actor type.

I conduct the analysis at the level of trial-combination, and I use the comparison of means on a range of trial, combination and combination’s components characteristics. I find that there is a significant heterogeneity between firm-sponsored and nonprofit-sponsored trials, as well as heterogeneity across trial types. Specifically, I find that trials on standard multi-drug combinations and trial on combinations non-conforming to the existing ecosystem architecture (e.g., combinations featuring only one ecosystem component) exhibit very different patterns in terms of firm-nonprofit roles.

Regarding standard combinations, I find a subtle division of labor between firms and nonprofits. Firms generally take the lead and test combinations with newer drugs for developed countries whereas nonprofits appear to “fill the voids” left by the for-profit actors. First, nonprofits tend to test older drugs in developing countries to improve the access to treatment for the patients in resource-constrained contexts. Second, in developed countries, nonprofits conduct trials that compare and contrast multiple combinations to confirm the efficacy and safety of newer drugs as well as establish compatibility of newer drugs with a wider range of complements. Nonprofit trials may result in producing full or partial substitutes for the firm-tested combinations, especially when it comes to the trials in developed countries. In addition, standard trials exhibit a clear time pattern: firms are the first to test the new drugs, but are far less active once the drug is approved which is when nonprofits “enter the game”. Importantly, both firms and nonprofits tend to leverage prior experience of the same actor type, and firms are particularly rare to replicate combinations from nonprofit trials.

For trials testing non-standard combinations, I find an opposite pattern. There are few differences in trial’s characteristics between firm-sponsored and nonprofit-sponsored trials. Importantly, nonprofits are more active compared to firms in conducting such trials, and, in contrast to standard
trials, firms often follow the nonprofits’ lead by, for instance, replicating the combinations previously tested by nonprofits. In particular, nonprofits have been highly active in testing combinations that eschew base component of the anti-HIV treatment as it was aligned with their objective of lowering treatment cost and achieving a better safety profile for patients. Firms, on the other hand, have been less involved in such trials, but in the recent years the firm with a weaker drug in the base component has also started to pursue non-standard combinations. Because such combinations are a major challenge to the bottleneck position of successful base drugs, these results demonstrate that nonprofit actors may enable and support the changes in the bottlenecks within ecosystem.

This essay is conceived as exploratory, and it allows to gain a number of insights on the role of a nonprofit actor in an ecosystem. In particular, it shows that, consistent with the differences in the actors’ incentives, nonprofits will often step in and fill the voids left by the firms thereby facilitating linkages among complements hitherto unconnected or revising value-creating capabilities of complements promoted by firms. Furthermore, the findings suggest that while firms are more incentivized to act within the existing ecosystem architecture and sustain its bottlenecks, nonprofit actors are more willing to challenge the them and in doing so may foster bottleneck shifts (Jacobianides, MacDuffie and Tae, 2016). Finally, the essay contributes to the literature on firm-nonprofit interaction by exploring the competition between nonprofits and firms over the provision of a non-rival and non-excludable good (Kaul and Luo, 2018) (where the good is a drug combination), which, however, can have direct benefits for the firm.

Table 2 provides the summary of the dissertation, including the main research question, the methods, the main findings and the key contribution of each essay.
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<td>How does a change in the value of the focal product affect the firms’ decision to make the complement compatible with multiple vs. just one product?</td>
<td>What is the role of nonprofit actors in establishing compatibility among complements in an ecosystem?</td>
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<td><strong>Method</strong></td>
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<td><strong>Main findings</strong></td>
<td>- The need to accommodate for-profit actors’ constraints leads to different outcomes of firm-nonprofit partnerships, including a “valley of frustration” where despite a high effort by the nonprofit the firm sees only minimal returns. - Firms with higher bargaining power vis-à-vis suppliers may prefer to internalize nonprofit functions. - Firms with higher bargaining power will match with nonprofits with stronger capabilities leaving less powerful firms and less capable nonprofits in the “valley of frustration”.</td>
<td>- Differences between firms and nonprofits depend on whether trials sustain or challenge existing ecosystem bottlenecks. - In trials that sustain firms take the lead, and there is division of labor: firms focus on newer drugs for developed countries while nonprofits test older drugs to maximize treatment access for developing countries or compare combinations to find the optimal treatment. - In trials that challenge (by eschewing the bottleneck component) nonprofits take the lead and firms follow suit.</td>
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<td><strong>Contributions</strong></td>
<td>- Show how a nonprofit can induce for-profit actors behavior by directly affecting economic value creation as opposed to antagonistic tactics. - Elucidate trade-offs that nonprofit is willing to make to achieve its goals. - Suggest explanations for empirical patterns (endogeneity, matching process).</td>
<td>- Conceptualize nonprofit actors as an integral part of the ecosystem. - Explore how nonprofit actors affect the emergence of complementarities and the evolution of an ecosystem. - Study the context where firms and nonprofits compete over the provision of social goods that, however, translate directly into economic value for the firms.</td>
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3 Essay 1: NGOs and the Creation of Value in Supply Chains

Abstract

Firms and NGOs often collaborate to establish new supply chains. With a formal model, we analyze how NGOs can alleviate market failures and improve supplier economic inclusion while strategically interacting with firms. We account for the specific goals of the NGO and the need to induce collaboration between firms and their suppliers. The analysis reveals a “valley of frustration”, when NGO efforts benefit all actors but only marginally the firm. We also show that more powerful firms might prefer to internalize NGO functions, while firms with lower bargaining power and higher investment requirements are better off collaborating with NGOs. Finally, we study NGOs-firms matching patterns and find that firms with higher bargaining power match with NGOs holding stronger capabilities.

Keywords: NGO; Non-Governmental Organizations; Nonprofit; Firm-NGO collaboration; Value creation

3.1 Introduction

Interactions between firms and nonprofit actors are a prominent feature of the modern economy. In particular, non-market corporate strategy often deals with managing relationships with nonprofit actors. A famous example is the collaboration between Starbucks and the nonprofit Conservation International in 1998, where Conservation International trained farmers in the Mexican region of Chiapas to produce sustainable shade-grown coffee, which was bought by Starbucks (Austin and Reavis, 2002). More recently, in 2007, Unilever partnered with the nonprofit Rainforest Alliance to make their Lipton tea brand fully sustainable, which involved developing the skills of local suppliers so that they could meet Unilever’s standards (Henderson and Nellemann, 2011). In another example, in Mozambique, SABMiller—the world’s second largest brewer—launched a beer based on locally sourced cassava root with the help of the nonprofit IFDC which provided support and assistance to local farmers regarding agricultural practices (Parmigiani and Rivera-Santos, 2015).

In all these cases, a nonprofit, or non-governmental, organization (NGO) collaborated with a firm to help suppliers change their practices, resulting in increased economic inclusion for the suppliers and a more valuable final product for the firm and its customers. These collaborations be-

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3 This essay was developed in collaboration with Olivier Chatain
4 This essay was developed in collaboration with Olivier Chatain
tween NGOs and firms are leading examples of situations where economic value creation through commercial activities, and the resulting changes in supply chains, are influenced by NGO activities undertaken in concert with for-profit actors. In spite of the importance of this phenomenon, a clear articulation of how value creation by firms and their suppliers is influenced by NGO activities is still lacking. Extant research has made great strides studying how NGOs foster economic value creation (McDermott, Corredoira, and Kruse, 2009) and how NGOs and firms interact strategically (Baron and Diermeier, 2007), but there is little analytical work combining both viewpoints and examining how value creation by firms and their suppliers can be facilitated by NGOs pursuing their goals.

In this paper we examine the interactions between firms and NGOs (non-governmental organizations) forming partnerships to include new suppliers in a supply chain. These partnerships bring together a profit-seeking firm that wants to source a differentiated input and an NGO who is interested in facilitating the access of hitherto isolated supplier to a commercial supply chain. The NGO’s goal can be directly related to helping as many suppliers as possible or, indirectly, to ensure a change of practices (e.g., environmentally related) within the population of suppliers. We show how interactions between these actors influence economic value creation as firm and supplier interests both enable and constrain NGO activities, giving rise to important tradeoffs. We draw strategic implications for firms seeking to enter such partnerships.

Our paper makes three main contributions to our understanding of strategic interactions between firms and NGOs. First, we elucidate the tradeoffs an NGO makes to ensure the firm captures enough value while fulfilling its mission. We characterize the conditions under which the NGO decides to create enough inducement to make the firm include new suppliers into its supply chain. However, we also show that for a range of parameters (the “valley of frustration”), the firm enjoys only a minimal additional value capture, creating the paradox of a large change of supply chain structure for little tangible improvement in the bottom line. Our analysis suggests that such “valley of frustration” is not a bug, but a feature of collaboration with NGOs which firms need to fully account for.
Second, we characterize a firm’s choice between collaborating with an NGO and integrating the supplier improvement functions of the NGO. We show that even though collaborating with an NGO can be an attractive proposition outside of the “valley of frustration” as the firm effectively shifts the costs of supplier development to the NGO, a firm may nevertheless prefer to integrate activities that the NGO is undertaking to better align incentives. This happens when the firm captures a large part of the value created and has supplier development capabilities comparable to those of the NGO.

Third, we study the outcome of competition between firms and NGOs to find the best partner. We investigate the stable competitive matchings between firms and NGOs given their characteristics and preferences in our model. We show that competition to form the better matches gives rise to a positive correlation between firm’s bargaining power and NGO’s efficiency among matched pairs of firms and NGOs which are themselves split into two separate clusters. Moreover, these correlations are negative within clusters, suggesting that empiricists should be very careful about interpreting observed correlations between the characteristics of firms and NGOs who are collaborating.

These results contribute to our understanding of the tensions between value capture and value creation in partnerships between for-profit firms and nonprofit actors. For-profit entities such as firms invest in value creation capabilities only if they expect enough value capture. Nonprofit entities (e.g., NGOs) can in turn frame for-profit behavior by influencing value creation and capture possibilities. Furthermore, this paper deepens our understanding of the interdependence of private organizations (firms and NGOs), which have different objectives (for-profit vs. nonprofit) but nevertheless work together to create economic and social value (Mahoney, McGahan and Pitelis, 2009).

We use methods from game theory and value-based strategies (Brandenburger and Stuart, 1996, 2007) to study this tension, distinguishing between economic value that is transferrable among for-profit actors and non-transferrable value that is subjective to nonprofit actors. Thanks to this, we can formally and rigorously analyze interactions among stakeholders who care for different types
of value (economic vs. social). By doing so, we provide analytically tractable answer to recent verbal contributions that highlight how value is differently appreciated and created by stakeholders (Bridoux and Stoelhorst, 2014; Garcia-Castro and Aguilera, 2015; Tantalo and Priem, 2016).

3.2 Theoretical background and positioning

Nonprofit sector literature and firm-NGO collaborations This research comes against the backdrop of a significant literature that has followed and studied the emergence of institutions belonging to the nonprofit sector. This sector comprises formal, independent organizations that are distinct from the government, do not distribute profits, rely on voluntary participation (Salamon and Anheier, 1992) and fulfill a public or community-related purpose (Salamon and Sokolowski, 2016). In this paper, we will call NGOs any organization that fulfills these criteria.

A large part of that literature has studied how and when nonprofit organizations establish collaborations with for-profit organizations. In particular, Austin (2000a, 2000b) argues that the collaborations can be located on a continuum from “Philanthropic” to “Integrative” with an intermediary “Transactional” stage. The philanthropic stage is one of low engagement and interactions between partners, with a relationship effectively confined to a limited transfer of monetary resources in return for reputational benefits. At the other end of the spectrum, the integrative stage is one of full alignment of goals, broad scope, and major strategic value (Austin, 2000a).

Our study is better understood as set in the intermediary “Transactional” stage. There, the relationship between the firm and the NGO is complex enough in that it involves frequent interactions and coordination, bilateral exchange of resources and services, and is of significant strategic value to the firm. Even if monetary transfers are involved, they only occur to support more coordinated activities. However, the firm’s goals are still not aligned with the mission of the NGO, and the organizations remain separate, making the collaboration fall short of being “Integrative”. “Cross-sector” partnerships of this type, between nonprofit and business, are typically considered to be integral part of firms’ CSR strategy (Seitanidi and Crane, 2009).
Cross-sector partnerships in the management literature These partnerships have also been studied by the management literature (Selsky and Parker, 2005; Wassmer, Paquin and Sharma, 2014). They can involve complex relationships that create new supply chains bringing actors that were previously excluded from the market (e.g., consumers at the “base of the pyramid” in Parmagiani and Rivera Santos (2015), and Perez-Aleman and Sandilands (2008)). They can also enable the development of new capabilities (McDermott, Corredoira and Kruse, 2009; Gatigon and Capron, 2016) and business models (Dahan, Doh, Oetzel and Yaziji, 2010) that are crucial for value creation. Our paper relates to these works by focusing on how an NGO works to facilitate supplier access to a supply chain by improving the suppliers’ capabilities and by explicitly incorporating value creation and value capture concerns in the decision making of the agents.

Our paper thus contributes to recent frameworks guiding the organization of these partnerships stemming from the nonprofit literature (e.g., Austin and Seitanidi, 2012; Al-Tabaa, Leach and March, 2014) and the management literature (e.g. Berger, Cunningham and Drumwright, 2004; Rondinelli and London, 2003; King, 2007; Rivera-Santos, Rufin and Wassmer, 2017).

Some important contributions (Rangan, Samii, and Van Vassenhove, 2006; Boddewyn and Doh, 2011) have studied the entire gamut of make-buy-ally arrangements between firms and NGOs for the provision of social goods, while others have studied each organizational form’s comparative advantage in this respect (Kaul and Luo, 2015). Even though our paper speaks narrowly to the make vs. ally decision, a key difference is our focus on enabling economic value creation in a commercial supply chain rather than the special case of the provision of social goods.

Public-private partnerships and the economics of regulation A different stream of literature in management studies has also looked at public-private partnerships. Such studies typically seek to understand how governments structure partnerships with private firms in order to achieve their goals by tapping into private sector capabilities (Kivleniece and Quelin, 2012; Quelin, Kivleniece, and Lazzarini, 2017) and developing their own contract management capabilities (Brown and Potoski, 2003; Cabral, Lazzarini and de Azevedo, 2013). More generally they draw on classic works...
in the economics of regulation of businesses by governmental agencies (e.g., Laffont and Tirole, 1993).

While we do not include government in the scope of our study, we nevertheless draw from the assumptions and logic of these works. Specifically, we see NGOs as strategic actors (like governments) who understand that they have to provide sufficient incentives to get profit-seeking firms to behave in a way that is compatible with their objectives. Specifically, private firms need to be made better off by participating and their participation constraint satisfied.

However, there is a significant difference. In the classic economics of regulation (Laffont and Tirole, 1993), government seeks to maximize welfare, giving equal weight to firm profits and consumer surplus. In our model, the objective function of the NGO does not easily map into that of a regulator. For one thing, the NGO gives no weight to firm profit beyond making sure the firm is incentivized to collaborate. For another, the NGO does not maximize the value capture of suppliers. Instead, it wants to maximize the probability that a supplier is given access to the supply chain.

**Private politics and stakeholder management**  Our paper relates directly to the political economy approach to relationships between NGOs and firms (Baron and Diermeier, 2007; Baron 2012) in its use of game theory to model NGO behavior. The biggest difference is that we posit that the NGO can help the firm do business and as a result help the NGO’s constituency (e.g., suppliers), rather than seeking to alter the firm’s behavior thanks to the use of carrots and sticks such as activist campaigns. While methods are different, the same remark applies to the sociological work studying activist campaigns against firms (e.g., McDonnell and King, 2013; McDonnell, King, and Soule, 2015). Our paper seeks to explore the collaboration side of NGO and firms partnerships, and does this by bringing into the model the economic value that the firm could be creating thanks to the efforts of the NGO, even though firm and NGO goals are not fully aligned.

Beyond the particular case of firm-NGO relationships, this paper is also an example of stakeholder management that blurs the boundary between market- and non-market strategy (Dorobantu,
Kaul and Zelner, 2017). In our model, the NGO is engaged in arm’s-length relationships with the firm that leverage the firm’s bargaining power (Bridoux and Stoelhorst, 2014) while the firm reaps the benefits from its engagement with the NGO (Henisz, Dorobantu and Narrey, 2014; Dorobantu and Odziemkowska, 2017) by capturing value in the market place. Firm-NGO ties thus enable capture of value in the product market, in a way reminiscent of the economic role played by other types of embeddedness (e.g., Rangan and Sengul, 2009).

Methods and roadmap  Our paper seeks to bring together in a unified model NGOs, firms, suppliers and the economic value created among these. We build on the strategic and game-theoretical approach that has focused on competition and conflict between NGOs and firms (e.g., Baron and Diermeier, 2007). We apply elements of that framework to the question of the collaboration between these actors and embed it in a supply chain where firms and their suppliers care about value creation and value capture (Brandenburger and Stuart, 1996). By doing so we can focus on the perspective of an NGO seeking to strategically collaborate with for-profit firms and facilitate the creation of economic value. We can also neatly distinguish between economic value that matters to for-profit stakeholders, and subjective (non-transferrable) value that matters to nonprofit stakeholders.

We model a strategic interaction between an NGO and a firm where the NGO’s goal is to increase the economic inclusion of agents that are potential suppliers of a firm. The goals of the NGO, of the suppliers, and of the firm diverge but are not fully antagonistic, creating the possibility of collaboration. At the same time, the environment for the collaboration is fully dependent on the creation of economic value in a vertical chain, which means that contributing to economic value creation is a necessary ingredient to the NGO’s ability to meet its ultimate goals. Using this game theoretical model, we bring to light the mechanisms relating the NGO’s behavior to the fundamentals of value creation in a vertical chain, including potential in value creation, the NGO’s capability and relative bargaining power among firms and suppliers.5 We investigate the tradeoffs NGOs are willing to accept or to impose in order to achieve their goals under the constraints of

5In appendix A.8 we offer a table contrasting our paper with related literatures.
the participation of the other economic actors. In particular, we can answer the following questions: What are the market characteristics that are conducive to collaborations between firms and nonprofit organizations? What is the strategy adopted by a nonprofit in such cases? When does the firm benefit from integrating NGO’s activities vs. partnering with the NGO? Which pairings of firms and nonprofits should we expect to observe given their characteristics and the characteristics of the market exchange environment in which they are embedded? Which empirical patterns should we expect to observe?

Section 3.3 describes and analyzes the base model. Section 3.4 extends the base model and provides the firm with the option to internalize the activities of the NGO. Section 3.5 analyzes the preferences of firms and NGOs over their partner’s characteristics. Section 3.6 draws the implications for the expected matching patterns. In section 3.7, we summarize several extensions and generalize some key results. All proofs and supplementary analyses are in the online appendices.

3.3 Model

To facilitate exposition we describe the model in two steps. In the first step, our goal is to establish sound foundations rather than immediately show new results. We do this with a model without NGO where value is created between a firm, and suppliers whose value creation abilities are uncertain. Both sides need to invest before knowing the actual value that can be created, resulting in a situation in which neither side can fully capture the returns from their investment, producing a classic result of underinvestment compared to the first best outcome (i.e., the outcome that maximizes welfare). In the second step (section 3.3.4), we build on these premises and include in the model an NGO that is able to increase the opportunities for value creation between the firm and the supplier.

3.3.1 Model setup without an NGO

We start with a model comprising only two players: a firm, and a supplier that we denote as $F$, and $S$ respectively. All players are risk-neutral. The firm and the supplier can each make an investment, $I_F$ and $I_S$ respectively. If both invest they can together make one unit of a product
creating value $v$ downstream. Buyers are assumed to be identical and numerous. Investments $I_F$ and $I_S$ are sunk and worthless outside of the relationship. $I_F$ represents the specialized investment made by the firm to transform, distribute and market the product for which it needs the supplier’s input. $I_S$ represents the specialized investment made by the supplier in order to produce an input that is valuable to the firm. We assume a one-off interaction. The game can thus be thought of as unfolding over a period of time corresponding to a seasonal crop season, without repetition.

**Contractibility and informational assumptions** In our model, unless otherwise mentioned, investments by the firm and the suppliers and effort by the NGO are not contractible.\(^6\) Moreover, as will be further explained below, the quality of the input that will be produced by the supplier is unknown before investments are sunk, including by the supplier, either because of true uncertainty about this quality or because the exact type of the supplier is unknown. However, the probability distribution of the quality (or, equivalently, of the types) is common knowledge.

**Quality of differentiated supplier’s input is unknown ex-ante** If both investments are made, the quality of the supplier’s input remains uncertain, and the value created $v$ is a draw from a uniform probability distribution $\mathcal{U}(0, \bar{V})$, where $\bar{V}$ is the maximum value that can potentially be created with the supplier, and zero the minimum value creation. The value creation $v$ is the difference between the buyer’s willingness to pay in the downstream market and the opportunity cost for the supplier.

The probability distribution over $v$ can be interpreted as the result of uncertainty about the quality that is unknown to both players *ex ante*. For instance, weather conditions may impact the quality of crops: a recent example is Nestle’s struggle with the supply of premium robusta coffee after heavy rains impeded the production of Vietnamese suppliers resulting in the impaired quality of the beans (Reuters, 2017). Similarly, suppliers may be unsuccessful in their efforts to meet quality standards developed by the firm because of a lack of knowledge. For example, Sue

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\(^6\)For expositional convenience, we will later assume that the investment of the supplier is contractible (but not the quality outcome) so that the burden of the investments can be entirely transferred to the firm.
Mecklenburg, former Director for Environment and Community Affairs at Starbucks, commenting on the collaboration with coffee farmers, said: “Many producers of coffee [...] never taste their coffee. They don’t roast it. They don’t drink it. And even if they were to taste it, they don’t have any idea what we’d be looking for on this end. So they lack information about what the market’s expecting.” (Austin and Reavis, 2002: 11). In this case, the NGO’s role is to provide the relevant information to the suppliers. Otherwise, uncertainty about $v$ is compatible with some information asymmetry: the firm does not know the quality of the supplier, but only the distribution of quality in the population, and the supplier is unable to credibly convey its own type to the firm.

Alternatively, the model can be interpreted as representing a firm facing a unitary mass of small suppliers (see, e.g., Chatain and Zemsky, 2011) whose types are uniformly distributed. Due to information incompleteness, the firm does not know the type of each supplier and the suppliers cannot convey (or do not known themselves) their type, which is only revealed after investment. Then, the uncertainty is about the type of the suppliers. In both cases, firms and suppliers may be reluctant to invest in the collaboration ex ante because the uncertainty about the quality diminishes the expected return from the investment.

**Value created with undifferentiated input is constant and known ex-ante** Instead of procuring the input from the supplier, the firm also has the outside option to create value without the supplier $S$. This may be the value created by the firm on its own, or with alternative suppliers of known reliability (who are in excess supply). For instance, a supermarket that is willing to re-sell organic fruits can have an outside option of working with industrial suppliers and selling non-organic fruits. This outside option creates an amount of value normalized to 1.

We make the simplifying assumption that the value of the outside option (i.e., the value created and the structure of the market for undifferentiated good) is not directly or indirectly affected by what is happening in the differentiated segment. We also assume that this value is certain. This permits us to focus on the mechanisms operating around the action of the NGO in holding downstream market competition constant. Both assumptions could be relaxed in future work seeking to
explore the full interactions between upstream and downstream competitive actions as in Chatain (2014).

The supplier has no outside option apart from its collaboration with the firm (or, alternatively, has an outside option whose value is normalized to zero). We set $\bar{V} > 1$, i.e., the potential maximum value creation with the supplier $S$ is higher than the firm’s outside option (otherwise the firm would never invest in the collaboration with the supplier).

When $v > 1$, we can interpret it either as a product which commands a higher willingness to pay from the consumers in the downstream market, than the firm’s outside option, or as a product which has lower cost than the firm’s outside option, or both. We should also note that both the willingness-to-pay and the cost may be higher than the firm’s outside option, but as long as the increase in the willingness to pay is higher than the increase in the cost the product will create a higher value than the firm’s outside option. Organic fruits are a good illustration: the cost is higher than that of industrial fruits (e.g. due to the use of natural fertilizers, the need to restore vegetation, efforts to prevent soil erosion, etc.), but the willingness-to-pay is also higher, as the consumers perceive organic fruits to be of a higher quality.

Stages of the game  
Summarizing the above, the game thus unfolds in three stages:

**Stage 1.** The firm $F$ and the supplier $S$ simultaneously decide whether to invest $I_F$ and $I_S$ respectively in order to create a product.

**Stage 2.** Nature draws the quality of the input produced by the supplier $S$ as a random draw $v$ from a uniform distribution $\mathcal{U}(0, \bar{V})$, $\bar{V} > 1$. The value of the draw is revealed to the players. If both the supplier $S$ and the firm $F$ have invested in stage 1, the supplier and the firm have the option to produce a product creating a value of $v$ for the buyers in the downstream market. If only one or none of them has invested, this option is not available.

**Stage 3.** The firm, the suppliers of differentiated and undifferentiated inputs and the buyers in the downstream market create and capture value in a free-form competitive interaction.

To solve the model, we use backward induction, starting from the last stage and rolling back
to the first one. In stage 3, we follow Brandenburger and Stuart’s (2007) biform formalism to calculate the payoffs as the outcome of a coalitional (i.e., cooperative) game representing a free-form competitive interaction. In this cooperative game, the value creation of the grand coalition is the maximum value creation that can be achieved by the players. Because the value creation from the collaboration between the firm and the supplier \( v \) is a random draw, the value creation of the game will depend on whether \( v \) is higher or lower than the firm’s outside option of 1. If \( v \geq 1 \), the value is maximized by the firm obtaining the input from the supplier and producing a superior product. If \( v < 1 \), the value is maximized by the firm not collaborating with the supplier and using its outside option to create a value of 1. Consequently, we can express the overall value creation with both the firm and the supplier as \( \max(1, v) \). With only the supplier, nothing (a value of 0) is created, while with only the firm, a value of 1 is created using the outside option.

These value creation possibilities can be compactly rewritten in the formalism of cooperative games with the characteristic function \( w(P) \) mapping a set of players \( P \) into the value they can create. The value created by the firm \( F \) and the supplier \( S \) is thus \( w(F, S) = \max(1, v) \). The value created by the firm on its own is \( w(F) = 1 \), and the value created by the supplier on its own is \( w(S) = 0 \). Let \( x_F \) be the value captured by the firm and \( x_S \) the value captured by the supplier. The core implies the following bounds on value capture: \( x_F \in [1, \max(1, v)] \) and \( x_S \in [0, \max(1, v) - 1] \).

As can be seen, the firm can guarantee a value capture of 1 for itself, as this is its outside option while the additional value that the firm and supplier can create together \((\max(1, v) - 1)\) is shared between the two players. We follow the biform games approach (Brandenburger and Stuart, 2007) and use the confidence index \( \alpha \) to obtain a point estimate of the value capture. The confidence index of the firm is denoted \( \alpha_F \) and the confidence index of the supplier is set at \( \alpha_S = 1 - \alpha_F \) so we can interpret these confidence indices as bargaining power indices (Chatain and Zemsky, 2007). Specifically, \( \alpha_F \) represents the share of the negotiable surplus that the firm will capture, while \( 1 - \alpha_F \) will be the share captured by the supplier. The negotiable surplus being here the added value of the supplier \((AV_S = \max(1, v) - 1 = \max(0, v - 1))\), the value capture by each
player in stage 3 of the game is calculated as follows:

\[ x_F = 1 + \alpha_F AV_S = 1 + \alpha_F (\max(0, v - 1)), \text{ and } x_S = (1 - \alpha_F) AV_S = (1 - \alpha_F)(\max(0, v - 1)). \]

Given the uniform distribution of \( v \), its range \([0, \bar{V}]\) and its density \( \frac{1}{\bar{V}} \), we can calculate the expected value of \( AV_S \) as:

\[ E(AV_S) = E(\max(v - 1, 0)) = \int_0^1 \frac{1}{\bar{V}} \times 0 \, dx + \int_1^\bar{V} \frac{1}{\bar{V}} (x - 1) \, dx = \frac{(\bar{V} - 1)^2}{2\bar{V}}. \]

We can now calculate the expected profits \( \pi_{F,\text{No NGO}} \) and \( \pi_{S,\text{No NGO}} \) in stage 3 under the assumption that both sides invest:

\[ \pi_{F,\text{No NGO}} = 1 + \alpha_F \frac{(\bar{V} - 1)^2}{2\bar{V}} - I_F, \text{ and } \pi_{S,\text{No NGO}} = (1 - \alpha_F) \frac{(\bar{V} - 1)^2}{2\bar{V}} - I_S. \]

### 3.3.2 Value creation in the absence of the NGO

We first find the range of parameters in which collaboration between the firm and the supplier occurs without the NGO. Assuming the supplier invests, the firm also invests in the collaboration with the supplier if its expected payoff in that case is no less than its payoff without investment (i.e., 1):

\[ \pi_{F,\text{No NGO}} = 1 + \alpha_F \frac{(\bar{V} - 1)^2}{2\bar{V}} - I_F \geq 1, \text{ or } \alpha_F \frac{(\bar{V} - 1)^2}{2\bar{V}} - I_F \geq 0. \]

Similarly, assuming that the firm invests, the supplier also invests if its payoff is non-negative:

\[ \pi_{S,\text{No NGO}} = (1 - \alpha_F) \frac{(\bar{V} - 1)^2}{2\bar{V}} - I_S \geq 0. \]

Deciding independently, both the firm and the supplier invest if and only if when they both expect non-negative profits (given the alternatives) under the assumption that they both invest. This is the case when the expected value of the supplier’s added value is high enough to cover
these investments, i.e., when $E(AS) \geq IF/\alpha_F$ and $E(AS) \geq IS/(1 - \alpha_F)$. Figure 19 in the appendix represents the boundary between the set of parameters for which no investment is mutually profitable (below the shaded surface) and the set for which it is (above the shaded surface) depending on the firm’s bargaining power $\alpha_F$, the levels of investment $IF$ and $IS$, and the expected added value of the supplier $E(AS)$. When the firm’s and the supplier’s bargaining positions are similar (i.e., at moderate levels of the firm’s $\alpha_F$) the constraint on the player’s participation is less stringent: the collaboration can happen when the expected value creation is quite low. When there is a strong imbalance between the firm’s and the supplier’s value appropriation abilities, which occurs at the extremes of $\alpha_F$, collaboration can only happen if the expected value creation is very high and allows sufficient value capture for the weaker actor. As the investment requirements increase, the area of collaboration becomes even more constrained, requiring even higher expected value creation and less extreme values for the firm’s bargaining power.

3.3.3 Market failure in the absence of the NGO

In order to understand whether the lack of collaboration between the firm and the supplier will lead to a market failure we now compare the investment area in the baseline case with the area in which the investment is socially beneficial.

In order to understand whether the lack of collaboration between the firm and the supplier will lead to a market failure we now compare the investment area in the baseline case with the area in which the investment is socially beneficial. We define social welfare as the total economic value created, net of the cost of investment, without accounting for distributional and aggregation issues among economic agents (i.e., the firm, suppliers, and customers, although customers capture no value by assumption in our specific model). This is narrower than the notion of public interest (Mahoney, McGahan and Pitelis, 2009) which accounts for the complexity of aggregating possibly contradictory private interests, encompassing economic but also political issues.

Formally, the investment is socially beneficial when $1 + E(AS) - IF - IS \geq 1$, where 1 is the value created and captured by the firm in the absence of collaboration. As a result, collaboration creates social welfare if $E(AS) \geq IF + IS$. This is represented by the area above the horizontal
line $I_F + I_S$ on Figure 1. From prior section, we also know that collaboration happens when $E(AVS) \geq \max\left(\frac{I_F}{\alpha_F}, \frac{I_S}{1-\alpha_F}\right)$. On Figure 1 this area is delineated by the curves representing the firm’s $(I_F/\alpha_F)$ and the supplier’s $(I_S/(1-\alpha_F))$ thresholds for investment.

If the expected value creation is too low to justify the investment (case when $E(AVS) < I_F + I_S$), the absence of the collaboration will not constitute a market failure. In contrast, if the expected value creation is between the two thresholds (i.e. when $I_F + I_S \leq E(AVS) < \max\left(\frac{I_F}{\alpha_F}, \frac{I_S}{1-\alpha_F}\right)$) or, in other words, is high enough to justify the investment for the society as a whole, but does not allow sufficient value capture for individual actors, the failure to collaborate will lead to the loss of social welfare (the shaded area between the curves and the $I_F + I_S$ line).

3.3.4 Model with NGO intervention

We have seen that different fundamentals about the potential for value creation can be a hurdle to the creation of relationships between a firm and its supplier, motivating the need to solicit help from NGOs to facilitate the creation of value. For instance, Dennis Macray, Starbucks’ business practices manager at the time, remarked on the shade-grown coffee project: “Starbucks does not
generally deal directly with individual farmers. We could not do this without [Conservation International].” (Austin and Reavis, 2002: 11). However, these NGOs also have their own agendas, the pursuit of which will be reflected in their collaboration decisions.

To explore this tension, we introduce into our model a third actor—the NGO—that does not directly participate in the production of the good but that has an interest in making that transaction happen. Specifically, we consider an NGO that seeks to increase the supplier’s chances of successfully entering the commercial supply chain and selling a differentiated input to the firm, and that can improve the supplier’s quality to achieve that end.\(^7\) The reason for this could be that the NGO is primarily interested in increasing the consumption of a product it especially cares about (e.g. organic fruits, shade-grown coffee, ecological textile, etc.). The NGO may also be interested in maximizing the adoption of a certain production process by suppliers because it wants to reduce certain environmental externalities. This closely resembles the mission statements of, for instance, environmentalist NGOs. Take the Rainforest Alliance whose mission is “to conserve biodiversity and ensure sustainable livelihoods by transforming land-use practices, business practices, and consumer behavior.”\(^8\) Similarly, the Forest Stewardship Council aims “to promote environmentally sound, socially beneficial and economically prosperous management of the world’s forests,”\(^9\) while UTZ Certified aims “to create a world where sustainable farming is the norm.”\(^10\) We thus posit that the NGO’s goal and the supplier’s objective function are distinct—the NGO is not acting just on behalf of the suppliers.

We introduce an initial stage into the game (stage 0) where the NGO can exert an effort \(e \geq 0\) to improve the supplier’s quality by \(e\) and shift the entire distribution of the supplier’s quality from \(U(0, \bar{V})\) to \(U(e, \bar{V} + e)\). This shift makes the new distribution preferable without changing its density, which remains \(1/\bar{V}\). Thanks to this, the NGO’s effort has an identical effect on the final outcome \((e)\) regardless of the initial draw. Because the expected quality of the supplier’s input

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\(^7\) In value-based parlance (Ryall and MacDonald, 2018), the NGO is extending the maximum value capture of all participants, while keeping their minimum value capture constant

\(^8\) http://www.rainforest-alliance.org/about (accessed 12 February, 2017)


is now higher, it is more likely that the value creation by the firm and the supplier will be above the firm’s outside option of 1, and, consequently, that the firm and the supplier will invest in the collaboration. We impose $0 \leq e < 1$ in order to preserve the uncertainty about the supplier’s quality compared to the firm’s outside option of 1.

We model the NGO’s utility as $U_{NGO} = z(e) - c(e)$ with $e \geq 0$. The first component of the NGO’s utility, $z(e)$, measures the success of the NGO’s preferred policy as a function of the NGO’s effort $e$. Here, as the NGO’s goal is to maximize the scope of the adoption of its preferred policy, $z(e)$ is the probability that the quality of the supplier’s input will allow for the value creation that is higher than the firm’s outside option of 1.

Let us assume that both the firm and the supplier make their respective relationship-specific investments and the NGO makes an effort $0 \leq e < 1$. Then this probability is equal to the integral of the density of $U(e, \bar{V} + e)$ for the realizations that are between 1 and $\bar{V} + e$:

$$z(e) = \Pr(U(e, \bar{V} + e) \geq 1) = \int_{1}^{\bar{V} + e} \frac{1}{\bar{V}} dx = \frac{\bar{V} + e - 1}{\bar{V}}.$$

In other words, if investment in the collaboration happens, $z(e)$ is the probability that the supplier will be considered by the firm for the collaboration once the supplier’s quality is revealed and is above 1. Intuitively, $z(e)$ increases in $e$. The greater the improvement in quality, the more likely it is that the value creation will be above 1, and the more likely it is for the collaboration between the firm and the supplier to occur. If there is no investment by either the firm or the supplier, investment never happens and the probability is equal to zero (i.e., $z(e) = 0$).

The second component, $c(e)$ represents the disutility that the NGO experiences from exerting an effort $e$. This disutility could be interpreted as the cost in terms of time and resources to provide training for the supplier, as well as the cost of reaching out and convincing the supplier to participate in the training. Another way to interpret it would be as the opportunity cost of time, which could otherwise have been spent on fundraising, as well as the opportunity cost of these funds given other activities of the NGO. Along similar lines, it can be thought of as the damage to the
NGO’s reputation from collaborating with a firm, etc. Overall, this disutility incorporates the idea of a monetary and non-monetary cost that the NGO must bear in order to improve the supplier’s quality. This disutility is incurred irrespective of the firm’s and the supplier’s investment decision, as the NGO makes the first move in the game, with a sunk investment.

For concreteness, we parameterize this disutility as \( c(e) = \mu e^2 \), where parameter \( \mu \) scales the NGO’s disutility (or NGO’s cost) of reaching out to the supplier. We can think of this parameter as the inverse of the NGO’s capabilities. Higher NGO capabilities imply lower cost (disutility) for the NGO and allow the NGO to exert a greater effort to improve the supplier’s quality, whereas lower capabilities imply higher cost (disutility) and constrain the level of improvement \( e \) that the NGO can exert. Similarly to the NGO’s disutility \( c(e) \), the NGO’s capabilities \( \mu \) can be interpreted broadly: it may be NGO’s reputation, prior connections with suppliers, marginal cost of raising the funds, knowledge stock (to develop the training), etc.

For example, Conservation International has already launched a pilot project on shade-grown coffee with several cooperatives prior to its partnership with Starbucks (Austin and Reavis, 2002), which in our model will correspond to low \( \mu \), while Rainforest Alliance had no experience with tea farmers in Africa before collaborating with Unilever on Lipton brand (Braga, et al., 2011b), i.e., high \( \mu \). More generally it may be cheaper for a larger and more renowned NGO to find and persuade suppliers to join their training program; it may also be easier for such an NGO to attract funds (and thus make the opportunity cost of the funds lower). We assume that \( \mu \) is high enough to ensure that the optimal \( e \) remains within interesting bounds in our analysis (in particular, so that it does not overshoot 1, making the analysis trivial).

We thus have, with \( e \geq 0 \):

\[
U_{NGO}(e) = \begin{cases} 
\frac{\bar{V} + e - 1}{V} - \mu \frac{e^2}{2}, & \text{if both the supplier and the firm invest in the collaboration,} \\
-\mu \frac{e^2}{2}, & \text{otherwise.}
\end{cases}
\]

It should be noted that if there is no investment in the collaboration, the NGO is better off making no effort at all and setting \( e = 0 \). If the NGO makes an effort \( e > 0 \), then the expected
value of a collaboration increases and the payoffs for the firm and the supplier are respectively:

$$\pi_F = \alpha_F \frac{(\bar{V} + e - 1)^2}{2\bar{V}} - I_F, \text{ and } \pi_S = (1 - \alpha_F) \frac{(\bar{V} + e - 1)^2}{2\bar{V}} - I_S.$$ 

Note that for simplicity’s sake we defined $\pi_F$ net of the value of 1 that the firm is guaranteed to appropriate in any case. This does not impact the analysis and simply normalizes the profit of the firm at zero if there is no collaboration with the supplier.

### 3.3.5 NGO equilibrium effort levels

In this section, we focus on the NGO’s decision and characterize the NGO’s optimal effort level. In the following, we assume $I_S = 0$, which can be interpreted as the supplier having nothing to invest to make a potentially usable input, or alternatively that this investment is entirely contractible and ultimately underwritten by the firm. This then subsumes $I_S$ into $I_F$. In that scenario, the supplier can verifiably make the appropriate investment using cash provided by the firm, even though the outcome (or the intrinsic ability of the supplier) remains unknown. We make this assumption (which we relax in appendix A.5) because it permits us focusing on the relationship between the firm and the NGO, as the firm is the actor that empirically seems to play the most pivotal role as it holds key complementary assets for the distribution and transformation of the suppliers’ input. In addition, this permits to significantly ease the exposition without obscuring the implications of the model.

To determine the NGO’s decision making in terms of effort $e$, we define three critical values of this effort. Consider first $\hat{e}$, the optimal level of effort under the assumption that investment by both the firm and the supplier will happen. This optimal effort level that maximizes the probability that the supplier can enter the market (the first part of the NGO’s utility equation) given the “cost” to the NGO (the second part of the equation), is $\hat{e} = \frac{1}{\mu \bar{V}}$. As is intuitive, $\hat{e}$ is decreasing when the NGO is less efficient (higher $\mu$). The effort is lower with a higher $\bar{V}$, meaning decreasing returns to effort if the initial distribution was more favorable.

Second, consider the strictly positive effort level at which the NGO is indifferent between not
making an effort (setting \( e = 0 \)) or making a strictly positive effort (\( e > 0 \)). This is the upper bound for the NGO’s effort. We denote this effort \( e^{ub} \) and find it by solving \( U_{NGO}(e^{ub}) = 0, e^{ub} > 0 \). Finally, consider the minimum strictly positive effort level at which the firm would prefer to invest if the supplier invests as well \( (e^{collab}) \), i.e., the smallest \( e \) for which \( \pi_F \geq 0 \). These effort levels are:

\[
e^{ub} = \frac{1}{\mu V} + \frac{\sqrt{1 + 2\mu V (V - 1)}}{\mu V} > \hat{e}, \quad \text{and} \quad e^{collab} = \max \left( 0, 1 - \bar{V} + \sqrt{\frac{2I_F \bar{V}}{\alpha F}} \right).
\]

The value of \( e^{collab} \) can be above or below either of \( \hat{e} \) or \( e^{ub} \). The following lemma shows that the optimal effort \( e^* \) of the NGO is determined by the relative order of these values.

**Lemma 1** Denote \( e^* \) the NGO’s effort that maximizes its utility function. Assuming \( I_S = 0 \), \( e^* \) can take three values depending on the relative levels of \( e^{collab}, \hat{e} \) and \( e^{ub} \).

1. If \( e^{ub} < e^{collab} \) the NGO’s optimal effort \( e^* \) will be equal to 0, and the firm will not invest in the collaboration with the supplier.
2. If \( \hat{e} < e^{collab} \leq e^{ub} \) the NGO’s optimal effort \( e^* \) will be equal to \( e^{collab} \), and the firm will invest \( I_F \) in the collaboration with the supplier.
3. If \( e^{collab} \leq \hat{e} \) and \( e^{collab} \leq e^{ub} \) the NGO’s optimal effort \( e^* \) will be equal to \( \hat{e} \), and the firm will invest \( I_F \) in the collaboration with the supplier.

The intuition for the result is as follows. The problem of the NGO is to make the effort that maximizes its utility under the constraint of the firm being willing to invest into collaboration. This constraint is met if the NGO invests at least as much as \( e^{collab} \). Given this constraint, the NGO can be in one of three situations. If \( e^{ub} < e^{collab} \), the NGO’s maximum acceptable effort \( e^{ub} \) is still not enough to meet the firm’s participation constraint. In this case, the NGO gives up on intervening and sets its effort to zero (\( e^* = 0 \)). If \( \hat{e} < e^{collab} \leq e^{ub} \), the NGO is able to meet the firm’s

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\(^{11}\)Note that \( \pi_F = 0 \) does not mean that the firm is earning accounting profits equal to zero. Rather it means that the firm is earning merely normal returns as value capture is net of opportunity costs in the value-based framework.
participation constraint by making an effort that is above its preferred effort of \( \hat{e} \) but still below the maximum acceptable effort. The NGO’s utility maximizing effort is then \( e^* = e^{collab} \) as any effort above this level reduces the NGO’s utility and is no longer necessary to make the firm invest. Finally, if \( e^{collab} \leq \hat{e} \), the NGO simply sets \( e^* = \hat{e} \) which allows the NGO to both set its effort at the unconstrained level \( \hat{e} \) and meet the firm’s participation constraint.

The import of this result is to show that the NGO’s policy will be largely determined by the need to meet the participation constraint of the firm. In particular, it shows that in order to induce participation from the firm, the NGO may have to exert a high level of effort while it would actually prefer to make less effort.\(^{12}\) This result is an extension to Hypothesis 1 in King (2007) that states that in order to induce a firm to choose an environmentally friendly production option a stakeholder may need to invest in order to make that option superior to the firm’s outside option. Our lemma provides further details by distinguishing between \( e^{collab} \) and \( \hat{e} \).

Moreover, finding that there are three different regimes of effort exertion for an NGO also helps interpreting cases and organizing evidence about NGO activities in relation to firms and suppliers. For instance, the IMD case on Unilever Tea (Braga et al., 2011a, 2011b) shows how Unilever’s partnership with the Rainforest Alliance, which set out to convert its suppliers for the Lipton tea brand to sustainable practices, varied between different countries.

The Rainforest Alliance found it relatively easy to certify large tea estates in Kenya and Tanzania as the ex ante quality was already high (many sites had already implemented certain sustainable practices), and the sites were easily reachable by Rainforest Alliance representatives. Marc Monsarrat, Rainforest Alliance manager for East Africa and South Asia, commented on the training of the managers of the large tea estates: “Usually, after a single training session, the staff of large tea estates was able to acquire the basic knowledge to start implementing the changes we required for certification […] In a few months we could stir sufficient changes to bring many to compliance level with certification standards.” (Braga et al., 2011b: 2). In the framework of our model, this

\(^{12}\)In appendix A.5 we show that this also applies to the participation constraint of the supplier. The central mechanism is the same except that there could be a fourth possible level of equilibrium effort for the case in which the NGO needs to make additional efforts to meet the supplier’s participation constraint.
could represent the situation in which the NGO is able to exert its optimal effort $e$. However, when Unilever extended the sustainable tea initiative to tea smallholders in Kenya and other countries, the Rainforest Alliance found it more difficult to reach the suppliers. In addition, the Rainforest Alliance had little prior expertise in tea industry, and small farmers, unlike the large tea estates, did not have many sustainable practices in place. In Kenya the initiative succeeded only with the help of a local agency (the Kenya Tea Development Agency) and required high levels of human and financial resources, leading to serious questions about the efficiency of a high touch approach to training farmers in this context (Braga et al., 2011b). The perceived need for additional resources to achieve a satisfactory outcome corresponds to the situation in which the NGO is forced to make additional and yet sub-optimal effort $e_{collab}$ in order to meet the constraint of the firm.

In Argentina, however, there was no way to organize tea farmers, in a manner similar to Kenya. Marc Monsarrat, Rainforest Alliance manager for East Africa and South Asia said: “It is definitely more challenging in other countries where smallholders operate on a one-to-one basis (and not as a group) with factories. It is generally a big struggle around the world to organize a large number of small producers in a competitive manner.” (Braga et al., 2011b: 5). Consequently, Unilever and Rainforest Alliance partnered with a regional NGO (Imaflora) that could bring small tea farmers to the discussion table. This can be interpreted as a situation where the effort required from the Rainforest Alliance was too costly ($e_{collab} > e_{ub}$), and the NGO was not capable of meeting the firm’s constraint on its own. Engaging another NGO with greater capabilities to reach the suppliers (Imaflora, in this case), allowed this situation to be transformed into the scenario where $e < e_{collab} \leq e_{ub}$ and where the NGO was able to make the effort required to bring about the collaboration. Overall, these examples illustrate how different level of NGO’s capabilities in different contexts resulted in different outcomes for the firm and the NGO, to the extent that another NGO had to be enlisted in order to meet the firm’s participation constraint.
3.3.6 NGO effort and the firm’s bargaining power

Building on Lemma 1 we can present additional analyses that relate features of the value creation and value capture environment to NGO’s equilibrium effort levels. In particular, the fact that the NGO’s effort is sometimes designed to induce the firm’s collaboration introduces non-obvious discontinuities in the NGO’s optimal effort leading to counterintuitive patterns.

For instance, we find that unless the firm has a very high bargaining power, the NGO actually benefits from the firm appropriating more value at the expense of the supplier, even though conventional wisdom would suggest that the NGO prefers the distribution of value favoring the supplier. The mechanism behind is that with the firm being able to capture a greater share of value the firm’s participation-inducing level of effort decreases thus allowing the NGO to make less effort when it has to meet the firm’s constraint.

The NGO’s compensatory reduction of effort when the firm’s bargaining power increases implies that the firm is not seeing any improvement in its value capture, even when there is more value created overall. The lack of change in value capture for the firm creates a “valley of frustration” when seemingly improving circumstances for the partnership would not lead to improved outcomes, as will be detailed below in section 3.5. Furthermore, from the firm’s perspective only the firms with a high bargaining power will be able to make positive profits from the collaboration with the NGO and the supplier, while the firms with moderate bargaining power will get only minimal profit.

We can reformulate Lemma 1 in terms of critical values for the firm’s bargaining power ($\alpha_F$):

**Proposition 2** Consider the decision of the NGO assuming $I_S = 0$, and that the firm is not investing in collaboration if $e = 0$. Then, there exist two thresholds $0 < \alpha_F^{\text{min}} < \alpha_F^{\text{opt}}$ such that:

1. If $0 \leq \alpha_F < \alpha_F^{\text{min}}$ the NGO’s effort is zero and there is no collaboration between the firm and the supplier.

2. If $\alpha_F^{\text{min}} \leq \alpha_F < \alpha_F^{\text{opt}}$ the NGO’s effort is equal to $e^{\text{collab}}$ and is decreasing in $\alpha_F$.

3. If $\alpha_F^{\text{opt}} \leq \alpha_F$ the NGO’s effort is equal to $\hat{e}$ and is decreasing in $\mu$. 

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Figure 2 provides illustration for this proposition. The two horizontal lines represent the optimal unconstrained effort for the NGO $\hat{e}$ and the maximum effort that the NGO can exert $e_{ub}$. The minimum effort required by the firm $e_{collab}$ is represented by the downward-sloping curve: the higher the firm’s share of value (higher $\alpha_F$) the smaller increase in value creation the firm needs to break even. At low levels of $\alpha_F$ there is no $e < e_{ub}$ that makes collaboration worthwhile for the firm. At $\alpha_F = \alpha_F^{min}$ we have $e_{ub} = e_{collab}$, meaning that the NGO is indifferent between making an effort and not making an effort just as the firm is indifferent between collaborating and not collaborating. From this point, as $\alpha_F$ increases, the NGO prefers to make an effort at level $e_{collab}$ while still providing sufficient inducement to the firm, which is still just breaking even. We call this area the “valley of frustration” as the firm captures only the minimum needed to break even while the NGO is making its largest effort. Finally, if $\alpha_F^{opt} \leq \alpha_F$, the NGO’s effort level attains its first best level $\hat{e}$ and is independent from $\alpha_F$. Intuitively, the NGO’s first best effort level $\hat{e}$ is higher when the cost of exerting the effort is lower (i.e. when the NGO has lower $\mu$).

The negative relationship between the firm’s $\alpha_F$ and $e_{collab}$ gives rise to a counterintuitive outcome: the NGO prefers the firm to have a higher bargaining power vis-à-vis the supplier. This is particularly striking as we would usually expect the NGO’s involvement in the supply chain result
in a higher value appropriation by the supplier. However, our model shows that if this is the case then the NGO is worse off unless the change in the value distribution between the firm and the supplier keeps the firm’s bargaining power $\alpha_F$ above the critical value $\alpha_F^{opt}$.

Suppose that the presence of the NGO bolsters the supplier’s bargaining position and the firm’s bargaining power drops to $\alpha_F' < \alpha_F$. If the reduction in the firm’s bargaining power results in $\alpha_F' < \alpha_F^{min}$, making the collaboration unattractive for the firm, then the NGO does not make the effort, the transaction between the firm and the supplier does not materialize, and all three players are left worse off. If the reduction in the bargaining power results in $\alpha_F^{min} < \alpha_F' < \alpha_F^{opt}$ the collaboration will still happen, however, it will necessitate a higher effort from the NGO. While the supplier will increase its welfare compared to the situation with the $\alpha_F$, the NGO will have to stretch its resources more in order to induce the firm to participate. This may explain the fact that NGOs like Rainforest Alliance and UTZ Certified do not require firms in coffee and cocoa markets to pay a premium price to farmers (i.e., accept a lower $\alpha_F$ in our model) (Gunther, 2015; McAllister, 2004).

If the NGO anticipates that there will be a reduction in the firm’s bargaining power such that $\alpha_F' < \alpha_F^{opt}$ the NGO will either not make the effort (if it expects $\alpha_F' < \alpha_F^{min}$) or will have the incentives to restore the original bargaining positions between the actors. The following corollary thus follows from proposition 2:

**Corollary 3** The anticipation of a decrease in $\alpha_F$ from above to below $\alpha_F^{min}$ will prevent collaborations from happening.

While a leading motive for the involvement of NGOs in the trade between weaker suppliers and powerful firms is to improve the terms of the exchange for the suppliers, this corollary shows that such improvement can backfire if it makes the firm giving up on the collaboration.

### 3.4 Firm internalizes the development of suppliers

So far we have assumed that only the NGO has the necessary technology to improve the quality of the supplier (we use “technology” as shorthand for the requisite knowledge and capabilities,
including those needed to reach the supplier). This is however a restrictive assumption as the firm could plausibly have the option to internalize the development of suppliers rather than delegating it to an NGO. For example, while some chocolate producers collaborate with NGOs (such as, e.g., UTZ Certified), Hershey and Cargill have established their own program to train cocoa farmers in Cote d’Ivoire in sustainable practices.\(^{13}\)

In such case, what will drive the firm’s choice between collaborating with the NGO versus improving by itself the quality of the suppliers? The answer depends on the balance of two opposite forces. On the one hand, the NGO is assuming costs that the firm does not need to expense, which pushes the firm to rely on the NGO, on the other hand, the NGO’s development decision is not the one preferred by the firm, which can make the firm prefer to internalize. Our analysis below suggests that the former is usually stronger than the other. In particular, we will show that the firms with high bargaining power benefit from the internalization of improvement effort, notably when the \textit{ex ante} quality of the supplier is high, and when the investment requirements are moderate.

We extend the baseline model and assume that the firm is able to make the effort to improve the supplier’s quality at the cost \(\mu_F e_F^2\), where \(\mu_F\) denotes the firm’s capabilities and \(e_F\) the level of effort by the firm. Note that we reserve the symbol \(e\), without subscript \(F\), for the effort of the NGO and use \(e_F\), and its variations, for the firm’s effort. The firm’s expected incremental profit \(\pi_F\) from collaboration with the supplier and the optimal level of effort \(\hat{e}_F\) by the firm (assuming it is better off not collaborating with the NGO and working with the supplier) are respectively:

\[
\pi_F = \alpha_F \left( \bar{V} + e_F - 1 \right)^2 \frac{2}{2V} - I_F - \frac{\mu_F e_F^2}{2}, \quad \text{and } \hat{e}_F = \frac{\alpha_F (\bar{V} - 1)}{\bar{V} \mu_F - \alpha_F}.
\]

The firm’s optimal level of effort \(\hat{e}_F\) increases in \(\bar{V}\), while the NGO’s optimal level of effort \(\hat{e}\) decreases in \(\bar{V}\) illustrating the difference in the firm’s and the NGO’s incentives\(^{14}\). While the NGO only needs the supplier to meet the firm’s quality threshold, the firm always prefers to achieve

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\(^{14}\)Technically speaking, \(\hat{e}_F\) increases in \(\bar{V}\) if \(\mu_F > \alpha_F\), however, in the case when \(\mu_F < \alpha_F\) we will have \(\hat{e}_F > 1\) making the analysis trivial.
higher value creation with the supplier as it can appropriate some of this value. This misalignment of the objective functions of the firm and of the NGO means that the firm would sometimes prefer the NGO to make a higher effort, while the NGO is satisfied at a lower level. The firm thus faces a trade-off between saving on costs by relying on the NGO, and spending more but achieving full alignment.

To analyze the firm’s decision we define two critical thresholds for its confidence index $\alpha_F$. Let us denote $\alpha^a_F$ the level of $\alpha_F$ at which $\pi_F(\hat{e}_F) = 0$. The firm will have positive profit from exerting the effort $\hat{e}_F$ when $\alpha_F > \alpha^a_F$, making internalization an option preferred to doing nothing. Let us denote $\alpha^b_F$ the level of $\alpha_F$ such that $\pi_F(\hat{e}_F) = \pi_F(\hat{e})$, i.e., when the firm is indifferent between improving supplier’s quality on its own and relying on the NGO. When $\alpha_F > \alpha^b_F$ the firm will have higher profits when making the effort on its own rather than collaborating with an NGO. Considering the thresholds $\alpha^{\min}_F$ and $\alpha^{\text{opt}}_F$ that provide the bottom thresholds for the NGO’s participation-inducing level $e^{\text{collab}}$ and first best level $\hat{e}$ respectively, we can show how the firm chooses between the absence of action, collaboration and internalization. We will assume that the firm is as efficient as the NGO by positing $\mu_F = \mu$, which says that the NGO has no capability advantage over the firm. This is a conservative assumption as research shows that pursuing economic objectives comes at the expense of efficiency in achieving social goals (Battilana, Pache, Sengul and Model, 2015).

**Proposition 4** Consider the decision of the firm assuming that it possesses the capability to improve the quality of the supplier. Denote $e^*$ the optimal effort of the NGO and $e^*_F$ the optimal effort of the firm. Assume that $I_S = 0$ and $\mu_F = \mu$. The firm’s decision is as follows:

- If $\alpha_F < \min(\alpha^{\min}_F, \alpha^a_F)$, the firm does not collaborate with the NGO, exerts no effort ($e^*_F = 0$), earns $\pi_F = 0$, and the NGO exerts no effort ($e^* = 0$).

- If $\alpha^{\min}_F \leq \alpha_F < \min(\alpha^{\text{opt}}_F, \max(\alpha^a_F, \alpha^b_F))$, then the firm collaborates with the NGO, exerts no effort ($e^*_F = 0$), earns $\pi_F = 0$, and the NGO exerts effort $e^* = e^{\text{collab}}$.

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15This divergence in objective functions and first best effort levels is somewhat similar to the analysis in appendix A.6 on the social welfare maximizing level of effort.
Figure 3: The areas of firm’s strategic options

- If $\alpha_{\text{opt}}^F \leq \alpha_F < \max(\alpha_F^n, \alpha_F^b)$, then the firm collaborates with the NGO, exerts no effort ($e_F^* = 0$), earns $\pi_F > 0$, and the NGO exerts effort $e^* = \hat{e}$.

- If $\alpha_F \geq \max(\alpha_F^n, \alpha_F^b)$, then the firm internalizes the effort, setting its level of effort at $e_F^* = \hat{e}_F$, earns $\pi_F > 0$, and the NGO is not active ($e^* = 0$).

Figure 3 illustrates this proposition by mapping the areas of the firm’s strategic choices depending on the firm’s bargaining power $\alpha_F$ and the investment requirement $I_F$. First, we can see that when the investment requirement $I_F$ is high, or when the firm’s bargaining power $\alpha_F$ is low, the effort is too costly for both the NGO and the firm, and thus the firm will not be able to transact with the supplier. As the investment requirement becomes lower and the firm’s bargaining power grows, internalization still remains prohibitively costly for the firm, but the NGO is able to make the participation-inducing effort $e_{\text{collab}}$ that makes the firm willing to use the supplier. The firm will thus collaborate with the NGO, though it still cannot make positive profit as it is still stuck in the “valley of frustration” (see next section). An exception is the case when the firm has very high capabilities (i.e., low $\mu_F$): at very high investment level the firm will forgo the collaboration with the NGO altogether and will integrate the effort directly (the upper right part of Figure 3a).
low levels of investment requirement, and higher $\alpha_F$, the NGO is finally able to make its first best effort $\hat{e}$, which means that the firm can get positive profits from the transaction with the supplier under collaboration with the NGO. At the same time, the firm is finally able to make the effort internally and get positive profits. This illustrates the tradeoff between the cost of effort and the misalignment of incentives where firms with lower bargaining power are better off working with the NGO while firms with higher bargaining power are better off internalizing the effort.

The intuition for these results is the following. When the firm’s bargaining power is low, the supplier captures most of the value created through the improvement of the quality, which, first, makes the firm unwilling to make a large effort, and, secondly, makes the net gain very small. Thus when the firm is weaker vis-à-vis the supplier the firm is better off collaborating with the NGO either because the NGO will actually make higher effort than the firm, or because not incurring the cost of effort outweighs the misalignment in incentives. As its bargaining power grows the firm is willing to make a larger effort to improve the supplier’s quality because it is going to appropriate a larger share of the ensuing value created. In this case the benefit of having higher value creation outweighs the benefit of getting a lower improvement at no cost, and the firm is better off internalizing the effort.

These findings are consistent with sustainability initiatives in the coffee market where large coffee roasters, such as Nestle and Mondelez, have their own sustainability training programs for farmers, while Starbucks, who has a lower market share, partners with Conservation International (Panhuysen and Pierrot, 2014). Interestingly, a small roaster Counter Culture Coffee originally established its own certification scheme but eventually abandoned it (MacGregor, Ramasar, and Nicholas, 2017), consistent with our results that weaker firms should not pursue internalization.

Furthermore, comparing Figures 3b and 3c we can see that as the supplier’s ex ante quality grows the area where the firm benefits from internalization also increases, while the area of collaboration with the NGO is reduced. For instance, HortiFruti—a Costa Rican supermarket chain—did not resort to the NGO for training the farmers in Costa Rica where the farmers exhibited already high level of agricultural practices. However, in Nicaragua the level of farmers’ skills was much
lower prompting HortiFruti to partner with several local NGOs to bring the quality level to the bar (Leguizamon and Ickis, 2009).

This analysis shows the benefit of an actor involved in the supply chain that has incentives that are divergent from those of the for-profit actors. First, even if the firm were able to improve the supplier’s quality on its own, weaker firms benefit from the existence of the NGO as the NGO’s involvement substitutes for the effort the firm would have made, allowing substantial saving. Furthermore, the existence of the NGO benefits society as a whole as it allows the transaction between the firm and the supplier to happen under the conditions where the firm would not have made the improvement effort itself (the area where the NGO makes effort $e^{collab}$). On the other hand, if the firm with high bargaining power has the capability to reach suppliers on its own, it can have higher profit that under NGO’s effort, and, provided it is highly efficient, it can have positive profit when under the NGO it would have earned zero profit (because the effort is too costly for the NGO).

### 3.5 NGO effort and supply chain participants’ preferences

So far we have focused on determinants of the equilibrium level of effort by the NGO and found that there are three regimes for the NGO. We will now investigate how the players’ outcomes (profitability and utility) vary in function of the characteristics of the other players, focusing on the effect of the NGO’s efficiency parameter $\mu$ and the effect of the firm’s bargaining power $\alpha_F$. We do this in the context of the base model where only the NGO is able to improve the distribution of the supplier’s outcomes and the firm cannot internalize such effort. This will help determine how each participant cares about the characteristics of their partners. For instance, when Unilever decided to train the suppliers of their Lipton brand in sustainable tea growing they were considering three NGOs as potential partners (Fairtrade, UTZ Certified and Rainforest Alliance) of which the latter was chosen (Braga et al., 2011a). Formal analysis of the model shows:

**Proposition 5** Assume $I_S = 0$, and that the firm is not investing in collaboration if $e = 0$. Then, the effects of $\mu$ on firm profits and of $\alpha_F$ on NGO utility are as follows:

1. If $0 \leq \alpha_F < \alpha_F^{\text{min}}$, we have $\pi_F = 0$, and $\frac{\partial \pi_1}{\partial \alpha_2} = 0$, $U_{NGO} = 0$, and $\frac{\partial U_1}{\partial \alpha_2} = 0$. 

2. If $\alpha_{F}^{\min} \leq \alpha_{F} < \alpha_{F}^{\text{opt}}$, we have $\pi_{F} = 0$, and $\frac{\partial \pi_{F}}{\partial \alpha_{2}} = 0$, $U_{NGO} > 0$, $\frac{\partial U_{NGO}}{\partial \alpha_{2}} > 0$ and $\frac{\partial^{2} U_{NGO}}{\partial \alpha_{2} \partial \mu} > 0$.

3. If $\alpha_{F}^{\text{opt}} \leq \alpha_{F}$, we have $\frac{\partial \pi_{F}}{\partial \alpha_{2}} > 0$, $\frac{\partial \pi_{F}}{\partial \alpha_{2}} < 0$, $\frac{\partial^{2} \pi_{F}}{\partial \alpha_{2} \partial \mu} < 0$, $U_{NGO} > 0$, and $\frac{\partial \pi_{F}}{\partial \alpha_{2}} = 0$.

The first part of the proposition is straightforward: at low levels of $\alpha_{F}$ there is no collaboration between the firm and the supplier, implying profits and utility equal to zero for everyone. The second and the third parts of the proposition allow to further expound the relationships between the parameters of the model to understand what each participant cares about in the other participants’ characteristics under each regime of NGO effort.

From the NGO’s point of view, stronger bargaining power of the firm is helpful at moderate levels of bargaining power ($\alpha_{F}^{\min} \leq \alpha_{F} < \alpha_{F}^{\text{opt}}$) as it relieves the NGO ($\frac{\partial \pi_{F}}{\partial \alpha_{2}} > 0$) and enables it to dial back its effort towards the first best $\hat{e}$ (as discussed in section 3.3.6). Because the NGO’s goal is to increase the consumption of the product, rather than supplier’s welfare, higher value appropriation by the firm does not decrease the NGO’s utility. This is even more pronounced when the cost of being away from the first best is high (higher $\mu$) as shown by $\frac{\partial^{2} \pi_{F}}{\partial \alpha_{2} \partial \mu} > 0$. From the NGO’s standpoint, own efficiency (lower $\mu$) and the firm’s bargaining power ($\alpha_{F}$) are substitutes. For instance, in the partnership between Cargill International and The Nature Conservancy on sustainable soy production in Brazil the firm—one of the three largest soy traders exporting from eighty to ninety percent of the soy produced in the region—did not pay a price premium to farmers, thus allowing Cargill to appropriate the entire value created (The Telegraph, 2007; Wasserman, Hull, and McCutchan, 2014). Given that after three years of collaboration only 20% of farmers were compliant (McAllister, 2008) this is consistent with the case when the NGO does not have sufficient capabilities and wants to work with a firm that appropriates more value.

These effects are no longer in play when the NGO is selecting its optimal effort $\hat{e}$, which happens at high levels of $\alpha_{F}$. It is no longer preoccupied with meeting the firm’s participation constraint and its utility no longer depends at the margin on the characteristics of the firm.

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Note that the positive cross partial $\frac{\partial^{2} U_{NGO}}{\partial \mu \partial \alpha_{F}}$ formally shows complementarity between bargaining power and inefficiency ($\mu$). Changing variables, this is equivalent to substitutability between bargaining power and efficiency ($1/\mu$), which is easier to interpret.
For the firm, the situation is reversed. At moderate levels of bargaining power, when the NGO exerts the participation-inducing effort $e^{collab}$, the firm is at the margin indifferent to the NGO’s characteristics because it is getting minimal profit no matter what happens on the side of the NGO. This is what we call the “valley of frustration”. The firm is just incentivized to participate thanks to the high level of NGO effort, but any change of parameter at the margin does not translate in change in value capture. The reason is that any factor leading to increased value capture by the firm is met by a compensatory reduction in effort by the NGO: seeing that the firm can capture more value (higher $\alpha_F$) or equivalently that there more value created overall, the NGO takes this opportunity to scale back its effort towards its preferred level $\hat{e}$.

However, at high levels of bargaining power, when the NGO makes its first best effort $\hat{e}$, the NGO’s efficiency does matter to the firm. A more efficient NGO (i.e., lower $\mu$) picks a higher $\hat{e}$ and creates a larger surplus in the supply chain, a slice of which is appropriated by the firm. As a result we have $\frac{\partial x_1}{\partial \nu_2} < 0$. Moreover, the firm appropriates even more from this surplus if it has high bargaining power, and thus $\frac{\partial^2 x_1}{\partial \nu_2 \partial \nu_3} < 0$. Here we see that for the firm its bargaining power ($\alpha_F$) and the NGO’s efficiency (lower $\mu$) are complements.

### 3.6 Patterns of stable NGO-firm matchings

Based on the results of proposition 5, we can work out how a matching process involving multiple competing firms and NGOs would unfold prior to the NGOs and the firms actually setting into motion their potential collaboration. This will allow understanding what overall matching pattern of NGOs and firms we should expect to emerge looking at a large population of firms and NGOs. We provide technical details about the actors’ preferences and the matching process in appendix A.3.

Figure 4 shows the density of stable matches found in the computational experiment. The first striking feature of this result is the partition of the stable matches into two disjoint areas. The first area comprises the high $\alpha_F$ firms and the low $\mu$ NGOs, in the upper left corner of figure 4. These matches are all above the line formed by the $\alpha_F^{opt}$ value. Matches happen in this area until the supply of both types is exhausted, which happens for a value of $\mu$ such that supply and demand in
Figure 4: Density of matches between firms and NGOs (1,000 simulations)

the optimal effort area are equalized. This value is a little bit different for each run in function of the randomization of cases of ties in preferences, giving the fuzzy vertical and horizontal boundaries.

Below and to the right of this point, below $\alpha_F^{opt}$ and above $\alpha_F^{min}$, lies the second cluster of matches. Firms matching in this area are relegated to higher values of $\mu$ due to the lower $\mu$ NGOs being competed away in the first cluster. At the bottom left corner of this cluster, we observe a concentration of matches. We interpret this bunching as the result of the accumulation of demand by firms with medium levels of $\alpha_F$ (e.g., $\alpha = 0.4$ in the figure) that are facing few matching opportunities because at their level of $\alpha_F$ most NGOs are not efficient enough to make matching better than not matching at all, while the more efficient NGOs are already taken by higher $\alpha_F$ firms.

The forces of selection and matching create strong empirical patterns. The population of matched organizations in the simulated data is showing a negative correlation ($\rho = -0.48$) between $\alpha_F$ and $\mu$ while there is a positive correlation within each cluster, equal to $\rho = 0.51$ in the upper left cluster and $\rho = 0.41$ in the medium right cluster. By contrast, if matching were random
and not subject to selection, there would be no correlation between $\alpha$ and $\mu$.

Let us imagine a hypothetical example of a market where a number of firms and NGOs are searching for partners. Our model can predict how the matching is going to unfold and provide recommendations to the actors for their search strategy. NGOs that have a high $\mu$ should probably not waste resources on trying to reach out to high $\alpha_F$ firms. Those are likely to be scooped by more efficient, low $\mu$, NGOs that will concentrate on securing partnerships in that segment of firms. Firms with high $\alpha_F$ can also confidently orient their search towards low $\mu$ NGOs. However, firms with intermediary levels of $\alpha_F$ (from approximately 0.35 to 0.75 in our figure) have the most at stake as they can either succeed in securing a very efficient NGO partner, or being stuck with a less efficient NGO as matches in-between are not stable. They have the most incentives to intensively search and propose partnership with very efficient NGOs.

### 3.7 Other extensions and robustness checks

In the appendix of this paper we include additional analyses and robustness checks. In appendix A.4 we allow for cash transfers between parties and find that while the firm never finds it profitable to subsidize the NGO the latter may often have an interest to motivate the firm’s participation through a direct cash transfer rather than through improvement in the value creation potential of the suppliers. In appendix A.5 we relax the assumption of the firm fully subsidizing the supplier. We find that in this case the NGO’s equilibrium level of effort is U-shaped in the firm’s bargaining power and, given the need to induce participation from the firm and the supplier alike, the NGO is able to exert its optimal $\hat{e}$ only at intermediate levels of the firm’s $\alpha_F$. In appendix A.6, we provide a detailed analysis comparing social welfare with the NGO to a situation where a planner having access to the NGO’s value improvement technology seeks to maximize economic welfare. This analysis shows that the NGO is generally making less effort compared to the social optimum but that there are also situations where it is making more effort. Finally, in appendix A.7 we explore the situation when the NGO is purely interested in the economic interests of the suppliers seeking to maximize their aggregated profits. We find that in such case the NGO’s optimal effort is no longer U-shaped in the firm’s bargaining power. Instead, once firm participation is secured, NGO’s effort
decreases monotonically with firm bargaining power, reflecting reduced returns to effort as more and more of the value created is captured by the firm, not by the suppliers.

### 3.8 Discussion and conclusion

Our analysis is consistent with the intuition that firms can markedly benefit from collaborations with NGOs. However, we substantially qualify the conditions under which these benefits will accrue, with implications for firm’s collaboration strategy with NGOs. We show that collaboration with NGO is usually preferable to internalization by the firm, especially for firms that have less bargaining power and when setting up a new supply chain requires higher investments. Firms and NGOs mutually benefit from collaboration especially when the NGO accepts lower value capture by the suppliers (implying more value capture for the firm) to meet its goal of broadening their access to the market.

There is nevertheless a flip side to the benefit of collaborating with an NGO. Our analysis reveals that firms are at risk of finding themselves in a “valley of frustration”, capturing just enough value to justify establishing the new supply chain, but without hope of capturing more than this minimum amount of value. This situation arises when the NGO is making effort above its preferred level to ensure the formation of the supply chain, but as a result tightly controls its effort. As a result, the firm does not capture more than the minimum necessary.

While the firm is not losing money in this situation and earns normal returns, it remains the actor benefiting the least from the increase in economic surplus. The effect on the firm’s profitability remains negligible even though there is a tangible increase of value created. To avoid being stuck in the “valley of frustration”, the firm needs not only to understand the NGO’s goals, but also the NGO’s capabilities, for it is a lack of capability, rendering its effort inefficient, that makes the NGO more likely to have to keep firm value capture at a low level. It is also possible that a firm satisfies itself with this situation once indirect benefits such as improved reputation are taken into account.

If NGO capabilities are key to firm performance, then there will be competition to secure access to better NGOs, as in any factor market. Our analysis shows that under competition, more capa-
ble NGOs will likely form collaborations with more powerful firms. This is counterintuitive as the more powerful firms will in turn strike a harder bargain with the suppliers but this reflects the trade-offs that some NGOs may be willing to make in their quest to expand the reach of opportunities for suppliers. The implication is that having a strong bargaining power with respect to suppliers can be an asset to secure NGO collaboration when the NGO’s objectives are broader than the value captured by supplier. However, this also implies that firms with lower bargaining power, that need NGO collaboration the most, may actually be outcompeted by firms with higher bargaining power and not see the benefits of the collaboration (ending up in the “valley of frustration”).

Our model also suggests that empirical research on the determinants of firm–NGO collaboration should account for the forces driving the matching process. Selection implies that certain pairings are not viable, and therefore not observed, while competition for matches will endogenously create correlations between matched firms and NGOs. This could be empirically tested using empirical matching models (Mindruta, Moeen, and Agarwal, 2016) and by paying detailed attention to the matching process itself (Gatignon and Capron, 2016). Understanding this matters because such patterns of association could also be thought of as being the result of assortative matching between organizations of high status in their respective domain.

We found a series of counterintuitive implications from the analyses of the tradeoffs faced by the NGO. While prior research has mostly focused on the divergence of firms’ and NGOs’ goals, our model implies that there can be some alignment between firms and NGOs, while NGOs’ goals may be less aligned with those of suppliers than commonly assumed. In this vein, Lyon (2010) mentions that different NGOs place different emphasis on the elements of the “triple bottom line”: people, planet, and profits — in our model the NGO puts most emphasis on the “planet dimension.”

This means that suppliers’ economic interests could be found to be somewhat ignored in spite of large NGO involvement. For example, The Nature Conservancy, along with other environmental NGOs, was highly supportive when Cargill International insisted on the implementation of the non-deforestation rule for soy farmers in Brazil, which required natural vegetation to be preserved on 80% percent of the farmer’s land. However, this posed a major challenge to small farmers
struggling to make a living out of only one fifth of their property. In the words of a farmer: “We feel oppressed. The NGO?s call us criminals. But we don?t want to work outside of the law [...] And we came here after the forest had been cut down, and just took advantage of what we found.” (McCarthy, 2007).

Furthermore, our model implies that the value split between the firm and the supplier cannot be understood independently of the NGO?s characteristics, in particular the NGO?s capabilities as modeled by the cost of effort parameter $\mu$. Because the NGO is willing to make tradeoffs between its effort and the value appropriation by the supplier ignoring the NGO’s cost of effort may lead to misunderstanding the reasons behind certain choices. For instance, one may explain the choice of many coffee retailers to collaborate with the environmentalist NGO Rainforest Alliance rather than the Fairtrade Foundation as due to the former not requiring a minimum price to be paid to the supplier (McAllister, 2004). However, our model shows that it may sometimes be necessary to allow the firm to capture higher value in order to enable the collaboration to happen.

It is important to clarify how the NGO deals with the pre-existing market failure. In our model, the firm and the supplier are not able to credibly commit ex ante on how they split the value created ex post. This, combined with lack of contractibility, creates the conditions for a market failure. In the base model, the NGO does not solve the root cause, but “greases the wheels” by creating more value in the system to make the firm and the suppliers nevertheless work with each other. In the extensions, we explore some ways in which the NGO is acting more fundamentally on the root causes. For instance, the NGO may be guaranteeing a certain division of value ex post by affecting the parameter $\alpha_F$, or may be transferring funds ex ante to get over the lack of contractibility between firm and suppliers. In these cases, the NGO is solving the market failure by fundamentally altering which contractual agreements are available.

From a modeling standpoint, the NGO acts similarly to a private regulator, in the same manner as a welfare-maximizing regulator proposes and enforces contracts to shape the behavior of private firms (Laffont and Tirole, 1993). However, as in recent work in CSR (de Bettignies and Robinson, 2015), we model actors who are neither profit- nor welfare-maximizing. For instance, while
related, the NGO’s goals are distinct from the welfare of the suppliers. Moreover, since our model marries features from the value-based perspective (Brandenburger and Stuart, 1996, 2007) with some of private politics literature (Baron and Diermeier, 2007) we are able to study the interplay between fundamental features of the market (e.g., potential for value creation), and of the main players (e.g., firm bargaining power, NGO efficiency) and how they influence value creation and capture.

In conclusion, we offer a formal analysis of an NGO’s contribution to value creation in a supply chain given the need to induce collaboration between firms and suppliers, and the specific goals of the NGO. Our formal model offers fresh insights for firm strategy and the empirical study of how firms and NGOs collaborate to create economic value in spite of differences in goals. It offers testable hypotheses with respect to the reciprocal influence of key parameters on firm and NGO behavior, but it also provides novel insights with respect to sources of endogeneity and sample selection. We hope this research will foster more formal analyses of firm–NGO interactions incorporating a detailed value creation environment and expanding the repertoire of NGO and firm actions.
4 ESSAY 2: COMPETITION IN MARKETS WITH COMPLEMENTS: HOW WITHIN-COMPONENT FIRM HETEROGENEITY SHAPES ECOSYSTEM STRATEGIES

Abstract

We study the strategies that firms adopt towards complementary products. Specifically, we look at whether firms choose to be compatible with certain complements only, whether they choose to integrate complements and if so, whether they make these complements exclusive. Combining individual-level data on the consumption of anti-HIV drug combinations and firm-level data on clinical trials we find that these strategies depend on the firm’s strength in its focal product. The owner of the focal product with broader customer base develops exclusive complements, which helps maximize value capture and maintain its bottleneck status. The owner of the focal product with narrower customer base faces a dearth of complement supply, and also develops its own complements but keeps them open. Moreover, it also seeks to shift the bottleneck in the ecosystem by attempting to make the focal product unnecessary.

Keywords: Complements, value creation, value capture, ecosystems, industry architecture.

4.1 Introduction

In November 2018 Apple announced that Apple Music, previously exclusive to the Apple’s own HomePod device, would be available on the Amazon Echo devices. This marked the first time that Apple opened its music service to a third party voice control service (Amazon’s Alexa). The move was even more surprising because the HomePod was poised to be the major hub for Apple Music. Yet given that Apple’s device sales did not seem to take off as expected, with sales eight times less than Amazon’s, the decision to make Apple Music available on other firms’ devices seemed the better way to make the most of Apple’s investment in its music service, breaking with the firm’s tradition of using services to bolster sales of devices.

Similarly to Apple, firms working in the contexts where their value creation depends on complementary products – which have been recently dubbed business ecosystems (electric vehicles, smartphones, combination therapy, to name a few) – have to make decisions as to whether make their product compatible with multiple complements or keep them exclusive for a specific complement. While we know that the availability of complements is crucial to enable value creation with the focal product (Adner, 2012; Adner and Kapoor, 2010) we know less about how different firms

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17 This essay was developed in collaboration with Olivier Chatain
attempt to shape the ecosystem in order to ensure higher value capture (Jacobides, Cennamo, and Gawer, 2018) and which strategies towards complements they adopt to this end.\textsuperscript{18}

Building on the seminal work of Teece (1986) on complementary assets, a burgeoning body of research has emerged in recent years to study ecosystems of complementary components that have to be assembled into a bundle to create value for the final customer. The trade-off often faced by firms in such contexts is between value creation by the whole ecosystem and value capture by an individual firm. So far, the literature has predominantly chosen to focus on either value creation or value capture as the driver of the firms’ strategy, but has rarely dealt with the tension between these two considerations.\textsuperscript{19}

On the one hand, a body of literature has focused on the value creation aspect of ecosystems: the importance of the complementary products to enable the performance of a focal product (Adner, 2006, 2017; Adner and Kapoor, 2010; Ethiraj and Levinthal, 2004). Firms need to align the producers of the complementary products – i.e. complementors – to ensure the availability of complementary products (Adner, 2012) to favor new product adoption (Adner and Kapoor, 2010), innovator’s performance (Adner and Kapoor, 2010), or survival of an incumbent product (Adner and Kapoor, 2016a, 2016b). To this end firms may attempt to affect the supply of complementary products by, for instance, selecting markets where the complements are already available (Kapoor and Furr, 2015), allying with producers of complementary products (Hannah and Eisenhardt, 2018; Kapoor, 2013; Kapoor and Lee, 2013), or developing complements in-house (Ethiraj, 2007).

However, we know less about the strategic behavior of the producers of these complements, and whether they choose to be compatible with all offerings in the focal product component. This stems in part from the assumption that the ecosystem is built around a given focal product (Adner, 2012, 2017), implying less emphasis put on the competition that can exist among multiple producers.

\textsuperscript{18}In this paper we focus on the contexts of complementary products where network effects are weak, thereby excluding the platform-mediated markets. Thus we do not rely on indirect network effects as the mechanism of value creation (for the review on the research on platform-mediated markets see two reviews by McIntyre and Srinivasan (2017) and by McIntyre and Subramaniam (2009).

\textsuperscript{19}There is an extensive body of literature on value creation - value capture trade-off in platform-mediated markets, which is driven by direct and indirect network effects. In contrast to that research, here we focus on contexts where network effects are non-existent and thereby we seek to identify other mechanisms driving firms’ decisions.
of the focal product. Secondly, less attention is given to the split of the value created among the participants of the ecosystem. In other words, the focus of this literature is on the strategies that enlarge the pie for all participants and not on those that can increase someone’s share of the pie, which sometimes could be at the expense of value creation.

By contrast, the industry architecture literature has focused on the value capture aspect, furthering Teece’s (1986) insights on who benefits from innovation (Jacobides, Knudsen, and Augier, 2006; Jacobides, Veloso, and Wolter, 2013) and linking it to the theoretical underpinnings of work on modular architecture (Baldwin and Clark, 2000), itself rooted in the seminal work of Simon (1962) on complex systems. Papers in this research stream typically look at how the value created is distributed across different modules, also called industry segments, which comprise the producers of a similar type of product (Jacobides and MacDuffie, 2013; Jacobides, MacDuffie, and Tae, 2016). Firms that find themselves in the “bottleneck” component, or “the part of the firms’ or the industry’s system that is in most scarce supply” (Jacobides et al., 2006) are able to capture a disproportionate share of value (Baldwin, 2015).

However, this research stream focuses on the component (i.e., modules, or industry segments), rather than the firm, level as both heterogeneity and value capture are studied at the component level. Similarly, all firms in a bottleneck component are expected to reap the benefits, though the size of benefits may differ (Jacobides and Tae, 2015). Therefore we know less about individual firm outcomes and how heterogeneity within component, as opposed to between components, affects these outcomes.

To summarize, while we know that complements are crucial to value creation (Adner, 2017; Adner and Kapoor, 2010) and that this value may be unequally distributed among ecosystem participants (Jacobides et al., 2006; Jacobides and MacDuffie, 2013) we know less about how competition among producers in the focal component affects incentives of complementors and value capture of ecosystem participants. What drives the firms’ decision to make the complement com-

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20In this paper we use the term component.
21Jacobides and Tae (2015) seek to account for within-component heterogeneity by studying “kingpins”, i.e. very powerful firms in a component, and how they sustain the bottleneck position of the component, yet value capture is still considered at the component level.
compatible with multiple vs. just one product? How does a change in the value of the focal product affect this choice?

In this paper we seek to answer these questions by modeling competition between horizontally differentiated offerings of the focal product, and how the producers of complements and of the focal product react to unexpected changes in the value creating capabilities of these offerings. We test our predictions in the context of anti-HIV drug market, where the standard treatment is a combination of several drugs, and a clinical trial is needed to ensure compatibility between complementary drugs. Using individual-level data on drug consumption allows us to see the evolution in the value of different drugs. We then use these insights to study the changes in firms’ R&D strategies focusing on the decision to develop complementary drugs and to make the latter exclusive to a specific focal drug as opposed to making them compatible with multiple drugs.

Our contribution to the literature is threefold. First, we bring the discussion on value creation and value capture trade-offs (Brandenburger and Nalebuff, 1997) into the literature on ecosystems by incorporating both value creation and value capture considerations as the drivers of the firm’s ecosystem strategies. In doing so we also seek to bridge the literature on business ecosystems, which looks at value creation at the firm-level, and the industry architecture literature, which looks at value capture, but at the component-level. Furthermore, we explore the impact of competition that has been studied less in both these literature streams. We show that different positions in the focal product component lead to different strategic choices by the firms in terms of managing complements (Toh and Miller, 2017) and excluding others from the access to these complements. By exploring the strategy of the “winning” firm as well as the “losing firm”, we are able to show how such a firm may survive in an ecosystem.

Moreover, by looking at how changes in the value of the focal product affects firms’ strategies we further develop a dynamic perspective on ecosystems (Hannah and Eisenhardt, 2018; Kapoor and Agarwal, 2017). Finally, we link the constructs of this literature to the fundamentals of the value-based strategy framework (Brandenburger and Stuart, 2007, 1996; Chatain and Zemsky, 2011; MacDonald and Ryall, 2004). In doing so we hope on the one hand to elucidate the trade-offs
between value creation and value capture that firms face in the contexts of complementary products (Brandenburger and Nalebuff, 1997). On the other hand we seek to contribute to the literature on value-based strategy (Brandenburger and Stuart, 1996, 2007) by enriching the empirical research on the subject (e.g., Chatain, 2011) and by exploring the concepts of value creation and added value in the context of complementary products.

4.2 Theoretical development and hypotheses

We use a formal model to develop the hypotheses to be tested. The contexts where value can be created in combination with complementary products often feature complex interactions making them amenable for the use of formal modeling that can help disentangle the effects. We develop the model using the framework of value-based strategy (Brandenburger and Stuart, 2007, 1996; MacDonald and Ryall, 2004) that considers value creation and value capture by coalitions of players, and is particularly well-suited to analyze the contexts with complementary products. We model a setting with two complementary components: a base component $B$ and an add-on component $A$. Each component may feature several alternative offerings by different firms$^{22}$. The value for the final customer can only be created by a bundle $\{B_i, A_j\}$; in other words, $V(B_i, A_j) > 0$, $V(B_i) = 0$, $V(A_j) = 0$. Actors within the same component are substitutes, while actors from different components are complements.

Base component $B$ comprises two firms, $b_1$ and $b_2$, each offering one unit of a product $B_1$ and $B_2$, respectively. $B_1$ and $B_2$ are horizontally differentiated. We use a Hotelling spatial differentiation model, where customers are uniformly distributed along a linear city at location $x$ in interval $[0, 1]$. We introduce heterogeneity in the base component by having a share $a$ of the customer base for which $B_2$ cannot create any value, i.e. $V(B_2, A_j) = 0$. For instance, $B_2$ may be incompatible with customers in segment $a$, while $B_1$ is compatible with all customers. We will call $B_1$ a “broad” actor, and $B_2$ a “narrow” actor in the base component. Therefore, the customer located at $x^* = \frac{1}{2-a}$ is indifferent between using combination with $B_1$ or $B_2$; the customer to the left of $x^*$ will choose

$^{22}$These components can be viewed as segments of the industry sector in the industry architecture literature (Jacobides et al., 2006), or modules (Baldwin and Clark, 2000), in that they unite the firms producing the versions of the same component.
a combination containing $B_1$, while the customers to the right of $x^*$ will choose a combination with $B_2$.

In the add-on component $A$, there is an incumbent firm $a_1$ with product $A_1$ that can create value $V$ in combination with each base $B_i$, and a new entrant $a_2$ offering $A_2$ that can create $V(1+R)$ when combined with a base $B_i$. The parameter $R$ denotes the superior quality of the new add-on complement. Figure 5 summarizes the model, and Figure 6 provides a graphical representation of the model. Therefore, the total value creation in the baseline case with incumbent $A_1$ is given as

$$V(B_1, B_2, A_1) = \int_0^{1/a} V(1-x)dx + \int_{1/a}^{1} V\frac{x-a}{1-a}dx = V\left(\frac{3-2a}{2(2-a)}\right).$$

The new entrant $A_2$ allows to create higher value, thus the preferred bundles are $\{B_1, A_2\}$ and $\{B_2, A_2\}$. The total value creation will be:

$$V(B_1, B_2, A_1, A_2) = \int_0^{1/a} V(1+R)(1-x)dx + \int_{1/a}^{1} V(1+R)\frac{x-a}{1-a}dx = V(1+R)\left(\frac{3-2a}{2(2-a)}\right).$$

However, in order to be able to create value with a base the add-on has to be compatible with that base, and that compatibility has a cost. The new add-on has to invest $I_{B_1}$ to be compatible.
with $B_1$ and $I_{B_2}$ to be compatible with $B_2$. Importantly, the add-on has to invest as per each base, in other words, if the add-on wants to be compatible with both bases it has to invest $I_{B_1} + I_{B_2}$. For the sake of simplicity we assume that these investments are equal (i.e., $I_{B_1} = I_{B_2}$).

We use the model to understand the actors’ choices in terms of compatibility with a specific base, and how these choices change when the value of the base changes. In particular, we focus on how the compatibility choices change when the narrow base $B_2$ becomes narrower (i.e., its customer base becomes more constrained). First we adopt the add-on producer perspective and look at the choice of $A_2$ as to whether pursue compatibility with both bases or just one. Then we adopt the perspective of the producers of the bases, who can also invest in the development of a new add-on. We then analyze whether the base producer chooses to keep its add-on exclusively compatible with its own base, or to make it compatible with both bases. We should emphasize that the bundle is ultimately chosen by the customer, however, the firms can affect which bundles are available to the customer.

We follow Brandenburger and Stuart (1996) to solve the model and calculate the payoffs of
each actor. The payoffs represent a range from the minimum to the maximum payoff that an actor can expect, which depend on the actor’s added value (i.e., the difference between the value created by the coalition of all actors and the value created if the actor is removed from the coalition) and the other actors’ added values. Each actor will have a guaranteed minimum payoff, however, an actor may capture more, up to the maximum payoff, which will depend on the actor’s bargaining capabilities. The minimum payoff is guaranteed by the competition that exists for that particular actor, or, in other words, if a given actor is in a scarce supply, then it has a high chance of having a positive minimum payoff (MacDonald and Ryall, 2004).

Here the value is created and split between the customer, $B_1$, $B_2$, $A_1$, and $A_2$. We use the method proposed by Montez, Ruiz-Aliseda, and Ryall (2017) to compute the payoffs. We further assume that the customer is only able to capture its minimum payoff, i.e., the customer will capture only what is guaranteed by the competition, and will not be able to bargain for more. This assumption allows us to significantly ease the exposition and concentrate on the interaction between the producers of bases and add-ons (and avoid a three-way bargaining between the customer, the base producer, and the add-on producer). This assumption is also consistent with the real-world situation where a limited number of firms faces a large number of customers who are not able to bargain individually with the firms. Detailed calculations are provided in appendix B.2.

First let us consider the choice of the producer of add-on $A_2$. Calculating the added value of the bundles $\{A_2, B_1\}$ and $\{A_2, B_2\}$ it is evident that the value creation by the add-on is augmented when $A_2$ partners with the broad base $B_1$. Intuitively, if $A_2$ were to choose only one base to be compatible with it would choose $B_1$. Thus the choice for $A_2$ is essentially whether to invest in compatibility with $B_2$ in addition to establishing compatibility with $B_1$. This choice is driven by two effects: the effect on value creation and the effect on value capture.

On the one hand, if $A_2$ chooses to invest in the compatibility with $B_2$ it can create higher value for the customers who prefer $B_2$ to $B_1$. This value will then be split among the customers, $A_2$ and $B_2$. As we assume that the customer will only be able to capture the minimum payoff, we can denote the remaining value that is split between $A_2$ and $B_2$ as $\pi_{A_2}^{\text{with}B_2}$. From the value creation
standpoint it makes sense for $A_2$ to invest in the compatibility with $B_2$ if the value that $A_2$ expects to capture is enough to cover the investment. Formally, we write $(1 - \alpha_{B_2}) \pi_{A_2}^{\text{with } B_2} - I_{B_2}$, where $\alpha_{B_2}$ is the bargaining power of $B_2$ vis-à-vis $A_2$. This is what we call the value creation effect. Intuitively, as $B_2$ becomes narrower (i.e. as $a$ increases) this effect goes down as the value creation opportunity with $B_2$ shrinks.

On the other hand, not being compatible with $B_2$ results in a lack of viable substitute for the bundle $\{A_2, B_1\}$ for the customers who prefer $B_1$ (the customers to the left of $x^*$ in Figure 6). Importantly, while these customers would have still preferred the bundle $\{A_2, B_1\}$, not having the bundle $\{A_2, B_2\}$ available at all means that the only alternative remaining to these customers is the bundle $\{A_1, B_2\}$ which creates less value compared to $\{A_2, B_2\}$. This results in a higher added value by the bundle $\{A_2, B_1\}$ (while the value creation by $A_2$, $B_1$ and customers to the left of $x^*$ is unchanged). Because the minimum payoff depends on the competition, not having a substitute bundle will result in a lower minimum payoff for the customers who prefer $B_1$. In other words, the removal of the bundle $\{A_2, B_2\}$ allows $\{A_2, B_1\}$ to appropriate more value at the expense of their customers. We denote the change in the added value of the bundle $\{A_2, B_1\}$ as $b$, and we formalize the effect as $(1 - \alpha_{B_1})b$, where $\alpha_{B_1}$ is the bargaining power of $B_1$ vis-à-vis $A_2$. We call this effect the effect on value capture. This effect, similarly to the effect on value creation, also decreases in $a$. The intuition behind is that as $a$ increases (i.e., $B_2$ becomes narrower) the threat from $B_2$ and the bundles formed with it also decreases. Therefore, alleviating the threat from $B_2$ matters less.

We have thus two effects that decrease in $a$, albeit at a different speed. The decision of $A_2$ depends on which effect will dominate. Formally, we write the decision by $A_2$ as

$$(1 - \alpha_{B_1})b - ((1 - \alpha_{B_2}) \pi_{A_2}^{\text{with } B_2} - I_{B_2}).$$

If the first part dominates (the value capture effect), then $A_2$ is better off being compatible only with $B_1$. If the second part dominates (the value creation effect) then $A_2$ is better off being compatible with both $B_1$ and $B_2$. Importantly, we want to understand how the relationship between the effects
changes with \( a \), which represents the “narrowness” of the narrow base \( B_2 \). Figure 7 provides an illustration. The two top panels of Figure 7 graph the two effects as a function of \( a \). We show that, depending on the value creation, investment cost, and superiority of the new add-on over the incumbent it may sometimes be beneficial for \( A_2 \) to be compatible only with \( B_1 \) when the difference between the bases is small (low levels of \( a \)), while at medium levels of \( a \) it is better for \( A_2 \) to be compatible with both bases. It also shows that when the narrow base is very narrow (high levels of \( a \)) \( A_2 \) is better off being exclusively compatible with \( B_1 \). We can thus expect that as the narrow base \( B_2 \) becomes narrower \( A_2 \) will have incentives to pursue compatibility with \( B_1 \) only.

**Hypothesis 1** As the market for the narrow base shrinks, add-on complements will be more likely to form bundles with the broad base, but not with the narrow base.

Let us now consider the choices by the producers of the bases who have an option to invest in the production of the add-on. These choices will be driven by the value creation and value capture effect described above. To avoid repetition we will thus highlight only the difference from the previous case and how they affect the decision of the base producers.

We will first focus on the decision by the producer of the broad base \( B_1 \). From the previous analysis we know that it will have the supply of good complements, and as the competing narrow base \( B_2 \) becomes narrower, the add-on will have an incentive to be exclusively compatible with \( B_1 \). However, own production of the add-on implies that the producer of \( B_1 \) will be able to keep the full value created by the bundle (after the customer captures its due). And if \( B_1 \) chooses to make its add-on compatible with \( B_2 \) it will also be able to appropriate a portion of the value created by the bundle \( \{A_2, B_2\} \).

Assuming that there is a cost to the development of the add-on, as long as this cost is not too high the base producer is better off developing the add-on itself. Then \( B_1 \) faces the choice similar to the one discussed previously: the effect on value creation means that \( B_1 \) benefits from making its add-on compatible with the rival base \( B_2 \) as it can appropriate a portion of the value created, while the effect on value capture suggests that \( B_1 \) benefits from making its add-on exclusive to itself because it deprives the customer from an alternative bundle. Because \( B_1 \) now owns the full
bundle and does not need to share value with the producer of the add-on, the later effect is even more pronounced (see the bottom left panel of Figure 7).

**Hypothesis 2** As the market for the narrow base shrinks, the broad base will be more likely to invest into add-on complements and make them exclusive to the broad base.

Finally, we will consider the decision of the the producer of the narrow base $B_2$. Given the predictions of Hypotheses 1 and 2 the narrow base will face a limited supply of good add-on complements. It will thus have incentives to invest itself in the development of good add-ons to be able to create higher value. It will then choose whether to make its add-on compatible with the rival base $B_1$. While its choice will be driven by the same two effects, the effect on value creation is no longer decreasing in $a$. As the customer base of $B_2$ shrinks it stands to gain more from making its add-on compatible with $B_1$ (the bottom right panel of Figure 7). At higher levels of $a$ the effect on value creation will dominate the effect on value capture. Therefore, the owner of the narrow base $B_2$ will have incentives to makes its add-on compatible with both its own base $B_2$, but also with the competing base $B_1$.

**Hypothesis 3** As the market for the narrow base shrinks, the narrow base will be more likely to invest into add-on complements and make them compatible with other bases.

While we predict that both actors in the base component will tend to invest in add-on complements, the mechanisms driving this choice, as well as the ensuing strategy of open vs. exclusive complements, are quite different. The narrow base $B_2$ invests out of necessity to compensate for the lack of good complements (which prefer to partner with the broad base $B_1$, as Hypothesis 1 suggests), and cannot afford to make its add-on complements exclusive due to its limited customer base. By contrast, the broad base $B_1$ invests in order to leverage its position as a bottleneck and capture more of the added value of the bundle, and does this by developing add-on complements and keeping them exclusive to its base $B_1$. This shows that while some of the behavior is similar, the motivations are very different.
(a) Choice of add-on producer, lower $I_{B_2}$

(b) Choice of add-on producer, higher $I_{B_2}$

(c) Choice of broad base $B_1$ producer

(d) Choice of narrow base $B_2$ producer

Figure 7: Comparison of value creation and value capture effects for $A_2$
4.3 Empirical context

We test our hypotheses in the context of the anti-HIV drug market. It is particularly amenable to our research because anti-HIV treatment represents a combination of several drugs, usually referred to as a “cocktail”, rather than a single drug. A standard treatment combines three antiretroviral drugs from different drug classes.\footnote{Sometimes the combination includes a fourth drug acting as a booster for the efficacy of the main drug. We do not focus our attention on the booster drug as it can be considered an adjuvant drug rather than the main drug of interest in a combination.} Such combination is more effective compared to a standalone drug because if the virus develops a resistance to one drug, the other drugs in the cocktail can still control the virus.

After the discovery of the HIV virus in 1983, the first anti-HIV treatment was approved in 1987. It was a drug belonging to the NRTI (nucleoside reverse transcriptase inhibitors) drug class (zidovudine by GlaxoSmithKline). In the following years several other drugs, both from NRTI and from other classes, came to the market. However, while these drugs provided a temporary improvement for the patients, the virus quickly developed resistance to the treatment, and many patients experienced a relapse of the disease.

The major breakthrough that shaped the HIV market until today came in 1996. A combination treatment of at least three drugs from different drug classes was found more effective than a single drug, because different mechanisms of action are better at keeping the virus at bay, and even if the virus develops resistance to one drug the remaining two drugs will still be active (Gulick et al., 1997). A three-drug combination of two drugs belonging to the NRTI drug class, and one drug belonging to another class has been the standard treatment ever since.

Therefore, an anti-HIV drug combination can be generally split into two parts. The first is commonly referred to as a treatment “backbone” and consists of two drugs from the NRTI (nucleoside reverse transcriptase inhibitors) drug class, and the second one is known simply as a ‘third agent’. This third drug is chosen among multiple drug classes, each featuring several alternatives.\footnote{As of now there are five drug classes among which the third drug is selected: NNRTI (non-nucleoside reverse transcriptase inhibitors), PI (protease inhibitors), FI (fusion inhibitors) and EI (entry inhibitors), IN (integrase strand transfer inhibitors), and CCR5 antagonists. In earlier years an NRTI drug (the “backbone”) could also be selected, but in late 2000s this practice became rare.}
though all drugs belong to the antiretroviral group the medical guidelines and recommendations always make the distinction between these two parts of the treatment. The two treatment parts map directly onto the two-component theoretical model: the base component represents the treatment backbone class, and the add-on component take the role of the third agent.

Biopharmaceutical firms generally concentrated their efforts in only one of the treatment parts (either treatment backbone (base), or the third agent (add-on)), as can be seen from Figure 13. Importantly, while some firms that originally produced base drugs later started manufacturing add-on drug, the firms that originally started with the add-on drugs did not go into the base component. Moreover, two out of the four firms that were involved in both add-on and base components (Roche and Bristol-Myers Squibb) could be considered add-on firms as their base drugs went out of use throughout 2000s.\textsuperscript{25} The other two firms, ViiV Healthcare and Gilead Sciences initially focused on the base drugs only, and only later started developing add-on drugs.

This separation between the two treatment parts is important as it makes them the semi-

\textsuperscript{25}Roche withdrew its only base drug, \textit{zalcitabine}, from the market in 2006. The two base drugs of Bristol-Myers Squibb, \textit{didanosine} and \textit{ stavudine}, had their use decline over 2000s.
independent components of the ecosystem rather than two different product lines for a single firm, and creates co-dependence between the firms. Furthermore, because the virus can develop resistance to the treatment it is paramount that the combination that is expected to create the highest medical value for the patient and reduce the possibility of developing resistance is selected. In addition, as the patient has to keep on taking the treatment for the rest of her life the choice of combination is highly individual with respect to patient’s co-existing conditions, and horizontal differentiation among drugs plays a large role. This implies that even if a firm producing a base drug also has an add-on drug in its portfolio it will still depend on other add-on producing firms to create medical value for the patients.

We now delve into more details about each component to explain the key features of the market that make it amenable to testing our hypotheses.

**Base component and unexpected shock to its value.** The base component, or the treatment backbone, consists of two drugs (NRTI class) which are selected among nine different molecules. We will refer to the combination of these two drugs as the “base”. Four firms were active in producing the drugs for this component, with two firms becoming the main contenders since mid-2000s: GlaxoSmithKline/ViiV Healthcare (in 2009 GlaxoSmithKline transferred its HIV assets to ViiV Healthcare where it owned 80% stake, thus for simplicity sake we shall refer just to ViiV Healthcare) and Gilead Sciences. ViiV Healthcare owns three drugs forming two bases: *zidovudine* + *lamivudine* and *abacavir* + *lamivudine*. Gilead Sciences owns *tenofovir* + *emtricitabine* and *tenofovir alafenamide* + *emtricitabine* bases, where *tenofovir alafenamide* is a safer version of *tenofovir* molecule. Because *tenofovir alafenamide* was approved in 2016, it leaves three main bases competing during most of the time.

The main interest lies in the first drug of the combination, as the alternatives for the second drug (*lamivudine* and *emtricitabine*) are similar in terms of their efficacy and safety.\(^{26}\) Regarding

\(^{26}\)While in theory the doctors could mix and match the first drug with either *lamivudine* or *emtricitabine*, they tend to prescribe the bases as suggested above. This could be explained by marketing efforts of the firms, but also by the fact that both firms developed single pills containing two molecules for their bases. Therefore, if the doctor or the patient wants to mix the base drugs from different firms the patient will have to take two separate pills as opposed to one if the patient uses the base drugs owned by the same firm. We thus consider the choice of the second base drug as largely determined by the choice of the first drug, and not vice versa.
the drugs owned by ViiV Healthcare the first base drug, *zidovudine*, was the first anti-HIV drug approved, and was used quite a lot in earlier years. However, in mid-2000s *zidovudine* was recognized as more toxic than other available alternatives, notably *abacavir* and *tenofovir*, and its use has declined over time. *Abacavir* was developed later, and faced a number of limitations in terms of its use as it was originally considered a high-risk drug due to the dangerous side effects associated (hypersensitivity). The drug of Gilead Sciences, *tenofovir*, on the other hand was viewed as a very good one in terms of efficacy and safety.

In 2008 a clinical trial conducted by AIDS Clinical Trials Group (ACTG) comparing *abacavir*+*lamivudine* to *tenofovir*+*emtricitabine* found that *abacavir* has lower efficacy compared to *tenofovir* in patients with higher viral load (Grant et al., 2013), resulting in *tenofovir* being a preferred option in this group of patients. ACTG is a major research organization working on HIV and AIDS, funded by the US National Institutes of Health, and its trials have considerable implications for the standards of treatment. This trial was fully sponsored by ACTG, without any industry involvement. Furthermore, the focus of the trial was ostensibly on the use of new add-on drugs rather than explicitly on the performance of different bases. Therefore we can consider this trial as an *exogenous shock* that has reduced the attractiveness of *abacavir* as a base drug for a certain patient population. The study started in September of 2005 and was completed in November 2009, however, already in 2008 the medical guidelines cited the results of this study, which is why we can consider 2008 as the year in which the customer base of *abacavir* shrunk further.

To conclude, we can think of three main periods featuring different broad base: 1990s when *zidovudine* could be considered as a broad base, the first half of 2000s when the leadership was contested between *zidovudine*, *tenofovir*, and *abacavir*, with *abacavir* being a narrow base and *tenofovir* emerging as a broad base, and post-2008 period when the base component was effectively contested between *tenofovir*, a broad base, and *abacavir*, a narrow base.

**Add-on component.** The add-on component, or the “third agent” features overall twenty one molecules. It has experienced three generation of drugs: drugs approved in 1990s, early half of 2000s, and second half of 2000s and beyond. While older drugs are still being used occasionally
(as some patients may be intolerant to newer drugs) newer generation of drugs generally substituted older generation as the former had better efficacy and/or safety profiles. By contrast, in the base component there was no new molecule on the market since 2003 (with the exception of tenofovir alafenamide, which was just an improved version of an existing molecule). The implication is that from a standpoint of a firm producing base drugs it was crucial that firm developing a newer add-on drug uses the former’s base in a bundle, for instance by using the base as a complement in the clinical trials on the efficacy and safety of the add-on drug. Table 19 lists the anti-HIV drugs that are approved or that have been investigated in clinical trials, their approval date in the US (FDA, or Food and Drug Administration), in Europe (EMA, or European Medicines Agency), and the the year when the drug was approved for commercialization in France.

**Clinical trials design and drug compatibility.** Another important feature of the market is that while it is necessary to combine several drugs to create value for the patient the doctors cannot prescribe a combination that has never been tested in a clinical trial. In other words, a clinical trials provides the compatibility between the drugs. In fact, the impact of a clinical trial is twofold: first, the design of a clinical trial (i.e., which drugs are used as complements to the main drug of the trial) directly affects the capability of the doctors to prescribe the given combination, and, secondly, it affects which combinations are included in the medical recommendations, which also affect the doctors’ prescribing behavior. Therefore, from the standpoint of the firm producing base drugs it is vital that its base is included in the trial with a new-generation add-on drug.

**Fixed-dose combinations.** Originally the standard HIV treatment consisted of three pills which placed a significant burden on the patient in terms of adherence and convenience. To make the administration of a drug cocktail more convenient firms started to develop single pills containing two or more molecules (the so-called fixed-dose combinations, or FDC). For instance, GlaxoSmithKline developed a single pill containing zidovudine and lamivudine, and later another single pill containing abacavir and lamivudine. Similarly, Gilead Sciences developed a single pill for tenofovir+emtricitabine (this has contributed to the fact that the base drugs from different firms (e.g., tenofovir+lamivudine or abacavir+emtricitabine) are rarely used together).
Even more interesting was the development of a single pill containing all three molecules. The first one was approved in 2006, and in the recent years most of the new add-on drugs have been developed as single pills. Because single pills offer higher ease of administration to HIV patients they can result in a higher adherence to treatment. At the same time developing an add-on molecule as a part of an FDC pill with a certain base means physically precluding another base from using that add-on. Thus the strategy of developing FDC pills as opposed to standalone pills can be seen as seeking higher value creation but also higher value capture by pursuing unique complements.

4.3.1 Consumption of anti-HIV drugs

In order to confirm the shifts in the value of different drugs we use the individual-level data on the consumption of anti-HIV combinations. We use the *Echantillon Generaliste Beneficiaire* database which is a unique dataset of individual-level healthcare consumption in France provided by the French State Health Insurance. It is a quasi-random sample of 1/97th of the French population tracking all medical acts, including drug purchases, which were reimbursed by the insurance.\(^{27}\) As of now the database includes around 680,000 individuals.

We selected all individuals who consumed HIV drugs and then identified the combinations of drugs that they were prescribed (most patients bought all drugs of the combination on the same date; we checked patients' purchase patterns and time lag between the consecutive purchases to account for separate drug purchases). We chose to focus on the patients’ first choice of treatment as this choice is critical for two reasons. First, once the treatment is chosen the patient has to keep on taking it lest the disease progresses. Secondly, because the virus can develop resistance to the treatment very quickly (in 3 weeks), and resistance to one of the drugs in a combination can “contaminate” the whole combination (patient becomes resistant to all drugs in a combination) choosing the right treatment at the beginning is paramount. Therefore, the first treatment choice

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\(^{27}\)This database was created in 2005 by including the individuals whose social security number ended with a two randomly selected digits. The social security number in France consists of fifteen digits. The last two digits of the social security number, or “control key”, represent the remainder from the division of the number formed by the first thirteen digits of the social security number by 97, and they range from 01 to 97. The database tracks reimbursed medical acts of the individuals with the selected digits since 2005, and retrieved their reimbursement data in 2003 and 2004.
is highly individual and the treatment selected should normally be expected to provide the highest value for the patient. This resulted in 893 HIV patients over 2004-2016.

Figure 9 shows the number of patients per year by the base selected. We can see that the three bases – zidovudine+lamivudine, abacavir+lamivudine, and tenofovir+emtricitabine – indeed, dominate the market. We further confirm that the use of the first drug of the base without the second one is very limited (the dotted areas on the graph) and we can therefore confidently concentrate on the base combinations. The graph confirms the changes in the value of the bases over time: an earlier period with zidovudine+lamivudine as a broad base, pre-2008 period of competition among the three bases, and later period when tenofovir+emtricitabine has emerged as a broad base, with abacavir+lamivudine as a narrow base, and the use of zidovudine+lamivudine went to virtually zero.

We also conducted a quantitative analysis of the individual level data (details provided in appendix B.3). We found that across the years combinations that included tenofovir+emtricitabine had a probability higher in the range of 0.2-0.3 to be selected as the first choice treatment, whereas for abacavir+lamivudine the effect was around 0.1 across the years, in most cases it was not statistically significant. Furthermore, we found that in late 2000s the inclusion of a good-quality add-on drug (usually, a newer generation add-on) became important as it resulted in a 0.15 higher probability of the combination being selected. These results support our intuition regarding the base drugs (tenofovir+emtricitabine as a broad base) and the importance of the base drug to be tested in combination with a good add-on drug.

4.4 Empirical analysis

4.4.1 Data and method

Because the doctors can only prescribe the combinations that has been tested in a clinical trial we look at the decisions regarding anti-HIV clinical trials’ design to test our hypotheses. Specifically, we look at the choice of base in the trials of add-on drugs. Clinical trials have traditionally been viewed as strategic investment given the cost and the effort required. As we explained before, the
Figure 9: Number of patients consuming anti-HIV drugs by base in a representative sample of French patients

The choice of base in an add-on trial has a two-fold effect: the base cannot be used with an add-on unless they have been tested together tested in a trial, and the base would not be considered a part of a high-value combination in medical guidelines unless that combination has been tested in a sufficiently large late-stage trial. Therefore, considering the impact of these trials we can expect that firms would approach the selection of the base drug strategically.

In this paper we focus on late-stage trials: phase III and phase II/III trials. These are the trials that are normally used in the drug’s registration and they are extremely costly to the firms due to the high patient enrollment requirements. As such we can view these trials as the embodiment of the firm’s ultimate commercialization intent. These are also the trials that are generally used by medical experts to develop the treatment guidelines. In addition, given the thriving innovation in HIV in the past years it is likely that clinical trials sponsors may have to adapt their phase III trial

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28Phase IV trials, which are postmarketing studies with the goal to ensure safety and efficacy of the drug in the general population, can also be an important input to the guidelines, however, these trials are observational, rather than interventional, meaning that the trial sponsor merely tracks the use of the drug of interest without making any choice as to how and with which complements it is administered.
design in response to the new entrants or new information about existing drugs.

Sample. We use the database of the clinicaltrials.gov website provided by the US National Library of Medicine. The website was created in 1997, and was made public in early 2000. Clinical trial sponsors (firms or non-profit actors, e.g., universities, research centers, hospitals, NGOs, etc.) submit information on clinical trials they intend to conduct to this website, and provide updated information until the study completion. While the website is US-based the firms and nonprofit actors usually publish their trials conducted in other countries as well. The database contains information on the trial’s start date, end date, first submission date, number of patients enrolled, trials status (completed, ongoing, withdrawn, terminated, etc.), trial sponsor, trial collaborators, sponsor type (industry, non-industry, etc.), city and country of the hospitals where the trial is conducted, phase of the trial, medical conditions involved, patient age and gender, and the intervention. For the latter the database provides the type of intervention, such as drug, biological (vaccine), device, behavioral (e.g. the impact of extra doctor visit, etc.) and the name of the specific intervention (e.g., the name of the drug). Importantly, the database distinguishes trial’s sponsor. Trial’s sponsor is the entity that makes decision on the trial design, whether the trial should be withdrawn, or terminated, whereas other entities (trial’s collaborators) merely provide the funding or drugs for the trial but are not decision makers.

From a set of 6,859 trial concerned with HIV, we removed trials that were not dealing with anti-HIV drugs, and we kept only later phase trials, resulting in 637 phase II/III and phase III clinical trials.

For each of these 637 trials we read the trial’s description on the clinicaltrials.gov and manually coded the characteristics of the clinical trial design and the trial type. While clinicaltrials.gov does provide the list of drugs used in the trial, we had to manually check what specific drug combinations were used, and based on this information we coded the key parameters of the trial design. We coded the main drug of interest in the trial, i.e. the drug whose efficacy or safety is ostensibly being tested. In most cases the database distinguishes between the experimental and the control groups of the trial, and specifies the drugs used in each group. Combined with the information provided in the
summary of the trial, and the title of the trial we identified the focal drug of the trial, and the complement drug(s) that were used in combination with the focal drug. If the trial was conducted on the base drug then the complement drug was the add-on drug, and vice-versa. In roughly half of the trials the complement drug is specified (usually in trials including naive patients), while in other trials the complement drug is referred to as “OBT” – optimized background treatment – in other words, any kind of appropriate complement can be used in combination with the drug of interest. The latter is often the case for trials on pre-treated patients: patients switch from the drug that they were using to the focal drug, while the rest of the combination may or may not change.

Based on the main drug of the trial we coded the type of the trial: whether it is an add-on trial, a base trial, or a trial on a full combination. The latter is the case when the trial summary does not specify the drug of interest and the trial tests the combination as a whole. We also coded whether the trial used only one designated complement drug (as opposed to multiple alternative complement drugs).

Similarly, we identified the comparator drug (the drug against which the focal drug is being tested, or placebo) and the complement of the comparator drug. In cases where either the trial summary explicitly stipulated that the trial compares several combinations, or it was impossible to determine the primary drug of interest we coded the trial as a multi-regime trial and considered all combinations as the combinations of interest. Based on the trial summary and the patient inclusion/exclusion requirements we also coded whether the trial enrolled naive, pre-treated patients, or both naive and pre-treated.

In the process of the manual check we have further identified trials which were conducted in HIV-infected patients but focused on the treatment of HIV complications or associated diseases. After removing those our dataset contained 476 trials, and one more trial was dropped due to its highly unusual design, resulting in the final dataset of 475 trials (and 898 combinations that were tested as the focal in those trials). We also excluded certain categories of trials that are either targeted at a specific patient population and thus involve drug combinations very different from standard treatment (e.g., trials on mother-to-child transmission prevention), or do not seek to
establish drug’s or combination’s superiority over the alternatives (e.g., trials designed to allow the patients the access to the drug in countries where the given drug is not approved yet), resulting in 333 trials. Finally, since our focus is on the choice of base as a complement for the add-on drug we limit the sample to the trials focused on testing an add-on drug or the full combination (thereby excluding trials where the drug of interest is a base drug) resulting in 264 trials.

_Dependent variable._ In order to test Hypothesis 1 we create three indicator variables for the use of each of the three main bases:

- **TenoEmtri**, a binary variable equal to 1 if the trial uses _tenofovir+emtricitabine_ or _tenofovir alafenamide+emtricitabine_ as a base,

- **AbaLami**, a binary variable equal to 1 if the trial uses _abacavir+lamivudine_ as a base,

- **ZidoLami**, a binary variable equal to 1 if the trial uses _zidovudine+lamivudine_ as a base.

Hypotheses 2-3 test the development of exclusive bundles. When a trial on an add-on drug uses only one specific base we consider this a proxy for the development of exclusive bundles. We create two indicator variables:

- **TenoEmtri Unique**, a binary variable equal to 1 if the trial _uniquely_ uses _tenofovir+emtricitabine_ or _tenofovir alafenamide+emtricitabine_ as a base (in other words, the trial does not use non-tenofovir base)

- **AbaZidoLam Unique**, a binary variable equal to 1 if the trial _uniquely_ uses either _abacavir+lamivudine_ or _zidovudine+lamivudine_ as a base, but no other bases. We grouped _abacavir_ and _zidovudine_ together because both are owned by Viiv Healthcare, therefore, if a trial uses both bases the bundle will still be exclusive to Viiv Healthcare.

We only focus on the combinations that were the focus of the trial, i.e. we do not consider the bases used in the control group of the trial. If multiple combinations were the subject of the trial

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29 We dropped the trials that we identified as focusing on the sexual transmission prevention, mother-to-child transmission prevention, timing of the treatment (in such trials the intervention of interest is the timing of the treatment rather than the drug per se), dosage (drug is compared to itself) and early access trials (the main purpose of the trial is to provide the previous trials’ patients with the drug under investigation in countries where the drug has not been approved yet).

30 _Tenofovir alafenamide_, or _TAF_, is a version of _tenofovir_ with a better safety profile developed recently by Gilead Sciences.
then the base in each combination is considered. The same trial can have more than one variable equal to 1 as the trial can test multiple combinations, or the add-on drug could use multiple base drugs.

**Independent variables.** The first main theoretical construct is the increase in the difference between the broad and the narrow bases. We use the exogenous shock that occurred in 2008 (the clinical trial sponsored by a nonprofit actor that established that *abacavir* has lower efficacy compared to *tenofovir* in patients with higher viral load). We create an indicator variable *Post2008* equal to 1 if the trial started in 2008 or later years. We assume that such trials would adjust the trial design based on the aforementioned study results.

Hypothesis 1 predicts the change in the behavior of the superior add-ons. We use the fact that most of the new add-on drugs have better efficacy and/or safety profiles that previous generation drugs. We use two ways to operationalize it. First, we construct a variable *AddonTimeSinceAvailability* which is equal to the number of years since the add-on drug became available for testing in phase III trials. We have estimated the year of drug availability for a phase III trial as the earliest year between the year when the interim results of the earliest phase II trial became available, and the year equal to three years prior to the drug’s approval by the Food and Drug Administration (FDA), a US drug approval agency. We used the FDA approval year as the firms usually register their drugs first in the US, and then in other countries; also for all anti-HIV drugs the FDA approval date precedes the approval date in Europe. In cases when a trial used several add-on drugs we chose the most recent one.

While for the majority of trials the start date of the trial was provided by the *clinicaltrials.gov*, for a subset of 29 trials this information was not available. In most cases these are older trials as the website started collecting the data in 1999. We have assumed that a phase III trial usually takes 2 years, and have estimated the start year based on the trial completion year, where available. For 22 trials that did not have completion year provided we used the first submitted year – the year when the firm makes the trial available to *clinicaltrials.gov* website – as the start year. The first submitted year is available for all trials. The main issue with this is that the earliest possible
submitted year is 1999, the year before the database became public, and therefore the actual start
date of the trial may be earlier. Therefore, for such trials we might overestimate the time since the
add-on availability as the true start year may be earlier than 1999. In other words, we may believe
that older add-on drugs were used in earlier trials. This would mainly represent a problem for
tenofovir: we expect to see that after 2008 new add-on drugs would be used more with tenofovir,
and overestimating the age of the add-on drugs used in trials with tenofovir before 2008 may
inflate the results. However, none of the 22 trials concerned used tenofovir as the base drug, which
assuages our concerns. For abacavir and zidovudine, as we expect that after 2008 newer add-on
drugs are less likely to be used with these bases, overestimating the age of drugs before 2008 would
lead to more conservative estimates.

In order to test Hypothesis 1 we need to show that after 2008 newer add-on drugs tended to use
tenofovir+emtricitabine more that abacavir+lamivudine or zidovudine+lamivudine. We therefore
use the interaction between Post2008 and AddonTimeSinceAvailability.

For Hypotheses 2 and 3 that predict the behavior of the firms producing the bases we created
two indicator variables for the firms owning the bases:

Gilead, a binary variable taking the value of 1 when the sponsor of the trials is Gilead Sciences,
and ViiV, a binary variable equal to 1 if the sponsor of the trial is GlaxoSmithKline (GSK) or ViiV
Healthcare. ViiV Healthcare was created in 2009 as a joint venture by GSK and Pfizer with GSK
holding 80% stake, and GSK transferred its infection diseases assets (including anti-HIV drugs)
to ViiV Healthcare. For this reason we combine the trials of these two firms (in earlier years the
sponsor is GSK, and in later years it is ViiV Healthcare).

Hypotheses 2 and 3 predict a change in the behavior in terms of developing exclusive bundles as
a function of the increase in the differentiation between the bases. We therefore use the interaction
between Post2008 and ViiV to test whether the behavior of ViiV Healthcare changes with respect to
using exclusively its own bases. We do not use the interaction for Gilead because Gilead Sciences
started to conduct phase III trials on add-on drugs only after 2008. We expect that the main effect of
ViiV will be positive (the owner of the base is more likely to use its base as an exclusive complement
than another firm), but the interaction $Post2008 \times Viiv$ to be negative to indicate the move of the inferior base owner towards open complements. Conversely, we expect that Gilead would have a positive effect indicating the development of exclusive bundle by the owner of the superior base.

**Control variables.** Given the limited sample size we carefully selected the most relevant control variables. We use the earliest between the patent expiry years in the US and the EU to control for the base being a generic drug. We control for whether the trial includes naive patients (as in trials on pre-treated patients only the complement base drugs are often not specified). We also control for whether the trial has a firm as a collaborator (as opposed to the trials fully funded by nonprofit actors).

**Econometric model.** Our unit of observation is clinical trial. Since our dependent variable is binary we use logistic regression with standard errors clustered at the sponsor level.

### 4.4.2 Results

Before starting the analysis of the add-on drugs trials we first checked the distribution of the trials on base drugs. This was important to understand the allocation of the innovative effort by the firms between the base and the add-on components. Figure 10 shows the number of trials where the main drug of interest was the base drug conducted in each year.\(^{31}\) Out of 333 trials only 51 trials focused on testing the base drug. Not surprisingly, most trials were conducted before 2001 (which was the year of tenofovir approval). In early 2000s most trials on base drugs tested fixed-dose combinations of abacavir+lamivudine and tenofovir+emtricitabine to demonstrate the equivalence of a single pill to two separate pills; these trials did not seek to prove the superiority of the molecule. After mid-2000s very few trials focused on base drugs, with the exception of Gilead Sciences trials on tenofovir alafenamide, a newer and safer version of their tenofovir molecule, in 2013-2015. Trials on older base drugs after 2005 were conducted in developing countries and sought to test whether low-cost old generation drugs could be used effectively and safely given budget constraints of the countries, rather than demonstrate drug’s superiority to competitors.

\(^{31}\)We consider the trials of single-pill formulations combining base and add-on drugs as the trials on add-on drugs as at this point the base drugs have already been available on the market, and the novel molecule is the add-on drug.
Phase II/III and phase III clinical trials on base drugs, number of trials

Figure 10: Phase II/III and phase III clinical trials in base drugs

From this we can infer that the discovery and the development of new base drugs was largely over by early 2000s, development efforts afterwards were mostly targeted at incremental improvement and sustaining of the existing drugs. A good illustration is the example of apricitabine, a base drug that was discontinued in 2010 after its developer, Avexa, failed to find the partner for further development after competing phase II/III trial in 2009 (see Figure 10). The reasons for the reluctance of the potential partners to engage in the development of apricitabine were the existence of attractive competitors in the market (at this point tenofovir+emtricitabine became the most widely used base), potential difficulties of developing a single-pill combination, and uncertainty about efficacy in combination with some of the new drugs\textsuperscript{32}.

We can thus conclude that the search for the base drug was effectively over once tenofovir has “won the battle” as a broad base (followed by its improved version), and firms had little incentives to further invest in the base component. The source of further improvement were thus the add-on drugs (the “constraint component” in the framework of Ethiraj (2007)). These findings highlight

\textsuperscript{32}Source: http://www.hivandhepatitis.com/recent/2010/0511_2010_d.html
an interesting tension between different definitions of the bottleneck. In the language of research on complex systems (Ethiraj, 2007) it is the add-on component that became the bottleneck: once the best base was found further improvements to value creation had to come from the add-on component (as evidenced by the lack of investment in the base component development and switch to add-on drug trials). Yet in the framework of the industry architecture literature (Jacobides et al., 2006) the bottleneck is the base component, specifically, *tenofovir*, as it is in the most scarce supply for add-on drugs to partner with.

We will now turn our attention to the trials in add-on drugs and the choice of the base drugs in such trials. Table 3 reports the descriptive statistics and correlations between variables. Table 4 presents the results of logistic regressions for the probability of each of the three main bases to be chosen in a trial. Models 1-3 show the results of the analysis for testing Hypothesis 1. To test Hypothesis 1 we removed from the sample the trials where the sponsor was the owner of the base of interest (otherwise we would have encountered an endogeneity problem as a firm owning base drugs may develop add-on drugs and test them with their own base drugs). Thus for the regression with *TenoEmtri* as the dependent variable we remove trials where the sponsor is Gilead Sciences (leaving us with 228 trials), and for the regressions with *AbaLami* and *ZidoLami* as dependent variables we remove the trials where the sponsor is GlaxoSmithKline (GSK) or ViiV Healthcare (reducing the sample to 223 trials).

We first notice that *Post2008* has positive and significant coefficient for *tenofovir+emtricitabine* outcome, while negative and significant coefficient for *zidovudine+lamivudine*. Computing average marginal effects for *Post2008* gives that after 2008 trials were 0.21 (p < 0.01) more likely to use *tenofovir+emtricitabine* as the base complement, and 0.11 (p < 0.05) less likely to use *zidovudine+lamivudine* as a complement base. For *abacavir* the marginal effect of *Post2008* is −0.04, though not significant. These results are in line with our intuition that trial sponsors react to the fact that *tenofovir* has become a widely used base drug and that the use of *zidovudine* has declined over years as it has been shown to be more toxic than *tenofovir* and *abacavir*.

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33We had to remove the control variable *BaseGx* from the regression with *ZidoLami* as the dependent variable because the pattern *BaseGx= 0 and Post2008= 1* predicted the outcome *ZidoLami= 0* perfectly.
Table 3: Descriptive statistics and pairwise correlation for variables used in the regression analysis

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<th>SecondGenAddon</th>
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<th>ViiV</th>
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* Standard errors clustered at sponsor’s level in parentheses
** $p < 0.1$, *** $p < 0.05$, **** $p < 0.01$
The interaction coefficient on Post2008*AddonTimeSinceAvailability is negative in Models 1-2, and positive in Model 3, though not significant. However, coefficients of interaction terms in non-linear models cannot be interpreted directly as the marginal effect of a variable is conditional on other variables. Therefore, to understand whether the decision to use a base drug pre- and post-2008 differed depending on the age of the add-on drug tested we look at the average marginal effect of Post2008 at different levels of AddonTimeSinceAvailability. Figure 11a shows the average marginal effect of Post2008 on the probability of using tenofovir+emtricitabine as a base complement. It is positive and significant when the trial is conducted on newer add-on drugs (low levels of AddonTimeSinceAvailability), it decreases along AddonTimeSinceAvailability and becomes non-significant when the trial uses older add-on drugs. For instance, trials on add-on drugs that have just came out of phase II trials (AddonTimeSinceAvailability equal to 1 or 2 years) are 0.27 ($p < 0.01$) more likely to use tenofovir+emtricitabine as the base complement after 2008 compared to before 2008, whereas the difference is smaller and not significantly different from 0 for trials using older add-on drugs.

We get the opposite picture when we graph the average marginal effect of Post2008 on the probability to use zidovudine+lamivudine (Figure 11c): is negative and significant for lower levels of AddonTimeSinceAvailability, i.e. newer drugs, and increases with higher levels AddonTimeSinceAvailability. Trials on the newest add-on drugs are 0.17 less likely to use zidovudine+lamivudine as the base complement after 2008 compared to pre-2008.

For abacavir+lamivudine the average marginal effect of Post2008 is negative, but not significant for the whole continuum of AddonTimeSinceAvailability (Figure 11b), though it appears to be slightly more negative for newer drugs. When we computed predictive margins of Post2008 we could see that if all trials were set after 2008 the average use of abacavir+lamivudine would be lower compared to the same outcome if all trials were set before 2008, though the difference between pre- and post-2008 is not statistically significant. The reason for this result could be that there were objectively few trials that used abacavir+lamivudine as a base making it difficult to achieve statistical significance for the pre- and post-2008 difference.
We conducted a further test of Hypothesis 1 by using *TenoEmtri Unique* as a dependent variable: we wanted to see whether newer add-ons tended to use *tenofovir+emtricitabine* as the *only* base complement. Model 4 shows the results, and Figure 11d graphs the average marginal effect of *Post2008*. The effect size is smaller than in Figure 11a but we can see a similar trend: trials on newer add-on drugs tended to use *tenofovir+emtricitabine* as the *only* base complement after 2008.

Overall, these results suggest that trials testing newer drugs, or combinations containing newer drugs, were associated with higher use of *tenofovir* as a base drug after 2008 compared to pre-2008, while less potent bases were used less, which is consistent with Hypothesis 1.

We will now turn our attention to Models 5 and 6 in Table 4 that test hypotheses 2 and 3. They predict that both firms would invest in the add-on component, but that the broad base owner will tend to develop exclusive complements, while the narrow base owner will make the complements compatible with other bases. Model 5 looks at the use of *tenofovir* as a unique base complement. Because Gilead Sciences conducted all of its trials on add-on drugs after 2008 the effect of *Gilead* will include both the sponsor’s effect and *Post2008* effect. We see that the coefficient of *Gilead* is positive and significant, indicating that *tenofovir* is more likely to be used as a unique base complement when the clinical trial is sponsored by its owner, Gilead Sciences. Computing average marginal effects gives us a 0.42 higher probability (*p* < 0.01) that a clinical trial on an add-on drug conducted by Gilead Sciences will use its own base as a complement.

Turning to Model 6, which looks at the use of the base drugs owned by ViiV Healthcare, *abacavir* or *zidovudine*, as a unique base complement gives additional interesting results. Because in non-linear models we cannot interpret the interaction term directly we compute average marginal effects at each level of the two variables (*ViiV* and *Post2008*), and then compute the difference-in-difference in average marginal effects. A trial sponsored by ViiV has a 0.31 higher probability of using ViiV-owned bases as a unique complement if it takes place before 2008, while after 2008 the effect is only of 0.12 (marginally significant, *p* = 0.066). The difference in these marginal

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34In Model 6 we exclude *Gilead* as an independent variable because *Gilead* = 0 predicted the negative outcome perfectly, and these observations were dropped from the regression by Stata.
Figure 11: Average marginal effects of Post2008 on the choice of the complement depending on the add-on drug’s time since availability for phase 3 trial
effects is negative and statistically significant, $-0.19$ ($p < 0.05$). Note that these results do not mean that ViiV Healthcare decreased the use of its bases in its trials. Rather, it means that before 2008 ViiV Healthcare was more likely to develop its add-on drugs as exclusive bundles with its own bases, while after 2008 it was less likely to develop exclusive bundles. In other words, ViiV Healthcare could run a trial using, for instance, both abacavir and tenofovir as a base complement. By contrast, Gilead Sciences was highly likely to conduct the trials on add-on drugs using its base drugs as a unique complement. Overall, these results are consistent with Hypotheses 2 and 3 in that the owner of superior base will tend to develop its add-on products as exclusive complements to its base products, while the owner of the inferior base will tend to keep its add-on products open.

4.4.3 Analysis of R&D strategies of base producers

We took an in-depth look at the clinical trials sponsored by Gilead Sciences and ViiV Healthcare to glean further insights about each firm’s strategy. In the overall sample of 333 trials (both on base and on add-on drugs) there were 49 trials with Gilead Sciences as the sponsor, and 62 trials where the sponsor was GSK or ViiV Healthcare. We created several categories for the trial type based on the focal drug of the trial (base vs. add-on drug) and the complement drug used in add-on trials. We mapped the evolution of clinical trials for each firm across the years.

Specifically, within the trials on add-on drugs we created several subcategories. First, we distinguished whether the firm tested its own add-on in the trial, or used the add-on of another producer (the latter is a very rare case). Secondly, we distinguished four cases depending on the complement used in the trial: using multiple bases as complements (own bases and other bases), using own base(s) only, using own base(s) in a single-pill combination, and not using the base drug at all (i.e., using another add-on drug as a complement). Using one’s own base as a part of a single-pill combination was of particular interest as it meant that the customer is in effect prevented from mixing and matching.

Figure 12 shows the cumulative number of patients enrolled by the trial category in each year for Gilead Sciences (top panel) and GSK/ViiV Healthcare (bottom panel). We did an alternative mapping using the number of trials per year and obtained similar results. Here we present the
results by the number of patients enrolled as this allows us to account for the size of the trial, which correlates with the trial’s cost and its strategic importance for the firm.

Consider first Gilead Sciences’s R&D strategy. The top panel of Figure 12 shows that until 2008 Gilead Sciences focused on its base drugs (tenofovir and emtricitabine), and then it switched to testing add-on drugs (trials on base drugs in 2014-2017 were on a newer version of its base tenofovir and can be considered an incremental innovation). While a few trials used other firms’ third generation add-on drugs (Gilead Sciences developed several single pills using its own base and add-ons owned by another firm), the majority of the trials, however, was on Gilead Sciences’s own third generation drugs. The most evident finding is that virtually all trials on its add-on drugs were conducted using only Gilead’s own bases: either tenofovir or tenofovir alafenamide. In fact, Gilead conducted only two trials that used multiple base drugs, and only one of these trials was large in terms of patient enrollment.

Furthermore, not only has Gilead Sciences been using its own bases as the only complements in its trials, but it also developed its add-on drugs as a part of a single pill (black-shaded columns). While limiting base complements of the add-on drugs in clinical trials to the firm’s own base drugs would affect which bundles of drugs are recommended by the medical guidelines and subsequently prescribed, developing add-on drugs available only as fixed-dose combination pills physically precludes other firms from using these add-on drugs. In other words, testing add-on drugs as fixed-dose combination pills means that bundles with these add-on drugs, while providing the benefit of a higher treatment adherence, will be exclusive to the firm’s own base drugs.

Gilead Sciences has been actively pursuing this exclusivity strategy. For instance, while Gilead Sciences developed its first add-on drug elvitegravir available both as a standalone pill and as a fixed-dose combination with tenofovir+emtricitabine it decided to withdraw the standalone pill from the market in 2016 citing low use (and implying the availability of the fixed-dose combination with the same molecule). And Gilead’s second add-on drug, bictegravir was tested in phase III trials only as a part of a fixed-dose combination pill with its base drugs. These findings are

35Source: https://gilead.com/ /media/files/pdfs/other/vitekta_withdrawal_letter.pdf?la=en
consistent with Hypothesis 2: once the broad base becomes a bottleneck its owner benefits from investing in complements and developing the latter as exclusive bundles with its base.

We now turn our attention to the strategy of GSK/ViiV Healthcare (the bottom panel of Figure 12). Similarly to Gilead Sciences, the trials on base drugs are constrained to the first half of 2000s, and very few trials used add-on drugs developed by other firms. When it comes to the trials on their own add-on drugs we see a very different picture. In the earlier years many trials on GSK add-on drugs (it owned two add-on drugs) used GSK bases (dark grey shaded bars), and those that did not were, in fact, trials in pre-treated patients that, as it quite common for trials in this patient population, did not specify the base at all (i.e., the add-on drugs could be used with any base drug, usually because the patient is switched from one add-on drug to another and keeps the original base drugs). GSK also conducted trials on a combination of its three base drugs, zidovudine+lamivudine+abacavir (on the graph this is subsumed in the “Base trials” category), which was later discouraged by the guidelines in favor of two base drugs plus add-on drug combination. Given that in this period GSK with its zidovudine+lamivudine base can be seen as the owner of a broad base (tenofovir was not approved yet), this behavior, consistent with Hypothesis 2, can be expected. GSK did not, though, develop single pills with its add-on drugs; however, at that time it might have been scientifically infeasible: its add-on drugs belonged to a class which could not be a part of a fixed-dose combination as the size of the pill would be too large for the patient to take (an indirect evidence of that could be that GSK did develop a single pill for its three base drugs combination).

Starting from mid-2000s we see a drastic change in the R&D behavior: add-on trials are no longer tested with GSK bases only, but with multiple bases (grey-shaded bars). This comes from two directions: first, GSK/ViiV Healthcare started to shift the focus towards drugs for pre-treated patients which, as customary in such trials, were tested without specifying the exact base. Secondly, starting from 2011 ViiV Healthcare (who at that point took over GSK infections portfolio) devoted significant R&D efforts to the development of the third generation add-on drug. In contrast to Gilead Sciences, ViiV developed this drug both as a part of a single pill with aba-
Figure 12: Phase II/III and phase III trials, enrolled patients
cavir+lamivudine) and as a standalone version, which was tested in combination with both abacavir and tenofovir. These findings are consistent with Hypothesis 3: as better add-on drugs started to be tested in bundles with a broad base only GSK/ViiV Healthcare invested in the complements and made them compatible with the rival base as well.

Further examining ViiV Healthcare strategy we see an even more intriguing finding: in the most recent years ViiV Healthcare has been conducting trials on its add-on drugs used in combination with another add-on drug, completely eschewing the base (the bars with horizontal stripes). Pursuing a two-drug combination as opposed to the conventional three-drug treatment was seen as a major strategic bet for ViiV Healthcare in the competition with Gilead Sciences. While the attractiveness of a two-drug combination, if successful, was evident – lower cost, fewer side effects – many doubted whether such combination would be as efficient as a three-drug combination. In November 2017 a combination of two add-on drugs tested by ViiV (consisting of ViiV’s dolutegravir and Janssen’s rilpivirine), was approved in the US for use in pre-treated patients, and is expected to challenge Gilead Sciences competitive position by establishing an alternative to a traditional three-drug treatment. We can interpret this strategy as ViiV Healthcare attempting to re-shape the architecture of the HIV market (Jacobides et al., 2006). In the past decade anti-HIV drug market became a battlefield between the two major base-owning firms: Gilead Sciences and ViiV Healthcare. Since Gilead Sciences apparently won the battle for the superior base with its base becoming a bottleneck, further sustained by Gilead’s strategy of developing exclusive complements, ViiV Healthcare has sought to eschew the existing bottleneck and create another one, this time in the add-on segment.

Contrasting the strategies of the two firms we see that they have very different approach to managing complements. The owner of the broad base pursues the strategy of developing fully-owned bundles with add-ons exclusive to its base (through single pills), which can be seen as an attempt to transform a distributed ecosystem of complementary products into a vertically integrated

supply chain. This would call into question the incentives of other ecosystem actors to innovate, in particular, the producers of add-on drug. While this is outside of this paper’s scope, we could expect that intensified competition for add-on drugs coupled with Gilead’s strategy of developing single pills will decrease the incentives of other add-on producers. For instance, Bristol-Myers Squibb, one of the add-on producers (mostly the first generation add-on drugs), has recently sold its HIV portfolio to Viiv Healthcare, including several third generation add-on drugs. On the other hand, the owner of the narrow base, wants to sustain the diversity of combinations available in the ecosystem by forming bundles with complements produced by other firms, but also seeks to shift the bottleneck away from the part of the ecosystem where its position is weaker.

4.5 Robustness checks

We conducted several robustness checks (Table 5). First, we created two indicator variables based on the add-on drug generation as an alternative to the continuous variable TimeSinceAvail. We created a variable ThirdGenAddon – third generation add-on – equal to 1 for drugs approved in 2005 and later, and a variable SecondGenAddon–second generation add-on– equal to 1 for drugs approved after 2000, but before 2005. We did not interact ThirdGenAddon with Post2008 because, while the third-generation drugs were available for testing before 2008 virtually all trials on these drugs happened after 2008. Consequently, the effect of the interaction would be subsumed into the direct effect of ThirdGenAddon variable. We found similar results. ThirdGenAddon is positive and significant for the model with tenofovir+emtricitabine outcome ($p < 0.01$), but negative and significant for zidovudine+lamivudine model ($p < 0.01$); it is negative, though not statistically significant for the model with abacavir+lamivudine. Computing average marginal effects of ThirdGenAddon, we have that clinical trials using third generation add-on drugs are on average 0.2 ($p < 0.05$) more likely to use tenofovir+emtricitabine as the base complement, and 0.15 ($p < 0.05$) less likely to use zidovudine+lamivudine. For abacavir+lamivudine the average marginal effect of ThirdGenAddon is $-0.06$, but it is not statistically significant.

Table 5: Choice of base in trials, robustness checks

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*p < 0.1, **p < 0.05, ***p < 0.01
We also repeated the original analysis with the subsamples of trials including naive patients (because trials in pre-treated patients often do not specify the base to be used) and in trials with 100 patients and above (excluding small trials), and found similar results. Computing average marginal effects, trials conducted by Gilead Sciences had 0.34 ($p < 0.001$) higher likelihood of using Gilead’s own bases as the unique base complement in the trials which included naive patients, and 0.44 ($p < 0.001$) higher likelihood in large trials. Trials with naive patients where the sponsor was Viiv Healthcare had 0.63 ($p < 0.001$) higher likelihood of using Viiv’s own bases if trials took place before 2008 and 0.19 ($p = 0.189$) higher likelihood if the trials took place after 2008, with the difference post-2008 being −0.45 ($p < 0.001$). For large trials the average marginal effects for Viiv Healthcare are 0.39 ($p < 0.001$) before 2008, and 0.16 ($p = 0.078$) after 2008, with the post-2008 difference being −0.22 ($p = 0.001$). While the size of the effect is smaller in the sample with large clinical trials, the effect still persists.

4.6 Discussion and conclusion

In this paper we set out to explore how firms attempt to shape an ecosystem to their advantage, depending on their position with respect to a competitor producing a similar component. In particular, we focus on the firm’s choice to keep complements compatible with the focal product. We study this phenomenon the context of anti-HIV drug market where the standard treatment consists of two semi-independent components (the base and the add-on components). We used individual-level data on the anti-HIV drug consumption to study the changes in value of drugs within each component. We then used the data on the design of the clinical trials in anti-HIV drugs focusing on the choice of the base drug used as a complement in the trials on add-on drugs, and how this choice changed following the change in value of certain base drugs. We found that as one of the base drugs emerged as creating benefits to a broader patient population, producers of the add-on complements sought to form bundles with that drug, but not with other, more narrowly useful, bases. The owner of the broader base invested in the production of its own add-on drugs and developed them as a part of an exclusive bundle with its base. Furthermore, it integrated its add-on drugs with its base into a single pill, moving from relying on other actors in the ecosystem to a fully integrated actor. By
contrast, the owner of the base compatible with a narrower patient population developed add-on
drugs as compatible with both its own base and the rival base. When this strategy did not seem to
work it attempted to re-shape the ecosystem by making the base component redundant, striving to
make the complement assume the status of bottleneck in the ecosystem.

These results have several implications for the literature on ecosystems and complements. By
explicitly accounting for competition in the focal product we seek to bridge the gap between the
two strands of literature that study complements: the business ecosystems literature, which looks
at firm-level outcomes but focuses predominantly on value creation aspect, and the industry archi-
tecture literature, which focuses on value capture but at the component-, rather than firm-, level. In
particular we bring together assumptions from both research streams and in doing so we highlight
how both value creation and value capture considerations shape firms’ decisions (Brandenburger
and Nalebuff, 1997).

Using a formal model to account for the competition in the focal product helps us further
qualify the predictions of these literature streams. First, while the industry architecture literature
suggests that all firms in a bottleneck component benefit in the same manner (Jacobides et al.,
2016) we show that the differentiation between products within the focal component can lead not
only to the differences in the size of benefits accruing to the firms in that component (Jacobides
and Tae, 2015), but also in the direction of the benefits. We find that an individual firm with a
stronger offering can become a bottleneck for the ecosystem reaping the benefits of such position,
while resulting in worse outcomes for other firms in the same component. Furthermore, by ac-
tively excluding the competitors from access to superior complements such firm attempts to shape
ecosystem in a way as to ensure its bottleneck position within the component, rather than the bot-
tleneck status of the given component as has been suggested by the prior literature on industry
architecture (e.g., Jacobides and Tae, 2015).

Secondly, the use of a formal model that incorporates value capture considerations into decision-
making allows us to show that firms may have incentives to integrate into complementary compo-
nent even when there is a sufficient supply of the complementary product. This comes in contrast
to the predictions of the business ecosystems literature which suggests that firms primarily need to invest in the production of the complements when the latter are not available (Kapoor and Furr, 2015). We show that firms may choose to integrate into complements not only to ensure their supply but also because this allows them to exclude certain producers from the access to the complementary product, which, in turn, allows to capture a portion of customer surplus by removing a substitute bundle. In other words, we show that there is a trade-off between value creation (having complements compatible with several versions of the focal product) and value capture of the consumer surplus (having complements compatible with only one version of the focal product). For instance, while it is possible to charge Tesla’s electric vehicle at a station owned by an external provider, Tesla has introduced the Supercharger network, which allows to charge a car within half an hour, but that is only compatible only Tesla vehicles.

This offers another perspective on firm boundaries decision. We show that firms may choose to integrate in contexts where transaction costs do not appear to be of high concern (add-on producers need the base to be able to create value for the patient, and provision of drugs for clinical trials is a fairly standard procedure) and where firms do not appear to have capability advantage over others (in pharmaceuticals there is high scientific uncertainty, and being good in the base drug does not imply that the firm is capable of developing a high-quality add-on that will be superior to existing add-ons).\textsuperscript{39} We offer an alternative argument, in addition to transaction cost (Williamson, 1975, 1985) and capability arguments (Argyres, 1996; Jacobides, 2008): firms choose to integrate because it allows them to restrict the access to the complementary product and therefore deprive their customers of alternative value proposition. Thanks to that they can capture more value from their customers.

This strategy has clear parallels with vertical foreclosure (Rey and Tirole, 2007). Yet, while firms practicing vertical foreclosure would normally restrict access to the dominant, or bottleneck, product to force customers to buy their competitive product (for example, Microsoft forcing cus-

\textsuperscript{39}In fact, Gilead’s first add-on drug,\textit{elvitegravir}, was eventually less effective compared to the existing alternative from the same drug class produced by another firm,\textit{raltegravir}, and GSK first add-on drugs,\textit{amprenavir} and\textit{fosamprenavir} had limited use as other add-on drugs from the same drug class were considered better in terms of efficacy and safety.
tomers to use Internet Explorer which was bundled with Windows), here firms restrict access to
the competitive product (the add-on) and not the bottleneck product (the base). This way the firm
is still able to increase its value capture – provided that it offers a competitive product of high
quality – but does not risk being accused of abusing its dominant position (for instance, Microsoft
was compelled to commit to the development of Microsoft Office and Internet Explorer for Mac
computers as otherwise it would have been accused of being a de facto monopoly).

The analysis of the decision to be exclusive and compatible with only one base can also be seen
as another perspective on the single-homing vs. multi-homing dilemma, but one set outside of the
platform-based markets (e.g., Cennamo, Ozalp, and Kretschmer, 2018; Cennamo and Santalo,
2013; Polidoro and Yang, 2018). In this paper we show that this issue is relevant also in the
contexts where network effects are non-existent, and that the driving mechanism for this decision
in such contexts is the trade-off between value creation and value capture vs. customers, rather
than value capture vs. complementors.

Finally, we attempt to provide a dynamic perspective on ecosystem evolution by showing how
ecosystem actors react to changes in the value of complements. What we find particularly interest-
ing is the contrasting approaches adopted by the “winner” and the “loser”, which ultimately shape
how the ecosystem can create value. While the “winner”, having become an ecosystem bottleneck,
attempts to transform the ecosystem into a vertically integrated supply chain, the “loser” seeks to
keep the ecosystem functioning, but tries to shift the bottleneck to another part of the ecosystem.
This offers a perspective on how the “loser” can still try to survive and turn around by changing
the shape of the ecosystem. For instance, in our introductory example, Apple decided to focus on
the content component (Apple Music) rather than the hardware component after HomePod proved
to be less successful than anticipated. In another similar move, Apple made its iTunes library
available on Samsung TV sets (Porter, 2019), which obviates the need to use Apple’s own Apple
TV device. Another example of a firm seeking to move the bottleneck to another component is
the strategic move of Microsoft in 2015 when, having missed out on the mobile apps ecosystem, it
decided to center its business around Microsoft Office, as opposed to Windows OS: “If Microsoft
can’t come up with a smartphone platform that can topple the iPhone or Android, why not just take over the iPhone and Android? While Windows has become less relevant, Microsoft Office is still the industry standard for getting stuff done.” (Weinberger, 2015). For a firm that has routinely put its Windows OS as the flagship product and designed other products to support the former this was a radical decision, and it is reminiscent of the strategy of ViiV Healthcare who decided to put the emphasis on the add-on drugs as opposed to the base drugs.

This paper has a number of limitations. It focuses on a specific industry – the anti-HIV drug market – which, while allowing to have an in-depth analysis, may limit generalizability to other contexts. For instance, because both components of the anti-HIV treatment are antiretroviral drugs there is little difference between components in terms of resources and capabilities resulting in a very low barrier to entry for the firms from the other component. This may not be the case in other industries, for instance, for a firm making a car engine to integrate into navigation systems requires the development of new capabilities. Thus it may be worthwhile to study when the difference between components in terms of resources and capabilities curbs the incentives for cross-component investment, and how firms may use it strategically to prevent a bottleneck actor from developing exclusive complements. Secondly, the pharmaceutical industry is a highly regulated one, particularly when it comes to prices: in most countries where drugs are reimbursed by state health insurances firms cannot unilaterally change a drug’s price after the drug’s approval. The implication is that differentiation among the drugs is driven by the underlying science, and as such is largely exogenous, while firms have little leeway to use prices strategically. For instance, in this paper we assume that the “narrowness” of the base was determined by the science, whereas in other contexts it may be a strategic decision. While the importance of science in this context helps to mitigate some of the endogeneity concerns, it would nevertheless be interesting to investigate, either theoretically or empirically, the strategic decisions of actors when they can choose to invest in order to improve the quality of their offering.

Despite the limitations we hope that this paper opens promising avenues into the research on ecosystems and complements. Its formal analysis and empirical results is suggestive of how het-
erogeneity within firms of an ecosystem can set in motion long-ranging changes in the architecture of the ecosystem itself. As we saw, the success of a bottleneck firm incentivizes competitors to try first to beat it at the same game, and, failing that, to attempt to change the game, with possibly significant repercussions.
5 ESSAY 3: HOW NONPROFIT ACTORS SHAPE BUSINESS ECOSYSTEMS:
NONPROFIT VS. INDUSTRY-SPONSORED CLINICAL TRIALS

Abstract

In this paper I explore how nonprofit actors actively shape a business ecosystem by comparing industry-sponsored and nonprofit-sponsored clinical trials on anti-HIV drugs. Because of the fundamental differences in incentives I hypothesize that nonprofit actors may pursue combinations that would be of lower interest to for-profit actors, such as combinations consisting of less expensive drugs, targeting smaller demographics or featuring fewer drugs. I examine the differences between industry-sponsored and nonprofit-sponsored trials in the choice of complements to be tested and in the use of prior clinical trials. I find that there is a subtle division of labor between firms and nonprofits as the latter tend to test combinations of older drugs to improve the access to treatment in developing countries. Because nonprofits do not have vested interest in drugs they also tend to contrast newer and older drugs to confirm the efficacy and safety (which may be less beneficial for firms), and to establish compatibility with a wider range of complements (which can sometimes be beneficial for firms). Furthermore, I find that nonprofits are active in trials on combinations that eschew a certain type of complements in the ecosystem. I speculate that this contributes to shifting the ecosystem bottleneck and affects how the value can be created in the ecosystem.

5.1 Introduction

In recent years strategy research has seen a rising interest in the concept of ecosystem – “the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize” (Adner, 2017), or “groups of firms that produce products or services that together comprise a coherent solution” (Hannah and Eisenhardt, 2018). This literature has been dealing with how firms can create and capture value in contexts where complementary products or capabilities are required to enable the firm to create value with its focal product. In particular, it focuses on how to ensure the availability of complementary products (Adner and Kapoor, 2010; Kapoor and Furr, 2015) or capabilities (Kapoor and Lee, 2013) of sufficient quality (Ethiraj, 2007) to favor the focal products’ adoption and performance. For instance, Michelin failed to capitalize on its innovative run-flat tires because automakers and garages were reluctant to make changes to their business to accommodate the innovation leaving the customers unable to benefit from the aforementioned innovation (Adner, 2006).

While the notion of the ecosystem and its boundaries appears quite broad empirical research
in the strategy literature has largely focused on the for-profit producers of complementary products. Yet the evidence suggests that nonprofit actors may play a crucial part of the ecosystem. For instance, a Swiss nonprofit Foundation for Innovative New Diagnostics (FIND) provided a substantial help in connecting Cepheid, the producer of tuberculosis diagnostic test, to hospitals and doctors to enable a widespread adoption of the test in the developing countries (Li and Garnsey, 2013).

On the other hand, a substantial body of literature has tackled the issue of the interaction between market and non-market actors (Cabral et al., 2019; Dorobantu, Kaul, and Zelner, 2017). While this literature has predominantly focused on confrontational interaction (McDonnell, King, and Soule, 2015) a growing stream of research explores contexts where the goals of these actors could be more aligned (Dorobantu and Odziemkowska, 2017). We know more about how these actors can interact to affect value creation (Gatignon and Capron, 2016; McDermott, Corredoira, and Kruse, 2009) and also how they can compete over the provision of value to constituents (Kaul and Luo, 2018; Rangan, Samii, and Van Wassenhove, 2006). Yet the research on stakeholders and that on non-market actors – despite some clear overlap – have developed independently from the business ecosystem research. While the extant ecosystem literature has explored the interactions between for-profit actors research explicitly focusing on the role of nonprofit actors in facilitating the alignment of ecosystems is lacking.

Given that nonprofit actors can be essential to the creation of value between for-profit actors (Chatain and Plaksenkova, 2018) the literature on ecosystems could benefit from incorporating nonprofit actors as an integral part of an ecosystem. As the example with Cepheid and the tuberculosis test suggests nonprofit actors can induce the links between complements which ultimately affects value creation in the ecosystem. At the same time using the ecosystem lens (Adner, 2012) can further our understanding of a broader impact of nonprofit actors on the relationships among for-profit actors and the evolution of such relationships. Because nonprofits have goals different from for-profit actors (Salamon and Sokolowski, 2016) the actions of the nonprofit actors may or may not be aligned with the firm’s interests.
In this paper I set out to explore the role of a nonprofit actor in an ecosystem, specifically, how such actors help establish compatibility among complements when such compatibility is costly. I study the context of anti-HIV drugs where the standard treatment represents a multi-drug combination, which has to be tested in a clinical trial to enable its prescription to the patients. Therefore, a clinical trial represents a way to establish compatibility among complementary products. Of particular importance are late-stage clinical trials as they have the most impact on the medical guidelines and thus the prescribing behavior. They also represent a significant cost to their sponsors. Given the number of anti-HIV drugs available it is clearly not feasible for a trial sponsor to test all possible combinations. Furthermore, once the knowledge about the quality of a drug combination is revealed it will be taken into account by prescribers making the trial’s impact irreversible. Given the cost and the crucial role that clinical trials play in establishing the viability of a drug combination a trial’s sponsor will choose a limited number of specific combinations in whose performance it is primarily interested.

HIV has a high societal impact. Thus is not entirely surprising that not only pharmaceutical firms, but also nonprofit actors, such as national and international research centers, hospitals, and universities are actively engaged in the anti-HIV treatment research. For instance, a high number of trials is conducted by the National Institute of Allergy and Infectious Diseases (NIAID), a US government agency, by the AIDS Clinical Trials Group (ACTG), a network of doctors and researchers established by the NIAID, l’Agence nationale de recherches sur le Sida et les hépatites virales, or the National agency for research on AIDS and viral hepatitis (ANRS), a French research agency. Other nonprofit actors include universities (e.g., University of Washington, University of Liverpool), hospitals (e.g., IRCCS San Raffaele, Germans Trias i Pujol Hospital), other national and international research agencies (e.g., Bamrasnaradura Infectious Diseases Institute, Fundacio Lluita Contra la SIDA).

What is intriguing is that nonprofit actors are engaged not only in early-stage research (as conventional wisdom would suggest), but also in late-stage research. Among 448 phase II/III and phase III clinical trials on anti-HIV drugs, 221 were sponsored by pharmaceutical firms and 227
were sponsored by nonprofit actors (and 162 trials have no industry funding at all). Furthermore, trials sponsored by nonprofit actors are similar in terms of size to those sponsored by firms (see Table 6). The high involvement of nonprofit actors could still be explained by different objectives of nonprofits: for instance, one could expect that pharmaceutical firms mostly conduct clinical trials on innovative drugs, while nonprofit actors conduct trials in developing countries testing combinations of less expensive or generic drugs. Yet, while nonprofit actors do conduct more trials in developing countries compared to pharmaceutical firms, this accounts for less than a half of nonprofit-sponsored trials (98 trials out of 227). The fact that nonprofit actors appear to be engaged in a similar type of R&D as for-profit actors, yet may have different goals, raises the question whether the combinations that nonprofits seek to enable are similar to those of firms, or whether there is still some division of labor. Do firms and nonprofits seek to establish similar kinds of compatibility among complements? Can nonprofits induce firms to seek certain types of complements?

Given the cost and the importance of clinical trials their sponsors need to strategically select combinations that they are most interested in testing. Firms are driven by profit maximization and can be expected to choose combinations comprising at least one of their own drugs, and that are likely to yield highest expected profits yet would not infringe too much on the combinations with firms’ drugs already tested and shown as effective and safe. By contrast, nonprofit actors, who do not have a vested interest in a specific drug or a combination and who do not seek to maximize profits, can be driven by the desire to lower the cost of treatment (and hence make it available to a wider range of patients) or to find combinations with highest medical value for the patient. In this paper I explore whether the characteristics of the nonprofit-sponsored trials and the types of combinations tested are different from those of the industry-sponsored trials, and whether the actors build on each others’ knowledge.

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40 Information from the online database clinicaltrials.gov provided by the US National Library of Medicine.
41 If we exclude the outliers trials (trials with more than 2000 patients) then the mean number of patients for an industry-sponsored trial is 370 patients, and for a nonprofit-sponsored trial it is 356 patients, with the difference not statistically significant (see Table 6). Very large trials (with patient enrollment ranging from 2000 to 5400 patients) are mostly sponsored by nonprofit actors (21 out of 24 trials). If we include those then nonprofit-sponsored trials would have on average 193 patients more than industry-sponsored trials.
I look at the context where for-profit and nonprofit actors possess similar capabilities to create value and are competing over the provision of goods, where the good is the combination of drugs. While firms are the only actors producing the drugs, they cannot prevent other actors from using their products in combination with other drugs.\textsuperscript{42} A combination tested in a trial is “assembled” by the trial’s sponsor, and firms would normally agree to provide their drugs to the trial’s sponsor, otherwise the trial’s sponsor always has an option of purchasing drugs in the market. A combination consumed by an individual is “assembled” by a prescriber, not by a firm, based on the medical guidelines that, in turn, are based on the results of clinical trials. A drug combination tested in a clinical trial represents, essentially, knowledge about whether the given combination is good, i.e., effective and safe, and whether it is superior or inferior to comparable combinations (which is why validating a certain combination in a clinical trial constitutes an irreversible change in the HIV ecosystem). As knowledge, a drug combination is a non-rival, non-excludable good, in contrast to a standalone drug. This context is similar to that in the research on the competition of for-profit and nonprofit actors over the provision of social goods (Chau and Huysentruyt, 2006; Kaul and Luo, 2018) with the difference that while social goods are normally expected to benefit the public, but not the firm, in this paper the good translates into a well-determined economic value that can directly benefit the firm.

By conceptualizing nonprofit actors as an integral part of the ecosystem I am bringing the ecosystem literature closer to a broader literature on stakeholders (Freeman, 1984). Furthermore, I continue the line of work on the endogeneity of complementarities in ecosystems started in Plaksenkova and Chatain (2019) by exploring how the divergence in goals between for-profit and nonprofit actors results in different kinds of complementarities. Finally, nonprofits, by the virtue of not being profit-oriented, may foster complementarities that challenge the established architecture of an ecosystem (Baldwin, 2015; Jacobides, MacDuffie, and Tae, 2016), for instance, by eschewing altogether a certain type of drugs in the treatment, and ultimately affect the evolution of an ecosystem.

\textsuperscript{42}The exception would be the case when a firm develops a drug combination as integrated into a single pill and not available as standalone pills, usually done in an attempt to achieve exclusive combinations. However, such cases are rare: so far only one firm – Gilead Sciences – has developed two combinations available as single pills only.
tem. By accounting for the role of nonprofit actors in such changes I seek to promote the dynamic perspective of an ecosystem (Ethiraj and Posen, 2013; Kapoor and Agarwal, 2017; Mäkinen and Dedehayir, 2013).

The paper also speaks to the literature on the interaction between for-profit and nonprofit actors. On the one hand, by studying the context where both for-profit and nonprofit actors are capable of enabling compatibility among complementary drugs I am incorporating the idea of the competition between for-profit and nonprofit actors (Kaul and Luo, 2018), but apply it to the setting where such goods directly translate into economic value for the firms. On the other hand, I acknowledge that the engagement of a nonprofit actor can result in benefits for a firm (McDermott, Corredoira, and Kruse, 2009), however, this is not always the case as the goals of the nonprofit are divergent from those of the firm. In doing so I attempt to account for a diverse palette of the outcomes of nonprofit-firm interactions.

In section 2 I provide an overview of the anti-HIV drugs context. Section 3 discusses the incentives of for-profit and non-profit actors related to the design of clinical trials on anti-HIV drugs. Section 4 describes the data, and sections 5 and 6 provide the results of the comparison between industry-sponsored vs. nonprofit-sponsored clinical trials. Finally, I summarize the key insights and draw conclusions in section 7.

### 5.2 HIV treatment context

Anti-HIV drugs represent a particularly interesting context to study questions of value creation and value capture in the setting with complementary products. The HIV virus was discovered in 1983, and in 1987 the first anti-HIV drug was approved. This discovery was followed by a string of

<table>
<thead>
<tr>
<th>Nonprofit trials</th>
<th>Industry trials</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>95% Conf. Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>355.532</td>
<td>369.866</td>
<td>-14.335</td>
<td>37.260</td>
</tr>
<tr>
<td>Obs.</td>
<td>205</td>
<td>217</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.1, **p < 0.05, ***p < 0.01
several other drugs (called antiretroviral drugs); however, the treatment with a single drug resulted in only temporary improvement, after which the disease returned. The reason was that the HIV virus quickly developed resistance to antiretroviral drugs. This led researchers to test whether a combination of two or more drugs would be more effective than a single drug at controlling the disease, and in 1986 a landmark trial demonstrated that a three-drug combination, with two drugs belonging to one drug class and the third drug belonging to another, is more effective than a single drug or a two-drug combination (Gulick et al., 1997). Because different drug classes have different mechanisms of action, combining antiretroviral drugs belonging to different drug classes means that even if the virus develops resistance to one drug it can still be contained by other drugs. Research on the anti-HIV treatment has been burgeoning ever since, with new drugs and new drug classes entering the market. As of now there are six different drug classes available, and forty different anti-HIV molecules have been investigated for their efficacy in the HIV treatment.

More specifically, medical guidelines split the treatment in two parts: the treatment backbone consisting of two drugs from NRTI (nucleoside reverse transcriptase inhibitors) drug class, which
I call the base component of the treatment, and the so-called third agent selected among multiple drug classes, which I call here the add-on component (see Figure 13). There are five drug classes among which the add-on drug is selected: NNRTI (non-nucleoside reverse transcriptase inhibitors), PI (protease inhibitors), FI (fusion inhibitors) and EI (entry inhibitors), IN (integrase strand transfer inhibitors), and CCR5 antagonists.\textsuperscript{43} In earlier years an NRTI drug (the base) could also be selected, but in late 2000s this practice became rare.

Besides belonging to different drug classes these two components follow very different trajectories. In the base component most innovation happened in 1990s, and no new drug has entered the market since 2003 (the exception is the new version of one of the existing drugs that came in 2016, however, this can be considered an incremental innovation). Similarly, except for the aforementioned drug there was little interest in developing new base drugs (the development of a new base drug in 2008 was quickly dropped). By contrast, innovation in the add-on component has been burgeoning since mid-1990s. Base component is also far more concentrated: by early 2000s three major bases emerged as the most widely used, while in the add-on component there has always been a lot of variety.

Importantly, pharmaceutical firms have traditionally focused either on base or on add-on drugs, making them two separate components within the anti-HIV treatment ecosystem. There were a few exceptions, as Roche and Bristol-Myers Squibb owned both base and add-on drugs, however the base drug owned by Roche has not been widely used and was eventually withdrawn from the market in 2006, and the use of the two base drugs owned by Bristol-Myers Squibb has steadily declined over 2000s. These two firms can thus be considered add-on firms. Two major firms in the base component, Gilead Sciences and ViiV Healthcare, at some point ventured into the add-on component; however, they continued to test combinations including other firms’ drugs.

\textbf{Clinical trials.} A particularly important feature of this context is that a doctor cannot prescribe a combination of drugs that has not been previously tested in a clinical trial. Clinical trials’ results

\footnotesize\textsuperscript{43}When the add-on drug belongs to the protease inhibitors drug class a fourth drug is added acting as a booster for the efficacy of the main drug. There are two boosters available: \textit{ritonavir} and recently developed \textit{cobicistat}. I do not specifically focus on the booster drug as it can be considered an adjuvant drug rather than the main drug of interest in a combination; however I include trials on booster drugs in the dataset.
also serve as the basis for the international and national medical guidelines, which, in turn, affect the doctors’ prescribing behavior. Given the number of drugs available there are many ways to form combinations: for instance, in the base component one needs to choose two drugs from nine drugs available; in the add-on component in the beginning of 2000s there were already eight different drugs, and by now there are twenty-seven drugs that have been approved or under investigation. Clearly, it is not possible to incorporate all options in a single clinical trial. Clinical trials are also costly, for instance, DiMasi and Grabowski (2007) estimate an average cost of phase III trial at 96 million USD. Taken together, this means that each actor at a single point in time can only conduct a limited number of trials, and has to be highly selective regarding the choice of combinations. The implication is that the design of a clinical trial in terms of combinations tested reflects the intent to make the selected drugs compatible.

**Non-standard combinations.** While a three-drug combination is considered a standard of care, other types of combinations are also available. Most often they target a special patient group – such as pregnant women to prevent mother-to-child transmission of the virus, people with HIV-infected partners to prevent sexual transmission of the virus. In such cases the treatment is different from the standard “base plus add-on” combination: for instance, to prevent mother-to-child transmission a single anti-HIV drug can be used (usually either a base drug zidovudine or an add-on drug nevirapine); to prevent sexual transmission a combination of two base drugs is used, tenofovir disoproxil + emtricitabine.

Furthermore, because a three-drug combination is costly and also entails many side effects researchers have been exploring the efficacy of combinations with two drugs only, or just one drug, as an alternative (usually add-on drugs only). Such combinations, called simplified therapy, would present saving opportunities for the payers, and would also entail a better quality of life for patients due to fewer side effects.

**Implications for ecosystem architecture.** Most simplified therapy combinations feature only add-on drugs, which poses a challenge to the existing ecosystem architecture (base plus add-on components), and to the firm(s) who have advantageous position in the base component. In fact,
the recent approval of a two add-on drug combination by ViiV Healthcare, with clinical trials on other simplified therapy combinations in its pipeline (Liu, 2018), is seen as a major challenge to the position of Gilead Sciences who in the past decade has attained the status of a leader in the base component with its tenofovir + emtricitabine base (Plaksenkova and Chatain, 2019). Therefore, trials on non-standard combinations are of particular interest as they not only establish links between new type of complements, but also have the power to drive a whole component redundant.

5.3 Clinical trials and incentives of for-profit and non-profit actors

In this context, we have firms and nonprofits competing in the space of clinical trials, and the product is a combination tested in a trial. The distinction between a drug and a combination is crucial here: only firms are the producers of drugs, but both firms and nonprofits can “produce” a combination through a clinical trial. The impact of a trial represents an irreversible change to the ecosystem: first, by showing that a certain combination is effective and/or safe the actor enables doctors to prescribe such combination, second, if a trial demonstrates that a certain combination is inferior this knowledge is also taken into account.

Both firms and nonprofits have similar capabilities with regard to linking drugs, yet they have different goals. There are two dimensions to the firms’ incentives when it comes to the new combinations: the expected profits they can get with the new combination net of the clinical trial cost, and the expected reduction in profits due to the substitution of the previously viable combinations with their drugs by the new combinations. The goals of nonprofits, on the other hand, could be to increase access to treatment (in particular in countries with limited resources), lower treatment cost, and find combinations with the best efficacy-safety profile.

Due to this difference in goals we can expect differences in choices when it comes to the clinical trials design. First, firms would not normally test a combination which does not feature their own drug(s), and, if possible, would maximize the number of their drugs in a combination (i.e., if the firm owns add-on and base drugs we could expect that it tests a fully owned combination). Second, firms would avoid testing a combination around which the uncertainty is higher or which does not promise high returns (for instance, testing a new drug in combination with drugs soon to become
generic, or the drugs with serious side effects even though for a portion of patient population these drugs are the preferred option). Third, if the firm has already conducted clinical trials on a certain combination it may be hesitant to test a given drug in a new combination as this combination may substitute the “incumbent” combination and prevent the firm from reaping benefits from its prior R&D efforts (the replacement effect in Arrow, 1962). More generally, if a firm has already conducted a successful trial on combinations featuring its drug it has low incentives to invest into further clinical trials as the return from new combinations is likely to be small, especially considering the replacement effect.

Nonprofits, on the other hand, are driven by the treatment cost reduction (and hence increasing access to treatment) and finding the “best” treatment. There is, in fact, a tension between these two goals: to lower the cost one would need to use older generation drugs, which are, or soon will be, generic, but these drugs have normally worse efficacy/safety profile compared to newer, more expensive drugs. In some cases, though, these goals would be aligned – for instance, pursuing non-standard combinations: simplified therapy combination of one or two add-on drugs will cost less than a three-drug combination and have a better safety profile; transmission prevention treatment would help avoiding the disease altogether. I expect nonprofits to be actively engaged in non-standard trials.

Outside of non-standard combinations nonprofits are likely to prioritize one or the other goal depending on the context. In developing, resource-constrained, countries the access to treatment is paramount (and arguably more important than the improvement in the treatment quality), but such contexts are of low interest to firms. I expect nonprofits to focus more on developing countries and test combinations of older drugs to lower the treatment cost and make it available for a larger patient pool.

In developed countries the need to lower treatment cost could be perceived as less relevant compared to developing countries, and the goal of finding a better treatment can be expected to dominate the one of lowering the cost. This is the area where I expect both firms and nonprofits to be active, but because nonprofits are not constrained by the drug ownership they may make
different choices in terms of trial design. First, while firms are more likely to promote combinations where they own all drugs, nonprofits may seek to establish compatibility with a broader range of complements, either because they believe that such combinations will be superior or because they want to expand the treatment options for patients. Second, nonprofits, unlike firms, would still be interested in testing combinations that have been proven successful—because they can contrast them with more recent combinations. In the absence of drug ownership nonprofits would be satisfied with the trial’s outcome independently of which combination is shown to be superior.

To conclude, given the differences in goals I would expect that nonprofits will pursue different types of combinations, such as older drug combinations for developing countries, non-standard combinations, or combinations with more diverse complements. Given the irreversibility of a trial, it is particularly interesting to explore how firms take the results of such trials into account.

5.4 Data

I use the dataset of late-stage clinical trials from Plaksenkova and Chatain (2019). This dataset was constructed by manually coding the trials in the online clinicaltrials.gov database by the US National Library of Medicine. The clinicaltrials.gov database is a major reference point for the pharmaceutical industry, and while the database is ostensibly US-based it is a usual practice to register trials outside of the US as well. I extracted all trials featuring “HIV” as a condition resulting in 6859 trials. I kept only the trials conducted on anti-HIV drugs explicitly treating HIV (for instance, a number of trials was conducted in HIV-infected patients, but focusing on the treatment of another disease) by retaining the trials where the intervention was coded as “Drug”, and where condition contained at least one of the five keywords: “HIV”, “immune deficiency”, “immunodeficiency”, “PREP”, “prophylaxis”. I chose to focus on late-stage trials as these trials have the most bearing on the medical guidelines and medical practice. This resulted in 630 trials, which I complemented with 7 more after cross-checking with the National HIV Curriculum website from AETC (AIDS Education and Training Centers) National Coordinating Resource Center, resulting in 637 trials. After the manual check I further removed 161 trials that focused on HIV complications or associated diseases rather than treating HIV, and one more trial was removed due to highly
unusual design resulting in 475 anti-HIV trials. Finally, I removed trials testing protective gels (since these trials do not involve drugs) and so-called early access trials. The latter are the trials organized by the firm in order to give the access to its drug in countries where the drug has not been approved yet. I removed these trials as they do not seek to establish drug’s efficacy or safety, and are considered a tool to support the drug’s uptake. The final sample consisted of 448 trials by firms and nonprofit actors.

For each trial I read its description provided on the clinicaltrials.gov website to manually code the drug combinations that have been tested in the trial. Specifically, I distinguished between the focal combination of the trial (the combination of drugs whose efficacy and safety are being tested) and the comparator combination (the combination of drugs used in the control group). The database often specifies the drug combinations used in the experimental group (the focal combination(s) of the trial) and in the control group; when this information was absent I inferred the focal combination from the trial’s summary, and, when in doubt, checked the publications that the database associated with the given trial. Sometimes trials did not distinguish between experimental and control groups: that is, rather than testing a specific combination, or combinations, vs. control combinations the trials pitched several combinations against each other. In such cases I considered all combinations as focal. The majority of trials tested only one focal combination of drugs, while 116 trials had more than one focal combination, including two particularly large trials, one with 50 combinations tested, and the other with 60 combinations tested. The resulting dataset contained 448 trials, and 869 trial-combinations. In the following sections I describe the characteristics of the trials and combinations that I used as variables in my analysis. Table 7 provides the summary of the variables and their definitions.

5.4.1 Characteristics of the trial

**Trial sponsor.** The database contains the names of the actors involved in the trial’s organization and funding. In particular, it distinguishes trial’s sponsor and trial’s collaborators. While collaborators can provide funding or drugs for the trial it is the trial’s sponsor that develops the trial’s design, makes decision regarding trial’s termination (if needed), and bears legal responsibility. The
database identifies the trial sponsor’s type as industry, government, National Institute of Health, or other; I have also manually checked the sponsor’s names to confirm whether these are firms or nonprofit actors. Based on the manual check of sponsors’ names I identified whether the trial was industry-sponsored or nonprofit-sponsored.

However, there are two cases among nonprofit-sponsored trials depending on the type of trial’s collaborators: trials where both the sponsor and the collaborators are nonprofit actors, and trials where the sponsor is a nonprofit actor, but firms are among trial’s collaborators. While it is clear that the former case is that of nonprofit-sponsored trials, it is less clear how to treat the latter (which represents 65 trials out of 448 trials in the sample). HIV specialists whom I interviewed suggested that sometimes nonprofit actors design trials and then ask firms to provide drugs, which makes firms collaborators; in this case firms are not involved in the decision-making around the trial’s design. On the other hand, these could be the so-called investigator initiated trials. Investigator initiated trials represent a collaboration between a pharmaceutical firm and a nonprofit actor where the firm is willing to provide the funding and the drug(s) for a trial on its drugs that is suggested by a nonprofit actor. Usually this is the case when a doctor in a large hospital expresses an interest to test the firm’s drug (in a different patient population, with a different complementary drug, etc.). In such cases, while the main decision maker is ostensibly a nonprofit actor, the trial’s design is developed in close collaboration with the firm. As I could not distinguish between the two cases I chose to be conservative and coded such trials separately as investigator initiated trials; furthermore, while I do take into account the knowledge obtained from these trials I exclude them from the nonprofit-sponsored trials group when I compare clinical trials by the industry and by nonprofits.

**Non-standard trials.** While the majority of the trials tested multi-drug combinations of base and add-on drugs (what I call standard trials) more than a third of the trials tested what I dubbed non-standard combinations. Non-standard trials, by the virtue of testing combinations with fewer drugs (or reduced treatment time) would naturally be of lower interest to firms, but would be aligned with the goals of nonprofits to lower the treatment cost and achieve a better safety profile
for the patients due to fewer side effects. Therefore it is important to compare the engagement of firms and nonprofits into such trials.

Below I provide more details about non-standard trials which can be classified based on the trials’ objectives:

*Simplified therapy trials:* trials testing combinations of two drugs or fewer in general patient population, in contrast to traditional three-drug combinations. In most cases these combinations consist of two add-on drugs (combinations without base), although a few trials tested a base drug and an add-on drug.

*Prophylaxis trials:* trials conducted in healthy patients whose partner is HIV-infected; these trials seek to prevent sexual transmission of HIV disease. Most such trials use base drugs (notably, the combination of two base drugs *tenofovir* and *emtricitabine*). It is commonly known as PrEP, or pre-exposure prophylaxis.

*Vertical transmission prevention trials:* trials to prevent mother-to-child transmission of HIV disease; usually these trials test giving either the base drug *zidovudine* or the add-on drug *nevirapine* to pregnant or breast-feeding women.

*Timing trials:* trials that study the timing of the treatment as opposed to the efficacy/safety of the combination per se. For instance, such trials may compare the outcomes in patients who had treatment interruption vs. patients who took treatment continuously; another example could be early vs. late treatment start.

Beside comparing firms’ and nonprofits’ activity in non-standard trials overall I further check whether the actors are active in simplified therapy trials. Since most of these trials do not contain base drugs such trials have the potential to make the entire base component irrelevant with the implications for the existing architecture of the HIV drugs ecosystem, hence simplified therapy trials are of particular interest. In addition, at the level of trial-combination, I check whether a combination uses base drugs or not (in most cases this overlaps with simplified therapy trials, but it can also include trials on add-on drugs for mother-to-child transmission prevention).

**Trial location.** I check the differences in terms of trial location which would provide evidence
on whether nonprofits seek to improve the access to treatment for patients in resource-constrained countries. For this variable I use the information on the location of hospitals involved in the trial provided by the clinicaltrials.gov database, and I check whether the trial happened outside of US, Europe, Japan, Canada, Australia, Iceland, or New Zealand.

5.4.2 Characteristics of the combination

In this section I describe variables at the level of trial-combination. First, I created several variables to test potential “commercial” motivation of the firms, i.e. whether firms tend to test combinations that maximize their profits but not necessarily produce high medical value.

**Ownership.** First I check the ownership of the drugs in a combination as I expect firms to select combinations containing the drugs that they own. I created three variables. First I checked the owner of each drug at the time of the trial and for industry-sponsored trials I checked whether the trial contains at least one drug belonging to the trial’s sponsor (this was defined at the level of the trial). Then I also checked if the sponsor owned all drugs in the combination. These two variables are only applicable for industry-sponsored trials. To be able to have a comparison with nonprofit-sponsored trials I also checked whether all drugs in the tested combination belonged to the same firm (irrespectively of the trial’s sponsor).

**Single-pill combinations.** Second, I check whether a combination is fully or partially contained in a single pill. While originally patients had to take three different pills, firms started to develop pills that integrated two or more drugs. For instance, by mid-2000s the three major bases were available in a single-pill form (i.e., one pill contained two base drugs). In the second half of 2000s firms started to develop single pills that integrated all three drugs to ease the treatment burden of the patient and to increase patient adherence to the treatment. While this does provide marginal benefit for the patient, such combinations do not provide any additional benefit in terms of efficacy or safety compared to separate pills, though they provide opportunities for the firms to exclude others from the access to their drugs (Plaksenkova and Chatain, 2019). The trial’s description allows to distinguish when the trial uses different pills or a single pill as it either specifies the brand name of the drug (for trials taking place after the drug’s approval) or explicitly indicates if
the drug combination is a single pill (so-called fixed-dose combination). Thus I check if the combination contains base drugs in the form of a single pill, and if the whole combination is a single pill.

**Characteristics of base and add-on components.**

In order to understand the differences between firm and nonprofit trials in terms of complements that they seek to make compatible I compare the characteristics of the focal combinations, more precisely, the characteristics of base and add-on components. To do this I distinguished the base component and the add-on component within each focal combination.

In terms of base, among 869 combinations tested, 740 contain at least one base drug. Among 156 of these the base drugs are not specified (that is, add-on drugs are used with any combination of base drugs appropriate for a given patient, which is usually the case in trials on pre-treated patients when the patient is switched from one add-on drug to another, but keeps the same base drug), and 323 contain one of the three major bases (including the newer version of one of those drugs). This means that more than half of the combinations that do specify base drugs feature one of the three major bases, which is in line with the concentrated nature of this component. By contrast, the add-on part of the treatment appears more diverse.

**Drug age.** In order to explore whether nonprofit actors tended to investigate older drugs I calculated the age of base and add-on components in the combination. Because the base component usually contains two drugs, and the add-on component may contain more than one drug I looked at the age of the “youngest” and the “oldest” base, and the “youngest” and the “oldest” add-on in the tested combination. If the combination contained only one add-on (or, what is rarer, only one base drug) then the minimum and the maximum ages were the same.

I applied the same method as in Plaksenkova and Chatain (2019) where I calculated drug’s age as the difference between the trial’s start year and the year when the drug became available for phase III testing. The latter I assumed to be either the year when the interim results from the first phase II trials became available, or three years prior to the drug’s approval by the Food and

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44The reason is that while some trials are conducted on already approved drugs, many trials include drugs that are still in development, thus I could not use the approval date to calculate the drug’s age.
Drug Administration (FDA), the US drug approval agency (whichever year happened first). The clinicaltrials.gov database provides the information on the starting year of the trial for most trials. For a few trials this information was not available, and I assumed the starting year as two years prior before the trial’s completion year (which is provided by the database). If the trial’s completion year was not available then I assumed that the year of the first submission to the clinicaltrials.gov by the sponsor is the trial’s start year. The chief concern with these trials would be that since 1999 is the earliest available year for the trial’s submission older trials may be assigned to a later starting date. This will lead to the underestimation of the drug’s age in such trials, and to the overestimation of the prior experience. However, most of such trials took place before 2000 and, as I have eventually restricted the sample to post-2000 trials, this concern is somewhat mitigated.

**Use of prior experience.** As I am interested in how for-profit and non-profit actors build on each other’s knowledge to create compatibility links between complementary drugs I look at whether a given combination in a given trial replicates a combination from prior trials, fully or partially. The former allows to understand whether for-profit actors attempt to replicate combinations previously tested by nonprofits, and vice versa. In other words, it is particularly interesting to understand whether and when nonprofit actors are instrumental in establishing compatibility which is then followed upon by for-profit actors (or vice versa). The latter, i.e. when a given combination uses a base or an add-on tested in prior trials, helps understand how for-profit and nonprofit actors can create knowledge that supports the intent for compatibility. Below I provide the details of the variables.

**Replication of combination.** First I check whether a given combination has been tested in at least one trial within the past two years. Then I further distinguished whether this was an industry-sponsored trial, a nonprofit-sponsored trial, or an investigator initiated trial. Because a two-year window may be too short I also use a five-year window for prior trials’ experience.

**Prior experience with base and add-on components of the combination.** Second, I check whether the add-on part of the combination has been tested in at least one trial in the prior two years. Similarly to the previous case, I further distinguish whether the prior trial was sponsored
by the firm, the nonprofit, or was an investigator initiated trial. Because some trials used more than one add-on drug in a combination (for instance, trials in pre-treated patients sometimes added another add-on drug on top of a three-drug combination) I also checked the prior experience with an individual add-on drug. I also create the same indicators using a five-year window.

Similarly, I checked for the experience with the base part of the trial; however, due to more limited number of drugs in that component and much higher use of the three major bases, it was very common that the base part has been previously tested in a trial and this information did not bring much value. For this reason I chose to focus on the prior experience with the add-on component.

### Table 7: List of variables

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristics of the trial</strong></td>
<td></td>
</tr>
<tr>
<td>TrialSponsor</td>
<td>Categorical variable taking on values of: <em>Industry</em>, if the trial is sponsored by a firm; <em>Non-profit</em>, if the trial is sponsored by a nonprofit, and includes no for-profit collaborators; or <em>Investigator Initiated</em>, if the trial is sponsored by a nonprofit, but includes for-profit collaborators</td>
</tr>
<tr>
<td>NonStandard_Trial</td>
<td>Equal to 1 if the trial belongs to the category of simplified therapy, prophylaxis (sexual transmission prevention), vertical transmission prevention or treatment interruption</td>
</tr>
<tr>
<td>SimplifiedTherapy_Trial</td>
<td>Equal to 1 if the trials belong to the simplified therapy category</td>
</tr>
<tr>
<td>ComboWithoutBase</td>
<td>Equal to 1 if the combination contains no base drugs</td>
</tr>
<tr>
<td>DevelopingCountry_Trial</td>
<td>Equal to 1 if the trial takes place in a developing country</td>
</tr>
<tr>
<td><strong>Characteristics of the combination</strong></td>
<td></td>
</tr>
<tr>
<td>SponsorOwnedDrug</td>
<td>Equal to 1 if the trial’s sponsor owns at least one drug in at least one focal combination of the trial</td>
</tr>
<tr>
<td>SponsorOwnedCombo</td>
<td>Equal to 1 if all drugs in the combination are owned by the trial’s sponsor</td>
</tr>
<tr>
<td>ComboSameOwner</td>
<td>Equal to 1 if all drugs in the combination are owned by the same firm</td>
</tr>
<tr>
<td>Base_SinglePill</td>
<td>Equal to 1 if base drugs of the combination are contained within a single pill</td>
</tr>
<tr>
<td>Combo_SinglePill</td>
<td>Equal to 1 if all drugs of the combination are contain within a single pill</td>
</tr>
<tr>
<td>MaxAgeBase</td>
<td>Number of years since availability for phase III testing for the oldest base drug in the combination</td>
</tr>
<tr>
<td>MinAgeBase</td>
<td>Number of years since availability for phase III testing for the youngest base drug in the combination</td>
</tr>
<tr>
<td>MaxAgeAddon</td>
<td>Number of years since availability for phase III testing for the oldest add-on drug in the combination</td>
</tr>
<tr>
<td>Variable name</td>
<td>Definition</td>
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<td>---------------------------------------</td>
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</tr>
<tr>
<td>MinAgeAddon</td>
<td>Number of years since availability for phase III testing for the youngest add-on drug in the combination</td>
</tr>
<tr>
<td>SameCombo_prior2years</td>
<td>Equal to 1 if the combination has been tested in at least one trial in the past 2 years</td>
</tr>
<tr>
<td>SameCombo_prior2years_Industry</td>
<td>Equal to 1 if the combination has been tested in at least one industry-sponsored trial in the past 2 years</td>
</tr>
<tr>
<td>SameCombo_prior2years_Nonprofit</td>
<td>Equal to 1 if the combination has been tested in at least one nonprofit-sponsored trial in the past 2 years</td>
</tr>
<tr>
<td>SameCombo_prior2years_InvIni</td>
<td>Equal to 1 if the combination has been tested in at least one investigator initiated trial in the past 2 years</td>
</tr>
<tr>
<td>SameCombo_prior5years</td>
<td>Equal to 1 if the combination has been tested in at least one trial in the past 5 years</td>
</tr>
<tr>
<td>SameCombo_prior5years_Industry</td>
<td>Equal to 1 if the combination has been tested in at least one industry-sponsored trial in the past 5 years</td>
</tr>
<tr>
<td>SameCombo_prior5years_Nonprofit</td>
<td>Equal to 1 if the combination has been tested in at least one nonprofit-sponsored trial in the past 5 years</td>
</tr>
<tr>
<td>SameCombo_prior5years_InvIni</td>
<td>Equal to 1 if the combination has been tested in at least one investigator initiated trial in the past 5 years</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_2yr</td>
<td>Equal to 1 if the add-on component of the combination has been tested in at least one trial in the past 2 years</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_2yr</td>
<td>Equal to 1 if at least one add-on drug of the combination has been tested in at least one trial in the past 2 years</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_2yr</td>
<td>Equal to 1 if the add-on component of the combination has been tested in at least one industry-sponsored trial in the past 2 years</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_2yr</td>
<td>Equal to 1 if the add-on component of the combination has been tested in at least one nonprofit-sponsored trial in the past 2 years</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_2yr</td>
<td>Equal to 1 if the add-on component of the combination has been tested in at least one investigator initiated trial in the past 2 years</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_2yr</td>
<td>Equal to 1 if at least one add-on drug of the combination has been tested in at least one industry-sponsored trial in the past 2 years</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_2yr</td>
<td>Equal to 1 if at least one add-on drug of the combination has been tested in at least one nonprofit-sponsored trial in the past 2 years</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInvIni_2yr</td>
<td>Equal to 1 if at least one add-on drug of the combination has been tested in at least one investigator initiated trial in the past 2 years</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_5yr</td>
<td>Equal to 1 if the add-on component of the combination has been tested in at least one trial in the past 5 years</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_5yr</td>
<td>Equal to 1 if at least one add-on drug of the combination has been tested in at least one trial in the past 5 years</td>
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<td>Equal to 1 if the add-on component of the combination has been tested in at least one industry-sponsored trial in the past 5 years</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_5yr</td>
<td>Equal to 1 if the add-on component of the combination has been tested in at least one nonprofit-sponsored trial in the past 5 years</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_5yr</td>
<td>Equal to 1 if the add-on component of the combination has been tested in at least one investigator initiated trial in the past 5 years</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_5yr</td>
<td>Equal to 1 if at least one add-on drug of the combination has been tested in at least one industry-sponsored trial in the past 5 years</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_5yr</td>
<td>Equal to 1 if at least one add-on drug of the combination has been tested in at least one nonprofit-sponsored trial in the past 5 years</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInvIni_5yr</td>
<td>Equal to 1 if at least one add-on drug of the combination has been tested in at least one investigator initiated trial in the past 5 years</td>
</tr>
</tbody>
</table>

5.5 Comparison of industry-sponsored and nonprofit-sponsored clinical trials

In this section I present the comparison of means for each of the variables described in the previous section. My aim here is not to establish causality but rather draw insights on for-profit and nonprofit interaction in the contexts with complementary products. I compare the characteristics of the trials sponsored by for-profit and nonprofit actors and find that there are vast differences in most parameters. Furthermore, I discover that there is a significant heterogeneity among trials depending on the trial’s type (standard vs. non-standard).

Because clinicaltrials.gov database does not have information on starting and ending dates of trials for a number of trials that took place before 1999 I had to assign the year of the submission to the database as the trial’s starting date for these trials – which in most cases was 1999. Because I risk underestimating the prior experience for such trials I chose to focus on the post-2000 trials only. I could have chosen even later starting date (e.g., 2002) as I may overestimate prior experience for trials that took place in 2000 and 2001, but in that case I would have reduced the sample too much.

I have three groups of trials: industry-sponsored, nonprofit-sponsored and investigator initiated trials. As I have explained in section 4 I chose to be conservative and exclude investigator initiated
trials from the nonprofit-sponsored group as I cannot be certain about firms’ involvement in clinical trials design in such trials. Because investigator initiated trials are very few it would be difficult to get meaningful results when comparing them to the other two groups. Therefore I chose to focus on industry-sponsored and nonprofit-sponsored trials only; however, I retain the information about prior experience in investigator initiated trials. Overall, I have 319 trials representing 668 trial-combinations. The comparison is done at the level of trial-combination.

5.5.1 Differences in the characteristics of trials and combinations between for-profit and nonprofit trials

Table 8 provides a first look at the comparison of for-profit (industry) and nonprofit trials along the highlighted dimensions. The first impression that for-profit trials and nonprofit trials differ significantly across virtually all dimensions.

Table 8 confirms the intuition about drug ownership: firms would not normally conduct a trial on drugs that they do not own, and they would also try to test combinations fully comprised of their own drugs. In more than 0.9 of cases the sponsor owns at least one of the drugs in at least one combination tested (SponsorOwnedDrug = 0.928), and 0.12 of combinations tested are fully owned by the trial’s sponsor (SponsorOwnedCombo). While nonprofits sometimes also test combinations belonging to one owner, such cases represent less than 0.08 (ComboSameOwner).

Table 8 also provides support for the intuition that firms would try to promote the use of single pills: roughly a quarter of the combinations tested in the industry-sponsored trials comprise a single pill for base drugs (Base_SinglePill), and 0.13 of combinations tested represent single pills (Combo_SinglePill). In the nonprofit trials, by contrast, only 0.07 combinations contain single pills of base drugs, and very few are tested as single pills.

We can also notice that more nonprofit trials tend to be conducted in developing countries (0.28 vs. 0.1 of combinations, DevelopingCountry_Trial). Nonprofits also tend to be more engaged in non-standard trials (trials on simplified therapy, disease transmission prevention, treatment timing):

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45The difference for industry-sponsored trials between SponsorOwnedCombo = 0.124 and ComboSameOwner = 0.176 is likely driven by the fact that firms may test more than one focal combination in a trial, where one may be fully owned by the sponsor while the other may be fully owned by another firm.
in fact, slightly over a half of combinations tested by nonprofits are within non-standard trials (Non-
Standard_Trial), and 14% of combinations are tested in simplified therapy trials (SimplifiedTher-
apy_Trial). By contrast, these numbers are only 10% and 5%, respectively, for industry-based
trials. All the differences between industry-sponsored and nonprofit-sponsored trials are highly
significant.

Nonprofits also tend to test combinations of older drugs compared to firms: base drugs used in
nonprofit trials are on average 3 years older than those used in industry trials (MinAgeBase, Max-
AgeBase), and add-on drugs can be as much as nearly 6 years older on average (MinAgeAddon).
It is interesting that there is a difference in the base drug age as base drugs are far more limited
in numbers compared to add-on drugs, and closer to each other in terms of the year of develop-
ment. Most likely the three-year difference comes from nonprofits using the oldest base drug once
it became generic, and from firms using the new version of one of the base drugs. When it comes
to add-on drugs the difference in age is even larger: nonprofits tend to use on average add-ons for
which phase II trials had been completed ten years before the trials start on average, while this
number is less than five years for industry-based trials (MinAgeAddon).

Even more interesting picture emerges when we look at the use of prior experience by firms
and by nonprofits. We can see that, on average, firms and nonprofits tend to replicate prior trials
(SameCombo_prior2years), i.e. they test combinations that had already been tested in prior trials
(the difference between firms and nonprofits is not statistically significant). However, when we
distinguish between who conducted prior trials, it appears that firms and nonprofits tend to replicate
the experience by the same actor type: 0.24 combinations tested by the firms had been tested within
the past 2 years in the industry-sponsored trials, but only 0.12 combinations tested by nonprofits
replicated combinations from industry-sponsored trials (SameCombo_prior2years_Industry). And
for nonprofits 0.23 combinations replicates those tested before in nonprofit-sponsored trials, while
for the firms this concerns only 0.06 combinations (SameCombo_prior2years_Nonprofit). The
same pattern is observed with the combinations previously tested in investigator initiated trials as
they are mostly replicated by nonprofits rather than firms (SameCombo_prior2years_InvIni). The
differences between firms and nonprofits are statistically significant.

I also check the differences using a five-year window. When it comes to combinations previously tested in nonprofit or investigator initiated trials the results are similar to those with two-year window: such combinations are mostly tested in nonprofit trials, but not firm trials (*SameCombo_prior5years_Nonprofit* and *SameCombo_prior5years_Initiator*). Interestingly, for combinations previously tested in the industry trials I observe a smaller difference between industry and nonprofit trials compared to that for a two-year window: the difference is 0.064, and only marginally significant, for the five-year window (*SameCombo_prior5years_Industry*) compared to 0.126 difference for the two-year window (*SameCombo_prior2years_Industry*). This seems to be driven by a higher share of these combinations tested by nonprofits when I look at the five-year window compared to the two-year window: it went from 0.12 for the two-year window to 0.22 for the five year window, while for the firms the share of such combinations only increased from 0.24 for the two-year window to 0.29 for the five-year window. Furthermore, looking at the overall use of prior experience (without distinguishing the “source” actor), nonprofits appear to replicate more than firms when I use a five-year window: 0.5 nonprofit-tested combinations are the same as those tested in prior trials compared to 0.33 industry-tested combinations, the difference is statistically significant (*SameCombo_prior5years*).

Finally, we can also see whether trials tend to use the same part of the combination or the same drug. Because the choice of bases is much more limited and has seen little innovation in 2000s we can expect that most combinations by default will use the same base as in the prior trial. For this reason I chose to focus on the add-on part of the treatment which boasts higher variety and innovation. I look at the use of the same add-on component (which may contain one or more add-on drugs) that had been used in prior trials (*AddOn_SameAsPriorTrial_2yr*), and I also look at the use of a single add-on drug (*AddOnDrug_SameAsPriorTrial_2yr*). For many combinations these two variables are the same (like standard combinations with two base drugs and one add-on drug), however, some combinations, in particular simplified therapy combinations, contain two or more add-on drugs; also trials in pre-treated patients sometimes test adding another add-on drug on top
Table 8: Comparison of means between industry-sponsored and nonprofit-sponsored trials: all trials, 2000-2018

<table>
<thead>
<tr>
<th>Category</th>
<th>Industry</th>
<th>Nonprofit</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DevelopingCountry_Trial</td>
<td>0.098</td>
<td>0.285</td>
<td>-0.186***</td>
<td>0.030</td>
<td>668</td>
</tr>
<tr>
<td>NonStandard_Trial</td>
<td>0.098</td>
<td>0.525</td>
<td>-0.427***</td>
<td>0.033</td>
<td>668</td>
</tr>
<tr>
<td>SimplifiedTherapy_Trial</td>
<td>0.049</td>
<td>0.138</td>
<td>-0.089***</td>
<td>0.023</td>
<td>668</td>
</tr>
<tr>
<td>ComboWithoutBase</td>
<td>0.042</td>
<td>0.097</td>
<td>-0.054***</td>
<td>0.020</td>
<td>668</td>
</tr>
<tr>
<td>ComboSameOwner</td>
<td>0.176</td>
<td>0.078</td>
<td>0.098***</td>
<td>0.025</td>
<td>664</td>
</tr>
<tr>
<td>SponsorOwnedDrug</td>
<td>0.928</td>
<td>0.000</td>
<td>0.928***</td>
<td>0.014</td>
<td>664</td>
</tr>
<tr>
<td>SponsorOwnedCombo</td>
<td>0.124</td>
<td>0.000</td>
<td>0.124***</td>
<td>0.017</td>
<td>664</td>
</tr>
<tr>
<td>Base_SinglePill</td>
<td>0.258</td>
<td>0.072</td>
<td>0.186***</td>
<td>0.027</td>
<td>668</td>
</tr>
<tr>
<td>Combo_SinglePill</td>
<td>0.131</td>
<td>0.017</td>
<td>0.114***</td>
<td>0.019</td>
<td>668</td>
</tr>
<tr>
<td>MaxAgeBase</td>
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<td>18.218</td>
<td>-3.168***</td>
<td>0.513</td>
<td>448</td>
</tr>
<tr>
<td>MinAgeBase</td>
<td>10.305</td>
<td>13.810</td>
<td>-3.505***</td>
<td>0.545</td>
<td>448</td>
</tr>
<tr>
<td>MaxAgeAddon</td>
<td>7.206</td>
<td>10.901</td>
<td>-3.694***</td>
<td>0.368</td>
<td>613</td>
</tr>
<tr>
<td>MinAgeAddon</td>
<td>4.608</td>
<td>10.394</td>
<td>-5.786***</td>
<td>0.390</td>
<td>613</td>
</tr>
<tr>
<td>SameCombo_prior2years</td>
<td>0.288</td>
<td>0.340</td>
<td>-0.052</td>
<td>0.036</td>
<td>668</td>
</tr>
<tr>
<td>SameCombo_prior2years_Industry</td>
<td>0.242</td>
<td>0.116</td>
<td>0.126***</td>
<td>0.029</td>
<td>668</td>
</tr>
<tr>
<td>SameCombo_prior2years_Nonprofit</td>
<td>0.056</td>
<td>0.227</td>
<td>-0.171***</td>
<td>0.027</td>
<td>668</td>
</tr>
<tr>
<td>SameCombo_prior2years_InvIni</td>
<td>0.016</td>
<td>0.066</td>
<td>-0.050***</td>
<td>0.016</td>
<td>668</td>
</tr>
<tr>
<td>SameCombo_prior5years</td>
<td>0.327</td>
<td>0.503</td>
<td>-0.176***</td>
<td>0.038</td>
<td>668</td>
</tr>
<tr>
<td>SameCombo_prior5years_Industry</td>
<td>0.288</td>
<td>0.224</td>
<td>0.064*</td>
<td>0.034</td>
<td>668</td>
</tr>
<tr>
<td>SameCombo_prior5years_Nonprofit</td>
<td>0.059</td>
<td>0.370</td>
<td>-0.311***</td>
<td>0.030</td>
<td>668</td>
</tr>
<tr>
<td>SameCombo_prior5years_InvIni</td>
<td>0.020</td>
<td>0.127</td>
<td>-0.107***</td>
<td>0.020</td>
<td>668</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_2yr</td>
<td>0.528</td>
<td>0.765</td>
<td>-0.237***</td>
<td>0.037</td>
<td>635</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_2yr</td>
<td>0.812</td>
<td>0.925</td>
<td>-0.113***</td>
<td>0.026</td>
<td>635</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_2yr</td>
<td>0.492</td>
<td>0.599</td>
<td>-0.108***</td>
<td>0.039</td>
<td>635</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_2yr</td>
<td>0.248</td>
<td>0.639</td>
<td>-0.391***</td>
<td>0.036</td>
<td>635</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_2yr</td>
<td>0.145</td>
<td>0.292</td>
<td>-0.147***</td>
<td>0.033</td>
<td>635</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_2yr</td>
<td>0.779</td>
<td>0.789</td>
<td>-0.010</td>
<td>0.033</td>
<td>635</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_2yr</td>
<td>0.462</td>
<td>0.813</td>
<td>-0.351***</td>
<td>0.035</td>
<td>635</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInvIni_2yr</td>
<td>0.350</td>
<td>0.500</td>
<td>-0.150***</td>
<td>0.039</td>
<td>635</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_5yr</td>
<td>0.584</td>
<td>0.822</td>
<td>-0.238***</td>
<td>0.035</td>
<td>635</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_5yr</td>
<td>0.842</td>
<td>0.961</td>
<td>-0.119***</td>
<td>0.023</td>
<td>635</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_5yr</td>
<td>0.551</td>
<td>0.705</td>
<td>-0.154***</td>
<td>0.038</td>
<td>635</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_5yr</td>
<td>0.366</td>
<td>0.756</td>
<td>-0.390***</td>
<td>0.036</td>
<td>635</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_5yr</td>
<td>0.195</td>
<td>0.515</td>
<td>-0.320***</td>
<td>0.036</td>
<td>635</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_5yr</td>
<td>0.812</td>
<td>0.880</td>
<td>-0.068**</td>
<td>0.029</td>
<td>635</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_5yr</td>
<td>0.587</td>
<td>0.898</td>
<td>-0.310***</td>
<td>0.032</td>
<td>635</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInvIni_5yr</td>
<td>0.482</td>
<td>0.678</td>
<td>-0.196***</td>
<td>0.038</td>
<td>635</td>
</tr>
<tr>
<td>Number of observations</td>
<td>306</td>
<td>362</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.1, ** p < 0.05, *** p < 0.01
of the three-drug combination. We can clearly see that both firms and nonprofits tend to use add-on drugs and add-on components that have been used in prior trials, nonprofits more so than firms. Even when I distinguish prior industry trials vs. prior nonprofit vs. prior investigator-initiated trials this pattern remains. And, similarly to the case of the replication of combinations, firms appear to build less on the prior experience of nonprofits.

Overall, I observe that there are significant differences between industry-sponsored and nonprofit-sponsored trials, which seem consistent with the hypothesized incentives of the actors. Firms tend to conduct trials on their own drugs, and use combinations with more commercial “appeal”, for instance, combinations comprising single pills, or combinations composed exclusively of their own drugs. By contrast, nonprofit actors tend to use older drugs and conduct more trials in developing countries, which is in line with the idea that nonprofits would “fill the voids” left by the firms. This could also explain lower use of single pills: because nonprofits are interested in the treatment cost reduction more than a marginal improvement in the drug’s ease of use they would choose to test combinations of generic drugs rather than branded single pills.

5.5.2 Differences within sponsor type: standard vs. non-standard trials

Given the importance of non-standard trials in the ecosystem evolution I decided to compare the differences between standard and non-standard trials within the same sponsor type to understand whether there is heterogeneity across trial types. For trials sponsored by nonprofits there are few differences between standard and nonstandard trials (Table 10): nonprofits use slightly older drugs in non-standard trials, most likely due to mother-to-child transmission prevention trials featuring some of the oldest base and add-on drugs.\footnote{There is also a significant difference for nonprofit-sponsored trials concerning the share of combinations tested in developing countries: 0.36 combinations for standard trials vs. 0.22 combinations for non-standard trials. However, this difference is likely driven by different number of combinations tested in a trial – in particular, by a large nonprofit non-standard trial featuring multiple combinations. In fact, checking the difference in DevelopingCountry_Trial at the level of the trial (as opposed to trial-combination), on average 50% of nonprofit trials are conducted in developing countries, irrespectively of the trial type.} By contrast, standard and non-standard trials appear quite disparate when sponsored by firms (Table 9).

There are 180 industry-sponsored trials resulting in 306 trial-combinations, of which 155 tri-
Table 9: Industry-sponsored trials: comparison of means between standard and non-standard trials

<table>
<thead>
<tr>
<th></th>
<th>Standard trials</th>
<th>Nonstandard trials</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DevelopingCountry_Trial</td>
<td>0.091</td>
<td>0.167</td>
<td>-0.076</td>
<td>0.057</td>
<td>306</td>
</tr>
<tr>
<td>Base_SinglePill</td>
<td>0.272</td>
<td>0.133</td>
<td>0.138</td>
<td>0.084</td>
<td>306</td>
</tr>
<tr>
<td>Combo_SinglePill</td>
<td>0.138</td>
<td>0.067</td>
<td>0.071</td>
<td>0.065</td>
<td>306</td>
</tr>
<tr>
<td>ComboSameOwner</td>
<td>0.181</td>
<td>0.133</td>
<td>0.048</td>
<td>0.073</td>
<td>306</td>
</tr>
<tr>
<td>SponsorOwnedDrug</td>
<td>0.942</td>
<td>0.800</td>
<td>0.142</td>
<td>0.049</td>
<td>306</td>
</tr>
<tr>
<td>SponsorOwnedCombo</td>
<td>0.127</td>
<td>0.100</td>
<td>0.027</td>
<td>0.064</td>
<td>306</td>
</tr>
<tr>
<td>MaxAgeBase</td>
<td>14.800</td>
<td>19.800</td>
<td>-5.000</td>
<td>1.710</td>
<td>200</td>
</tr>
<tr>
<td>MinAgeBase</td>
<td>10.005</td>
<td>16.000</td>
<td>-5.995</td>
<td>1.958</td>
<td>200</td>
</tr>
<tr>
<td>MaxAgeAddon</td>
<td>7.206</td>
<td>7.207</td>
<td>-0.001</td>
<td>0.874</td>
<td>291</td>
</tr>
<tr>
<td>MinAgeAddon</td>
<td>4.439</td>
<td>6.138</td>
<td>-1.699</td>
<td>0.920</td>
<td>291</td>
</tr>
<tr>
<td>ComboSameOwner</td>
<td>0.181</td>
<td>0.133</td>
<td>0.048</td>
<td>0.073</td>
<td>306</td>
</tr>
<tr>
<td>SameCombo_prior2years</td>
<td>0.286</td>
<td>0.300</td>
<td>-0.014</td>
<td>0.087</td>
<td>306</td>
</tr>
<tr>
<td>SameCombo_prior2years_Industry</td>
<td>0.261</td>
<td>0.067</td>
<td>0.194</td>
<td>0.082</td>
<td>306</td>
</tr>
<tr>
<td>SameCombo_prior2years_Nonprofit</td>
<td>0.040</td>
<td>0.200</td>
<td>-0.160</td>
<td>0.043</td>
<td>306</td>
</tr>
<tr>
<td>SameCombo_prior2years_InvIni</td>
<td>0.004</td>
<td>0.133</td>
<td>-0.130</td>
<td>0.023</td>
<td>306</td>
</tr>
<tr>
<td>SameCombo_prior5years</td>
<td>0.322</td>
<td>0.367</td>
<td>-0.044</td>
<td>0.090</td>
<td>306</td>
</tr>
<tr>
<td>SameCombo_prior5years_Industry</td>
<td>0.301</td>
<td>0.167</td>
<td>0.134</td>
<td>0.087</td>
<td>306</td>
</tr>
<tr>
<td>SameCombo_prior5years_Nonprofit</td>
<td>0.043</td>
<td>0.200</td>
<td>-0.157</td>
<td>0.044</td>
<td>306</td>
</tr>
<tr>
<td>SameCombo_prior5years_InvIni</td>
<td>0.004</td>
<td>0.167</td>
<td>-0.163</td>
<td>0.025</td>
<td>306</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_2yr</td>
<td>0.511</td>
<td>0.690</td>
<td>-0.179</td>
<td>0.097</td>
<td>303</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_2yr</td>
<td>0.810</td>
<td>0.828</td>
<td>-0.017</td>
<td>0.077</td>
<td>303</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_2yr</td>
<td>0.489</td>
<td>0.517</td>
<td>-0.028</td>
<td>0.098</td>
<td>303</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_2yr</td>
<td>0.226</td>
<td>0.448</td>
<td>-0.222</td>
<td>0.084</td>
<td>303</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_2yr</td>
<td>0.128</td>
<td>0.310</td>
<td>-0.183</td>
<td>0.068</td>
<td>303</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_2yr</td>
<td>0.777</td>
<td>0.793</td>
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<td>0.081</td>
<td>303</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_2yr</td>
<td>0.438</td>
<td>0.690</td>
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<td>0.097</td>
<td>303</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInvIni_2yr</td>
<td>0.325</td>
<td>0.586</td>
<td>-0.261</td>
<td>0.092</td>
<td>303</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_5yr</td>
<td>0.569</td>
<td>0.724</td>
<td>-0.155</td>
<td>0.096</td>
<td>303</td>
</tr>
<tr>
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<td>0.072</td>
<td>303</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_5yr</td>
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<td>0.586</td>
<td>-0.039</td>
<td>0.097</td>
<td>303</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_5yr</td>
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<td>0.552</td>
<td>-0.205</td>
<td>0.094</td>
<td>303</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_5yr</td>
<td>0.179</td>
<td>0.345</td>
<td>-0.166</td>
<td>0.077</td>
<td>303</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_5yr</td>
<td>0.807</td>
<td>0.862</td>
<td>-0.055</td>
<td>0.077</td>
<td>303</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_5yr</td>
<td>0.573</td>
<td>0.724</td>
<td>-0.151</td>
<td>0.096</td>
<td>303</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInvIni_5yr</td>
<td>0.471</td>
<td>0.586</td>
<td>-0.115</td>
<td>0.098</td>
<td>303</td>
</tr>
<tr>
<td>Number of observations</td>
<td>276</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.1, **p < 0.05, ***p < 0.01
Table 10: Nonprofit-sponsored trials: comparison of means between standard and non-standard trials

<table>
<thead>
<tr>
<th></th>
<th>Standard trials</th>
<th>Nonstandard trials</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DevelopingCountry_Trial</td>
<td>0.355</td>
<td>0.221</td>
<td>0.134*</td>
<td>0.047</td>
<td>362</td>
</tr>
<tr>
<td>Base_SinglePill</td>
<td>0.099</td>
<td>0.047</td>
<td>0.051*</td>
<td>0.027</td>
<td>362</td>
</tr>
<tr>
<td>Combo_SinglePill</td>
<td>0.023</td>
<td>0.011</td>
<td>0.013</td>
<td>0.013</td>
<td>362</td>
</tr>
<tr>
<td>ComboSameOwner</td>
<td>0.070</td>
<td>0.086</td>
<td>-0.015</td>
<td>0.028</td>
<td>358</td>
</tr>
<tr>
<td>MaxAgeBase</td>
<td>16.941</td>
<td>19.377</td>
<td>-2.436*</td>
<td>0.674</td>
<td>248</td>
</tr>
<tr>
<td>MinAgeBase</td>
<td>12.881</td>
<td>14.654</td>
<td>-1.772*</td>
<td>0.674</td>
<td>248</td>
</tr>
<tr>
<td>MaxAgeAddon</td>
<td>9.890</td>
<td>11.827</td>
<td>-1.938*</td>
<td>0.506</td>
<td>322</td>
</tr>
<tr>
<td>MinAgeAddon</td>
<td>9.721</td>
<td>11.012</td>
<td>-1.291*</td>
<td>0.544</td>
<td>322</td>
</tr>
<tr>
<td>ComboSameOwner</td>
<td>0.070</td>
<td>0.086</td>
<td>-0.015</td>
<td>0.028</td>
<td>358</td>
</tr>
<tr>
<td>SameCombo_prior2years</td>
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<td>0.342</td>
<td>-0.005</td>
<td>0.050</td>
<td>362</td>
</tr>
<tr>
<td>SameCombo_prior2years_Industry</td>
<td>0.140</td>
<td>0.095</td>
<td>0.045</td>
<td>0.034</td>
<td>362</td>
</tr>
<tr>
<td>SameCombo_prior2years_Nonprofit</td>
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<td>0.247</td>
<td>-0.044</td>
<td>0.044</td>
<td>362</td>
</tr>
<tr>
<td>SameCombo_prior2years_InvIni</td>
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<td>0.068</td>
<td>-0.004</td>
<td>0.026</td>
<td>362</td>
</tr>
<tr>
<td>SameCombo_prior5years</td>
<td>0.477</td>
<td>0.526</td>
<td>-0.050</td>
<td>0.053</td>
<td>362</td>
</tr>
<tr>
<td>SameCombo_prior5years_Industry</td>
<td>0.238</td>
<td>0.211</td>
<td>0.028</td>
<td>0.044</td>
<td>362</td>
</tr>
<tr>
<td>SameCombo_prior5years_Nonprofit</td>
<td>0.314</td>
<td>0.421</td>
<td>-0.107*</td>
<td>0.051</td>
<td>362</td>
</tr>
<tr>
<td>SameCombo_prior5years_InvIni</td>
<td>0.122</td>
<td>0.132</td>
<td>-0.009</td>
<td>0.035</td>
<td>362</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_2yr</td>
<td>0.811</td>
<td>0.723</td>
<td>0.089*</td>
<td>0.046</td>
<td>332</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_2yr</td>
<td>0.956</td>
<td>0.896</td>
<td>0.060**</td>
<td>0.029</td>
<td>332</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_2yr</td>
<td>0.616</td>
<td>0.584</td>
<td>0.033</td>
<td>0.054</td>
<td>332</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_2yr</td>
<td>0.654</td>
<td>0.624</td>
<td>0.030</td>
<td>0.053</td>
<td>332</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_2yr</td>
<td>0.396</td>
<td>0.197</td>
<td>0.200***</td>
<td>0.049</td>
<td>332</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_2yr</td>
<td>0.786</td>
<td>0.792</td>
<td>-0.006</td>
<td>0.045</td>
<td>332</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_2yr</td>
<td>0.862</td>
<td>0.769</td>
<td>0.093**</td>
<td>0.043</td>
<td>332</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInvIni_2yr</td>
<td>0.535</td>
<td>0.468</td>
<td>0.066</td>
<td>0.055</td>
<td>332</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_5yr</td>
<td>0.843</td>
<td>0.803</td>
<td>0.039</td>
<td>0.042</td>
<td>332</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_5yr</td>
<td>0.962</td>
<td>0.960</td>
<td>0.003</td>
<td>0.021</td>
<td>332</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_5yr</td>
<td>0.736</td>
<td>0.676</td>
<td>0.060</td>
<td>0.050</td>
<td>332</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_5yr</td>
<td>0.723</td>
<td>0.786</td>
<td>-0.063</td>
<td>0.047</td>
<td>332</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_5yr</td>
<td>0.553</td>
<td>0.480</td>
<td>0.074</td>
<td>0.055</td>
<td>332</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_5yr</td>
<td>0.881</td>
<td>0.879</td>
<td>0.002</td>
<td>0.036</td>
<td>332</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_5yr</td>
<td>0.874</td>
<td>0.919</td>
<td>-0.045</td>
<td>0.033</td>
<td>332</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInvIni_5yr</td>
<td>0.673</td>
<td>0.682</td>
<td>-0.009</td>
<td>0.051</td>
<td>332</td>
</tr>
</tbody>
</table>

Number of observations 172 190

*p < 0.1, **p < 0.05, ***p < 0.01
als (276 trial-combinations) are standard and 25 trials (30 trial-combinations) are non-standard. Looking at Table 9 it is clear that there are a lot of differences between the two trial types when it comes to leveraging prior trials’ experience.\(^{47}\) In section 5.5.1, when I looked at all industry trials combined, it appeared that firms tended to replicate primarily industry-sponsored trials rather than nonprofit trials (both as a full combination, and as an add-on part). Looking at the split sample we see that the aforementioned results hold true for standard trials, but not for nonstandard trials. Indeed, firms tend to replicate prior standard trials by the industry but not by nonprofits, yet when it comes to non-standard trials firms appear to replicate a lot the experience by nonprofits: 0.2 combinations tested by the firms in non-standard trials have been tested before by nonprofits compared to only 0.04 combinations in standard trials (SameCombo_prior2years_Nonprofit), the results hold true both for two-year and five-year windows. Likewise, non-standard trials are more likely to use an add-on component, or add-on drugs, that have been tested before by nonprofits, compared to standard trials: 0.45 combinations vs. 0.22 combinations for add-on component (AddOn_SameAsPriorTrial_byNonp_2r), and 0.69 vs. 0.43 for add-on drugs (AddOn-Drug_SameAsPriorTrial_byNonp_2r) in the two-year window, the differences are statistically significant and hold for the five-year window as well. We can observe a similar pattern with combinations previously tested in investigator-initiated trials. These findings suggest that there is a significant heterogeneity within industry trials depending on the trial’s type, in particular, firms appear to leverage more the prior nonprofit trials when it comes to non-standard trials while focusing on industry trials when designing a standard trial.

5.5.3 Comparison between firms and nonprofits in non-standard trials

Given the differences between standard and non-standard trials observed in industry-sponsored trials, I repeated the analysis of Table 8 that compared firms and nonprofits, but looked separately at standard trials and non-standard trials. From Table 11 we can see that the results documented in Table 8 (for the whole sample) hold true for standard trials, and there is a sharp distinction between

\(^{47}\)The difference of 5 years in the age of base drugs should be interpreted with caution: only 16 out of 30 non-standard trials contain base drugs, and those who do mostly use an older one, which drives the difference.
industry-sponsored and non-profit sponsored trials. Yet when we look at Table 12 we see a very different picture as some features of the industry-sponsored trials are more similar to those of the nonprofit-sponsored trials.

First, the difference in the drug’s age between firm and nonprofit trials becomes smaller for non-standard trials, less than 5 years on average (MinAgeAddon). This is because the average age of add-on drugs in industry-sponsored non-standard trials is 6.14 years compared to 4.44 years in standard trials (the difference of 1.7 years is statistically significant, see Table 9). Furthermore, if we look only at simplified therapy trials the difference in the add-on drugs’ age between industry-sponsored and nonprofit-sponsored trials virtually disappears (6.7 vs. 6.5 years, not statistically significant, in MinAgeAddon, see Table 13). The difference in age that persists in non-standard trials is likely driven by the disproportionate number of nonprofit trials on mother-to-child transmission (19 trials by nonprofits compared to 3 trials by firms) that test some of the oldest HIV drugs.

Second, when it comes to the use of prior experience we observe the patterns opposite to those in standard trials: firms replicate combinations tested in nonprofits’ prior trials and use the add-on drugs previously tested by nonprofits. The share of combinations or add-ons tested previously in nonprofit-sponsored trials within the two-year window is not different, or only marginally different, between industry trials and nonprofit trials (see variables SameCombo_prior2years_Nonprofit, Addon_SameAsPriorTrial_2yr, AddOnDrug_SameAsPriorTrial_2yr). When we look at the five-year window nonprofits do replicate more compared to the industry when it comes to prior nonprofit trials (see variables SameCombo_prior5years_Nonprofit, Addon_SameAsPriorTrial_5yr, AddOnDrug_SameAsPriorTrial_5yr), but the difference is smaller compared to the one in standard trials. Moreover, if we look only at simplified therapy trials (Table 13) all differences in terms of the use of prior nonprofit experience disappear. In fact, taking together the results in Tables 9 and 12 we observe that firms appear to leverage more of prior nonprofit experience than prior industry experience, when it comes to non-standard trials.
Table 11: Comparison of means between industry-sponsored and nonprofit-sponsored trials: standard trials, 2000-2018

<table>
<thead>
<tr>
<th></th>
<th>Industry</th>
<th>Nonprofit</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DevelopingCountry_Trial</td>
<td>0.091</td>
<td>0.355</td>
<td>-0.264</td>
<td>0.038</td>
<td>448</td>
</tr>
<tr>
<td>ComboWithoutBase</td>
<td>0.011</td>
<td>0.006</td>
<td>0.005</td>
<td>0.009</td>
<td>448</td>
</tr>
<tr>
<td>ComboSameOwner</td>
<td>0.181</td>
<td>0.070</td>
<td>0.111</td>
<td>0.033</td>
<td>447</td>
</tr>
<tr>
<td>SponsorOwnedDrug</td>
<td>0.942</td>
<td>0.000</td>
<td>0.942</td>
<td>0.018</td>
<td>447</td>
</tr>
<tr>
<td>SponsorOwnedCombo</td>
<td>0.127</td>
<td>0.000</td>
<td>0.127</td>
<td>0.026</td>
<td>447</td>
</tr>
<tr>
<td>Base_SinglePill</td>
<td>0.272</td>
<td>0.099</td>
<td>0.173</td>
<td>0.038</td>
<td>448</td>
</tr>
<tr>
<td>Combo_SinglePill</td>
<td>0.138</td>
<td>0.023</td>
<td>0.114</td>
<td>0.028</td>
<td>448</td>
</tr>
<tr>
<td>MaxAgeBase</td>
<td>14.800</td>
<td>16.941</td>
<td>-2.141</td>
<td>0.619</td>
<td>308</td>
</tr>
<tr>
<td>MinAgeBase</td>
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<td>12.881</td>
<td>-2.876</td>
<td>0.658</td>
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</tr>
<tr>
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<td>MinAgeAddon</td>
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<td>-5.282</td>
<td>0.479</td>
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</tr>
<tr>
<td>SameCombo_prior2years</td>
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<td>0.337</td>
<td>-0.051</td>
<td>0.045</td>
<td>448</td>
</tr>
<tr>
<td>SameCombo_prior2years_Industry</td>
<td>0.261</td>
<td>0.140</td>
<td>0.121</td>
<td>0.040</td>
<td>448</td>
</tr>
<tr>
<td>SameCombo_prior2years_Nonprofit</td>
<td>0.040</td>
<td>0.203</td>
<td>-0.164</td>
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<td>SameCombo_prior2years_InvIni</td>
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<td>0.064</td>
<td>-0.060</td>
<td>0.015</td>
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<td>SameCombo_prior5years</td>
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<td>-0.154</td>
<td>0.047</td>
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<tr>
<td>SameCombo_prior5years_Industry</td>
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<td>0.238</td>
<td>0.062</td>
<td>0.043</td>
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<tr>
<td>SameCombo_prior5years_Nonprofit</td>
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<td>-0.270</td>
<td>0.032</td>
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<td>0.046</td>
<td>433</td>
</tr>
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<td>0.956</td>
<td>-0.146</td>
<td>0.034</td>
<td>433</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_2yr</td>
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<td>0.616</td>
<td>-0.127</td>
<td>0.049</td>
<td>433</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_2yr</td>
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<td>-0.428</td>
<td>0.044</td>
<td>433</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_2yr</td>
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<td>0.041</td>
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</tr>
<tr>
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<td>0.843</td>
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<td>0.045</td>
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</tr>
<tr>
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<td>0.736</td>
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<td>0.673</td>
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<td>0.049</td>
<td>433</td>
</tr>
</tbody>
</table>

Number of observations 276 172

*p < 0.1, ** p < 0.05, *** p < 0.01
Table 12: Comparison of means between industry-sponsored and nonprofit-sponsored trials: non-standard trials, 2000-2018

<table>
<thead>
<tr>
<th>Category</th>
<th>Industry</th>
<th>Nonprofit</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>Obs.</th>
</tr>
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<tbody>
<tr>
<td>DevelopingCountry_Trial</td>
<td>0.167</td>
<td>0.221</td>
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<td>0.081</td>
<td>220</td>
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<td>SimplifiedTherapy_Trial</td>
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<td>0.263</td>
<td>0.237***</td>
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</tr>
<tr>
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<td>0.179</td>
<td>0.154**</td>
<td>0.078</td>
<td>220</td>
</tr>
<tr>
<td>ComboSameOwner</td>
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<td>0.086</td>
<td>0.048</td>
<td>0.057</td>
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<tr>
<td>SponsorOwnedDrug</td>
<td>0.800</td>
<td>0.000</td>
<td>0.800***</td>
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<td>217</td>
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<td>0.000</td>
<td>0.100***</td>
<td>0.022</td>
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</tr>
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<td>Base_SinglePill</td>
<td>0.133</td>
<td>0.047</td>
<td>0.086*</td>
<td>0.046</td>
<td>220</td>
</tr>
<tr>
<td>Combo_SinglePill</td>
<td>0.067</td>
<td>0.011</td>
<td>0.056**</td>
<td>0.026</td>
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</tr>
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<td>MaxAgeAddon</td>
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<td>-0.042</td>
<td>0.093</td>
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</tr>
<tr>
<td>SameCombo_prior2years_Industry</td>
<td>0.067</td>
<td>0.095</td>
<td>-0.028</td>
<td>0.057</td>
<td>220</td>
</tr>
<tr>
<td>SameCombo_prior2years_Nonprofit</td>
<td>0.200</td>
<td>0.247</td>
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<td>0.084</td>
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</tr>
<tr>
<td>SameCombo_prior2years_InvIni</td>
<td>0.133</td>
<td>0.068</td>
<td>0.065</td>
<td>0.053</td>
<td>220</td>
</tr>
<tr>
<td>SameCombo_prior5years</td>
<td>0.367</td>
<td>0.526</td>
<td>-0.160</td>
<td>0.098</td>
<td>220</td>
</tr>
<tr>
<td>SameCombo_prior5years_Industry</td>
<td>0.167</td>
<td>0.211</td>
<td>-0.044</td>
<td>0.080</td>
<td>220</td>
</tr>
<tr>
<td>SameCombo_prior5years_Nonprofit</td>
<td>0.200</td>
<td>0.421</td>
<td>-0.221**</td>
<td>0.095</td>
<td>220</td>
</tr>
<tr>
<td>SameCombo_prior5years_InvIni</td>
<td>0.167</td>
<td>0.132</td>
<td>0.035</td>
<td>0.068</td>
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<tr>
<td>AddOn_SameAsPriorTrial_byInd_2yr</td>
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<td>0.584</td>
<td>-0.067</td>
<td>0.100</td>
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</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_2yr</td>
<td>0.448</td>
<td>0.624</td>
<td>-0.176*</td>
<td>0.098</td>
<td>202</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_2yr</td>
<td>0.310</td>
<td>0.197</td>
<td>0.114</td>
<td>0.082</td>
<td>202</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_2yr</td>
<td>0.793</td>
<td>0.792</td>
<td>0.001</td>
<td>0.082</td>
<td>202</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_2yr</td>
<td>0.690</td>
<td>0.769</td>
<td>-0.079</td>
<td>0.086</td>
<td>202</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_2yr</td>
<td>0.586</td>
<td>0.468</td>
<td>0.118</td>
<td>0.100</td>
<td>202</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_5yr</td>
<td>0.724</td>
<td>0.803</td>
<td>-0.079</td>
<td>0.082</td>
<td>202</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_5yr</td>
<td>0.862</td>
<td>0.960</td>
<td>-0.097**</td>
<td>0.045</td>
<td>202</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_5yr</td>
<td>0.586</td>
<td>0.676</td>
<td>-0.090</td>
<td>0.095</td>
<td>202</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_5yr</td>
<td>0.552</td>
<td>0.786</td>
<td>-0.234***</td>
<td>0.085</td>
<td>202</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_5yr</td>
<td>0.345</td>
<td>0.480</td>
<td>-0.135</td>
<td>0.100</td>
<td>202</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_5yr</td>
<td>0.862</td>
<td>0.879</td>
<td>-0.017</td>
<td>0.066</td>
<td>202</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_5yr</td>
<td>0.724</td>
<td>0.919</td>
<td>-0.195***</td>
<td>0.061</td>
<td>202</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_5yr</td>
<td>0.586</td>
<td>0.682</td>
<td>-0.096</td>
<td>0.095</td>
<td>202</td>
</tr>
<tr>
<td>Number of observations</td>
<td>30</td>
<td>190</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.1, **p < 0.05, ***p < 0.01
Table 13: Comparison of means between industry-sponsored and nonprofit-sponsored trials: simplified therapy trials, 2000-2018

<table>
<thead>
<tr>
<th>Category</th>
<th>Industry</th>
<th>Nonprofit</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DevelopingCountry_Trial</td>
<td>0.200</td>
<td>0.080</td>
<td>0.120</td>
<td>0.091</td>
<td>65</td>
</tr>
<tr>
<td>SimplifiedTherapy_Trial</td>
<td>1.000</td>
<td>1.000</td>
<td>0.000</td>
<td>0.000</td>
<td>65</td>
</tr>
<tr>
<td>Base_SinglePill</td>
<td>0.000</td>
<td>0.020</td>
<td>-0.020</td>
<td>0.037</td>
<td>65</td>
</tr>
<tr>
<td>Combo_SinglePill</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>65</td>
</tr>
<tr>
<td>ComboWithoutBase</td>
<td>0.667</td>
<td>0.260</td>
<td>0.407</td>
<td>0.133</td>
<td>65</td>
</tr>
<tr>
<td>MaxAgeBase</td>
<td>18.750</td>
<td>15.462</td>
<td>3.288</td>
<td>2.989</td>
<td>17</td>
</tr>
<tr>
<td>MinAgeBase</td>
<td>18.750</td>
<td>11.615</td>
<td>7.135</td>
<td>3.241</td>
<td>17</td>
</tr>
<tr>
<td>MaxAgeAddon</td>
<td>7.867</td>
<td>9.286</td>
<td>-1.419</td>
<td>1.089</td>
<td>64</td>
</tr>
<tr>
<td>MinAgeAddon</td>
<td>6.733</td>
<td>6.490</td>
<td>0.244</td>
<td>1.141</td>
<td>64</td>
</tr>
<tr>
<td>SameCombo_prior2years</td>
<td>0.333</td>
<td>0.260</td>
<td>0.073</td>
<td>0.133</td>
<td>65</td>
</tr>
<tr>
<td>SameCombo_prior2years_Industry</td>
<td>0.000</td>
<td>0.060</td>
<td>-0.060</td>
<td>0.062</td>
<td>65</td>
</tr>
<tr>
<td>SameCombo_prior2years_Nonprofit</td>
<td>0.200</td>
<td>0.180</td>
<td>0.020</td>
<td>0.116</td>
<td>65</td>
</tr>
<tr>
<td>SameCombo_prior2years_InvIni</td>
<td>0.133</td>
<td>0.080</td>
<td>0.053</td>
<td>0.086</td>
<td>65</td>
</tr>
<tr>
<td>SameCombo_prior5years</td>
<td>0.400</td>
<td>0.340</td>
<td>0.060</td>
<td>0.143</td>
<td>65</td>
</tr>
<tr>
<td>SameCombo_prior5years_Industry</td>
<td>0.067</td>
<td>0.160</td>
<td>-0.093</td>
<td>0.103</td>
<td>65</td>
</tr>
<tr>
<td>SameCombo_prior5years_Nonprofit</td>
<td>0.200</td>
<td>0.240</td>
<td>-0.040</td>
<td>0.126</td>
<td>65</td>
</tr>
<tr>
<td>SameCombo_prior5years_InvIni</td>
<td>0.200</td>
<td>0.080</td>
<td>0.120</td>
<td>0.091</td>
<td>65</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_2yr</td>
<td>0.733</td>
<td>0.408</td>
<td>0.325</td>
<td>0.144</td>
<td>64</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_2yr</td>
<td>0.933</td>
<td>0.980</td>
<td>-0.046</td>
<td>0.052</td>
<td>64</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_2yr</td>
<td>0.533</td>
<td>0.306</td>
<td>0.227</td>
<td>0.141</td>
<td>64</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_2yr</td>
<td>0.533</td>
<td>0.388</td>
<td>0.146</td>
<td>0.147</td>
<td>64</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_2yr</td>
<td>0.267</td>
<td>0.143</td>
<td>0.124</td>
<td>0.112</td>
<td>64</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_2yr</td>
<td>0.933</td>
<td>0.939</td>
<td>-0.005</td>
<td>0.073</td>
<td>64</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_2yr</td>
<td>0.867</td>
<td>0.857</td>
<td>0.010</td>
<td>0.104</td>
<td>64</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInvIni_2yr</td>
<td>0.733</td>
<td>0.755</td>
<td>-0.022</td>
<td>0.130</td>
<td>64</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_5yr</td>
<td>0.733</td>
<td>0.469</td>
<td>0.264*</td>
<td>0.146</td>
<td>64</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_5yr</td>
<td>0.933</td>
<td>0.980</td>
<td>-0.046</td>
<td>0.052</td>
<td>64</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInd_5yr</td>
<td>0.533</td>
<td>0.367</td>
<td>0.166</td>
<td>0.146</td>
<td>64</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byNonp_5yr</td>
<td>0.733</td>
<td>0.429</td>
<td>0.305**</td>
<td>0.145</td>
<td>64</td>
</tr>
<tr>
<td>AddOn_SameAsPriorTrial_byInvIni_5yr</td>
<td>0.333</td>
<td>0.163</td>
<td>0.170</td>
<td>0.119</td>
<td>64</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInd_5yr</td>
<td>0.933</td>
<td>0.980</td>
<td>-0.046</td>
<td>0.052</td>
<td>64</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byNonp_5yr</td>
<td>0.933</td>
<td>0.857</td>
<td>0.076</td>
<td>0.099</td>
<td>64</td>
</tr>
<tr>
<td>AddOnDrug_SameAsPriorTrial_byInvIni_5yr</td>
<td>0.733</td>
<td>0.796</td>
<td>-0.063</td>
<td>0.124</td>
<td>64</td>
</tr>
<tr>
<td>ComboSameOwner</td>
<td>0.133</td>
<td>0.080</td>
<td>0.053</td>
<td>0.086</td>
<td>65</td>
</tr>
<tr>
<td>SponsorOwnedDrug</td>
<td>0.800</td>
<td>0.000</td>
<td>0.800***</td>
<td>0.057</td>
<td>65</td>
</tr>
<tr>
<td>SponsorOwnedCombo</td>
<td>0.133</td>
<td>0.000</td>
<td>0.133***</td>
<td>0.049</td>
<td>65</td>
</tr>
</tbody>
</table>

Number of observations 15 50

* p < 0.1, ** p < 0.05, *** p < 0.01
5.6 Results interpretation through nonprofits’ incentives

We have seen significant differences in standard trials between firms and nonprofits, both in terms of the age of drugs used and in the use of prior experience, yet more similarity in non-standard trials. I will now discuss these results further and link them to the actors’ incentives. I hypothesized that nonprofits are primarily driven by two goals: make treatment affordable to patients in poorer countries, and find the treatment with the highest medical value for the patients.

Results of the comparison between firms and nonprofits when it comes to standard trials provide evidence for the first goal – expanding the access to treatment for patients in developing countries – as we have seen that nonprofits conduct a significant portion of their standard trials in developing countries and they tend to use, on average, older drugs compared to firms. In fact, Table 14 suggests that the difference in drugs’ age observed in standard trials between firms and nonprofits is driven mostly by the nonprofit trials in developing countries. The top panel of Table 14 repeats the findings from Table 11 for the whole sample of standard trials, while the bottom panel shows that the difference in drugs’ age becomes much smaller or even entirely disappears when we consider only the trials conducted in developed countries: more than 5 years difference in age for the “youngest” add-on drug between nonprofit-sponsored and industry-sponsored trials is reduced to 3.4 years when we look at trials in developed countries, and the differences for other drugs are much smaller and not statistically significant (or only marginally significant). A further comparison confirms that standard nonprofit-sponsored trials conducted in developing countries test older drugs than those in developed countries (Table 15): drugs tested by nonprofits in the developing countries are on average from four to five years older than those that nonprofits test in developed countries. Overall, these results lend support to the intuition that nonprofits would seek to increase the access to treatment for patients in resource constrained countries by conducting trials in developing countries on older, less expensive, drugs.

Another incentive of nonprofits that I hypothesized is finding the best treatment for the patients. The evidence that in developed countries nonprofits use less old drugs lends support to this motive. To get further insights I took a closer look at combinations that firms and nonprofits tested by
Table 14: Standard trials: comparison of means of drugs’ age in industry-sponsored vs. nonprofit-sponsored trials

<table>
<thead>
<tr>
<th></th>
<th>Industry</th>
<th>Nonprofit</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All countries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MaxAgeBase</td>
<td>14.800</td>
<td>16.941</td>
<td>-2.141***</td>
<td>0.619</td>
<td>308</td>
</tr>
<tr>
<td>MinAgeBase</td>
<td>10.005</td>
<td>12.881</td>
<td>-2.876***</td>
<td>0.658</td>
<td>308</td>
</tr>
<tr>
<td>MaxAgeAddon</td>
<td>7.206</td>
<td>9.890</td>
<td>-2.684***</td>
<td>0.461</td>
<td>416</td>
</tr>
<tr>
<td>MinAgeAddon</td>
<td>4.439</td>
<td>9.721</td>
<td>-5.282***</td>
<td>0.479</td>
<td>416</td>
</tr>
<tr>
<td><strong>Developed countries only</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MaxAgeBase</td>
<td>14.894</td>
<td>15.000</td>
<td>-0.106</td>
<td>0.684</td>
<td>251</td>
</tr>
<tr>
<td>MinAgeBase</td>
<td>9.917</td>
<td>11.239</td>
<td>-1.323*</td>
<td>0.801</td>
<td>251</td>
</tr>
<tr>
<td>MaxAgeAddon</td>
<td>7.502</td>
<td>8.162</td>
<td>-0.660</td>
<td>0.524</td>
<td>338</td>
</tr>
<tr>
<td>MinAgeAddon</td>
<td>4.548</td>
<td>7.990</td>
<td>-3.442***</td>
<td>0.566</td>
<td>338</td>
</tr>
</tbody>
</table>

*p < 0.1, **p < 0.05, ***p < 0.01

Table 15: Nonprofit-sponsored standard trials: comparison of means of drugs’ age in developing vs. developed country trials

<table>
<thead>
<tr>
<th></th>
<th>Developed countries</th>
<th>Developing countries</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MaxAgeBase</td>
<td>15.000</td>
<td>19.872</td>
<td>-4.872***</td>
<td>0.906</td>
<td>118</td>
</tr>
<tr>
<td>MinAgeBase</td>
<td>11.239</td>
<td>15.362</td>
<td>-4.122***</td>
<td>0.848</td>
<td>118</td>
</tr>
<tr>
<td>MaxAgeAddon</td>
<td>8.162</td>
<td>13.000</td>
<td>-4.838***</td>
<td>0.643</td>
<td>154</td>
</tr>
<tr>
<td>MinAgeAddon</td>
<td>7.990</td>
<td>12.836</td>
<td>-4.846***</td>
<td>0.639</td>
<td>154</td>
</tr>
</tbody>
</table>

*p < 0.1, **p < 0.05, ***p < 0.01
Table 16: Nodes color code

<table>
<thead>
<tr>
<th>Node color</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>Base component</td>
</tr>
<tr>
<td>Blue</td>
<td>Add-on component</td>
</tr>
<tr>
<td>Orange</td>
<td>Refers to the case when the component represents “optimized background treatment” (node reads “OBT”), which could be any combination of base drugs suitable for the patient in a trial on add-on drugs, or any suitable add-on drug in a trial on base drugs (usually the case in trials on pre-treated patients when the patient changes only one drug and keeps the rest of the combination)</td>
</tr>
<tr>
<td>Red</td>
<td>Refers to the case when one component (base or add-on) is absent from the combination (node reads “NONE”). This, rather than simply leaving the drugs tested as a single node, was done to indicate that such trial took place in case the same drug(s) was used as a part of a standard combination</td>
</tr>
<tr>
<td>Yellow</td>
<td>Anti-HIV drugs that do not belong to the antiretroviral class</td>
</tr>
<tr>
<td>Grey</td>
<td>Non-HIV drugs when the trial is conducted on anti-HIV drugs in patients suffering from additional diseases, e.g., patients co-infected with HIV and Hepatitis B</td>
</tr>
</tbody>
</table>

visually representing combinations of drugs as networks of drugs changing over time. I interpreted each drug combination as a dyad of a base (usually including two drugs) and an add-on component (usually one drug, but could be more). Figures 14-16 show the networks of base and add-on components tested in trials by for-profit (left-hand panels) and nonprofit (right-hand panels) actors split as per two-year windows to see the evolution. Green nodes stand for base drugs and blue nodes stand for add-on drugs; Table 16 provides the details about the color code of the nodes.

Looking at Figures 14-16 we can observe that industry-sponsored trials feature few recurring add-on drugs, while nonprofit-sponsored trials tend to be more “repetitive” in the use of add-on drugs (such as efavirenz (EFV), nevirapine (NVP, especially in mother-to-child transmission prevention trials), lopinavir (LPV)), and are also more extensive in terms of the variety of combinations compared to industry trials. These findings hint at two different ways that nonprofits may achieve the goal to find a better treatment for the patient. First, nonprofits could seek to induce compatibility between the new drug and other drugs that firms didn’t use as complements (for instance because they care less about compatibility with the drugs that they do not own, or because the drugs have limited appeal in terms of patient population). Higher variety observed in nonprofit trials appears consistent with this motive. For instance, one of the important add-on drugs, lopinavir (“LPV” on Figures 14-16), after being initially tested by its owner in 1999
Figure 14: Combinations tested by the industry and by nonprofits, 2000-2005
Figure 15: Combinations tested by the industry and by nonprofits, 2006-2011
Figure 16: Combinations tested by the industry and by nonprofits, 2012-2018
with one particular base, was tested by nonprofits in combinations with other bases, including *zidovudine*+*lamivudine* and *abacavir*+*lamivudine*, the former being the oldest base (and quickly approaching the patent cliff) and the latter being a newer base yet with serious side effects (nevertheless it is an important option for patients who cannot take or who develop resistance to other base drugs). Similarly, another add-on drug, *atazanavir*, initially tested by its owner in combination with *zidovudine*+*lamivudine* base was later tested by nonprofits in combination with other bases, including *abacavir* + *lamivudine* and *tenofovir* + *emtricitabine*.

Second, nonprofits could seek to compare and contrast combinations previously tested by firms to find the best treatment. For example, nonprofits may contrast several new combinations against each other, or they may compare newer combinations to those that have previously performed well. Because nonprofits do not have vested interest in a certain drug they would benefit irrespectively of which combination is proven superior, while a firm benefits only when the combination with their own drug is proven superior; hence nonprofits stand to gain from head-to-head comparisons. The fact that nonprofit trials feature “recurring” add-on drugs is in line with this explanation.

Further evidence of nonprofits’ objective to compare and contrast is provided by the fact that nonprofits appear to test more combinations in a single trials compared to firms (Table 17): nonprofits tend to test between two and three combinations on average as per single trials whereas firms tend to test just one combination of interest. Furthermore, the difference is statistically significant only for standard trials; in non-standard trials the difference, while large, is not statistically significant, mostly because it is driven by one particularly large nonprofit trial that tested fifty different combinations. In fact, if I exclude the four largest trials with more than fifteen combinations tested the difference in the number of combinations becomes 0.67 and is only marginally significant. The difference in the number of combinations between nonprofits and firms for standard trials also appears higher when trials take place in developed countries. Together with the evidence from drugs networks these results suggest that when it comes to developed countries nonprofits

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48Because the description of the trial design would not distinguish such combination as belonging to control group it will still be coded as “focal” in my dataset
seem to act on their incentive to find the best treatment for the patient and would thus compare and contrast multiple combinations, including the combinations with more recent drugs.

Table 17: Number of combinations tested in a trial

<table>
<thead>
<tr>
<th></th>
<th>Industry</th>
<th>Nonprofit</th>
<th>Diff.</th>
<th>Std. Error</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of combos</td>
<td>1.039</td>
<td>2.432</td>
<td>-1.393</td>
<td>0.376</td>
<td>319</td>
</tr>
<tr>
<td>Number of combos</td>
<td>1.026</td>
<td>1.877</td>
<td>-0.851</td>
<td>0.192</td>
<td>236</td>
</tr>
<tr>
<td>Number of combos (non-standard trials)</td>
<td>1.120</td>
<td>3.207</td>
<td>-2.087</td>
<td>1.454</td>
<td>83</td>
</tr>
<tr>
<td>Number of combos (standard trials, developed countries)</td>
<td>1.031</td>
<td>2.209</td>
<td>-1.179</td>
<td>0.270</td>
<td>174</td>
</tr>
<tr>
<td>Number of combos (standard trials, developing countries)</td>
<td>1.000</td>
<td>1.500</td>
<td>-0.500</td>
<td>0.217</td>
<td>62</td>
</tr>
</tbody>
</table>

*p < 0.1, ** p < 0.05, *** p < 0.01

Implications for ecosystem architecture

We can also observe from Figures 14-16 that add-on drugs appear more central in nonprofit trials, but less so in firm trials, which are centered around base drugs. Specifically, one of the central drugs in the industry-sponsored trials is Teno+Emtri, which stands for tenofovir+emtricitabine, the base that from the beginning has shown high promise in terms of efficacy and safety profile, and has eventually emerged as a bottleneck in the HIV ecosystem (later it started to be replaced by its newer version, TAF+Emtri). The network representation of combinations clearly confirms the bottleneck status of this base (especially starting from mid-2000s). By contrast, nonprofit-sponsored trials appear to be centered around add-on drugs. While this is partially driven by nonprofits recurrent testing of add-on drugs as we have seen above, the other reason is that nonprofits conduct more non-standard trials which often use add-on drugs only (see the cases when add-on nodes are connected to the “NONE” nodes, which mean that the base component was omitted). In fact, nonprofits conduct twice as many trials on non-standard combinations compared to the firms (58 trials vs. 25, and another 25 trials are investigator initiated trials); they have been consistently pursuing such trials across the years while firms started getting involved mostly in later years.

These findings suggest that firms are more interested in acting within the existing ecosystem architecture and in sustaining existing bottlenecks by conducting standard trials with Teno+Emtri base, while nonprofits seem more willing to challenge that architecture by making add-on drugs
a potential bottleneck. Pursuing trials with add-on drugs only is in line with nonprofits incentives to find “the best” treatment for the patient (omitting the base component means fewer side effects for the patient) and also to reduce the treatment cost (two drugs instead of conventional three-drug combination). But for firms such combinations can be perceived as riskier and also as generating less profits due to fewer number of drugs – it is not surprising that firms do not pursue these combinations as the first choice, and would do so only due to competitive pressure. For instance, nine out of twenty-five industry-sponsored non-standard trials were conducted by ViiV Healthcare, a firm whose base drugs were considered to have a worse efficacy/safety profile compared to tenofovir+emtricitabine, and who started to actively explore two add-on drugs combinations in 2015-2016 (Liu, 2018).

**Implications for industry dynamics**

The findings also offer interesting insights regarding the industry dynamics and drug’s “life cycle” in terms of trials. Tracing trials of individual add-on drugs allows to construct the following timeline: firms are generally the first to conduct trials on a drug (trials whose results are later used for the drug’s approval), normally as a part of a standard “base plus add-on” combination, then the drug is approved, and then nonprofits and firms conduct further trials on the drug, but firms are less active in these post-approval trials. The fact that firms are less involved in post-approval trials is in line the hypothesized replacement effect as the driver of firm’s decision: firms are reluctant to conduct further trials on a drug already proven as a good one because a new combination may encroach on the already “approved” one. In fact, when firms do conduct post-approval trials it is usually because they want to prove that the drug has a more favorable profile than shown previously, or because they seek compatibility with complements that were shown to better than those which were originally used. For instance, when tenofovir+emtricitabine emerged as a better base the owners of add-on drugs that had been tested with other bases conducted trials with tenofovir+emtricitabine as a base.

This explains the observed pattern regarding the use of prior experience: in standard trials firms tend to leverage prior firms’ experience, but not nonprofits’ experience: because firms take the lead
in standard trials there is little prior experience overall to replicate, and it is usually prior trials by
the same firm. Nonprofits, who enter into trials later, are in the situation with more prior experience
available; we also saw that nonprofits tend to compare newer combinations to established older
ones. This is why we observed a higher use of prior nonprofits’ experience by nonprofits (most
likely nonprofits keep on testing a few well-performing combinations against new ones) and also
the use of prior firms’ experience when I used a longer time frame.

When it comes to non-standard trials, however, it is firms who appear to follow the nonprofits’
lead by replicating prior nonprofit experience, which explains the similarities between industry-
sponsored and nonprofit-sponsored trials. If I exclude trials on mother-to-child prevention (that
usually feature some of the oldest anti-HIV drugs) then nonprofits are often the first to test a non-
standard combination, which explains why firms would repeat their experience. Coupled with the
findings from the drugs networks these findings suggest that nonprofits can “pave the way” for the
changes in how ecosystem creates value.

Figure 17 provides a summary of the different cases of firm and nonprofit involvement in a 2x2
matrix by the trials type and the sponsor type.

5.7 Discussion and conclusion

In this paper I explore how actors with different types of incentives make choices regarding com-
patibility of complementary products. In particular, I compare the choices of anti-HIV drug combi-
nations selected by firms and nonprofits in clinical trials. I find that there are significant differences
in the characteristics of the drugs and the use of prior trials experience between industry-sponsored
and nonprofit-sponsored trials, but there is also heterogeneity among industry-sponsored trials in
terms of testing standard combinations of base and add-on drugs and testing combinations with
only base or only add-on drugs. Specifically, firm and nonprofit trials feature many differences
when it comes to standard combinations: firms generally test newer drugs in developed countries
followed by nonprofits contrasting newer combinations versus older standard of care, or testing
combinations of older drugs in developing countries. In such trials firms either test novel combina-
tions or drugs, or replicate a combination or a drug from a prior firm trials, but not a prior nonprofit
### Figure 17: Summary of comparison

<table>
<thead>
<tr>
<th>Standard trials</th>
<th>Non-standard trials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industry-sponsored</strong></td>
<td><strong>Nonprofit-sponsored</strong></td>
</tr>
<tr>
<td>1) –</td>
<td>1) Developing countries Old drugs</td>
</tr>
<tr>
<td>2) Developed countries New drugs</td>
<td>2) Developed countries Older drugs (but less than for developing) Multiple combinations per trial</td>
</tr>
<tr>
<td>Few combinations per trial</td>
<td>If replicate then mostly nonprofit trials</td>
</tr>
<tr>
<td>If replicate then firm trials, not nonprofit trials</td>
<td></td>
</tr>
<tr>
<td><strong>Developed countries</strong></td>
<td><strong>Nonprofit-sponsored</strong></td>
</tr>
<tr>
<td>Older drugs</td>
<td>Older drugs</td>
</tr>
<tr>
<td>If replicate then mostly nonprofit trials</td>
<td>If replicate then mostly nonprofit trials</td>
</tr>
</tbody>
</table>

By contrast, nonprofits tend to replicate mostly prior nonprofit trials, but they also replicate firms’ prior trials if we take into account longer time period. However, with respect to nonstandard trials nonprofits are much more active, and firms appear to follow suit; there are few differences in the trials’ characteristics.

Figure 18 maps the strategies adopted by firms and nonprofits depending on the interest that a given combination represents for the actor. Combinations in quadrant 1 comprising of drugs with very low efficacy and safety, which are not offset even by the cost advantage, will be left out as they are of low interest to either actors (for instance, less good drugs of the older drug generations). Quadrant 2 corresponds to combinations that offer little additional benefit for patients beyond the ease of use but can be expected to yield high returns because, for instance, they allow firms to develop exclusive bundles. An example of such combinations would be single-pill combinations where all drugs are owned by the same firm. Such combinations will be of high interest to firms and they are expected to take the lead here (for example, recent trials of Gilead Sciences testing if patients can switch from a three separate pills combinations to its single-pill combination), but not
Figure 18: Firm and nonprofit strategies

to nonprofits.

Quadrant 3 comprises combinations that appeal to both firms and nonprofits – combinations with high efficacy and good safety profile, expected to be superior to existing alternatives, such as new drugs combined with non-generic existing drugs. While such combinations are of interest to both firms and nonprofits, the latter can take the back seat and let firms take the lead: in most cases these are the trials used by firms to get their new drugs approved.

Finally, quadrant 4 would contain combinations that can have high benefit for the patient yet limited potential profitability. Examples of such combinations would include combinations containing generic drugs (older generation but with good efficacy/safety profile), combinations targeted at small demographics (e.g., pregnant women), combinations targeted at demographics with low willingness to pay (e.g., patients in developing countries; such combinations are likely to consist of generic drugs), or be combinations with fewer drugs as they automatically imply lower profitability. Combinations in this quadrant would be of a low appeal to firms, but of high interest to nonprofits who will take the lead and fill the voids left by firms.
The implications for for-profit actors depend on the type and the outcomes of non-profit trials. For instance, trials in developing countries testing older drugs can be seen as providing partial substitutes as the firms’ revenues from such countries are already limited. Trials in developed countries can sometimes be beneficial as they establish drug’s compatibility with other complements, especially if the firm has few anti-HIV drugs in its portfolio limiting the replacement effect. Yet such trials may have negative consequences for the firms whose drugs were shown to be inferior to others; in such cases nonprofit trials will result in a combination(s) that are full substitutes to the ones preferred by the firm. For example, a nonprofit-sponsored trial found that a combination of three base drugs, abacavir + lamivudine + zidovudine, all belonging to one firm, GlaxoSmithKline, is less effective compared to combinations comprising base and add-on drugs (Gulick et al., 2004). The combinations that were found superior in this trial can be seen as partial substitutes to the one owned by GlaxoSmithKline because they still contain at least two of its base drugs, and one option even contains all three base drugs plus an add-on drug (owned by another firm). At the same time this trial has a beneficial effect on the owner of the add-on drug. Another example is a nonprofit trial comparing an add-on drug belonging to a new drug class, raltegravir, to two other add-on drugs, and finding that raltegravir is superior in terms of efficacy and safety, which is clearly beneficial to the owner of raltegravir.

The impact of non-standard trials, in particular simplified therapy, on firms is less clear. Simplified therapy can be seen as beneficial for the producers of potent add-on drugs that have been shown to be effective without base, yet for the base owners it has clear negative consequences. Based on the number of clinical trials it appears, however, that firms are less incentivized to work on non-standard combinations compared to nonprofits, and would do so when their drugs are in a disadvantageous position in standard combinations.

The latter offers some intriguing insights into the evolution of bottlenecks in ecosystems (Hannah and Eisenhardt, 2018). From the literature on industry architecture we know that firms who attain the position of a bottleneck become the point of value creation and value capture (Baldwin, 2015), yet we know less about how bottlenecks emerge, persist and change over time (Jacobides,
MacDuffie, and Tae, 2016). This paper suggests that the shifts of bottlenecks within ecosystems (here, for instance, the challenge by certain add-ons of the dominant base position due to the trials on add-on drugs combinations) could be the result of the actions by nonprofit actors. In fact, it is the very nature of these actors in that they do not seek to maximize profits as opposed to for-profit actors that incentivizes them to take actions that move the bottleneck to another part of an ecosystem, while bottleneck firms want to reinforce these bottlenecks.

The results support the research on the interaction between market and non-market actors. For instance, the findings show that non-market actors can affect the strategies and the outcomes of for-profit actors even in the absence of direct engagement (Henisz, Dorobantu, and Narne, 2014), either as a cooperation (Gatignon and Capron, 2016; McDermott, Corredoira, and Kruse, 2009) or as a confrontation (McDonnell, King, and Soule, 2015). Marrying the ecosystem literature and the literature on non-market actors could enrich the understanding of how complementarities emerge in the ecosystem and provide a new context for the research on non-market strategies. Another illustration could be the IT sector where for-profit firms often have to compete with open-source software which affects the choices of the developers, for instance the competition between Linux, a free operating system around which complements can assemble, and proprietary systems like Windows and Apple.

The findings also have implications for the literature on innovation. For instance, having a nonprofit able to innovate alongside a firm can add a new nuance to the debate on the choice to innovate by an incumbent and by a new entrant. In the setting with for-profit actors the decision of the incumbent is shaped by the efficiency effect (Gilbert and Newbery, 1982) – the incumbent has higher incentives to innovate to preempt the new entrant out of fear of losing its monopoly position, – and by the replacement effect (Reinganum, 1983) – the incumbent has lower incentives to innovate as the innovation will replace part of the profits it earned with the existing product. Yet in the context with a nonprofit actor the efficiency effect can be expected to be extremely low: the firm does not lose per se from the new combination as the drugs it comprises are still owned by firms, and even if the results of the trial are not beneficial to the drugs owned by the given
firm the latter cannot prevent the negative impact by conducting a similar trial beforehand. In fact, by conducting a trial casting its drugs in a favorable light a firm may deter another firm from a trial against that combination, but a nonprofit, having no vested interest in drugs, may still have incentives to compare different combinations. The replacement effect, though, is still important, with the implication that firms should be less likely to conduct further trials once their drug is approved. This is what we can observe in the setting: firms mostly conduct trials in the early stage of the drug’s “life cycle”, and later trials are conducted by nonprofits. This may also explain why the firms appear to be more reluctant to conduct trials on simplified therapy.

The role of nonprofit actors in fostering compatibility among complements and, in particular, in furthering the changes in the ecosystem can also have normative implications. It speaks to the debate regarding the role of public funding in the innovation (Azoulay et al., 2015) and the value appropriation by private actors from this innovations. For instance, there is currently a debate surrounding the access to the HIV prophylaxis treatment (i.e. the treatment to prevent sexual transmission of the virus) as some activists contend that since the major bulk of the development effort has been carried out by nonprofit actors then private actors should have only marginal benefit, and the price of the drugs has to be cut (Sagonowsky, 2018). Indeed, virtually all trials on two base drugs as pre-exposure prophylaxis (PrEP), or the preventive treatment for people with a high risk of contracting HIV, have been conducted by nonprofits, with only one trial sponsored by Gilead Sciences, the owner of the said drugs.

There are a number of limitations in the paper. The reported results are exploratory only, and are subject to endogeneity concerns. For instance, I do not account for the trial’s results, which should be of a major importance when it comes to the replication of the prior trials and the use of drugs tested in prior trials. One of the further directions could be to incorporate the outcomes of the trials into the analysis which would, on the one hand, provide exogenous variation in the value creating capabilities of the combinations, and, on the other hand, allow to better account for the choice of the combination to be tested. For instance, it could be interesting to verify the intuition whether firms stop their efforts once they their combination of interest is validated as successful.
Another direction could be to investigate whether nonprofits attempt to re-test combinations that have not been successful. I focus only on late-stage trials as the most expensive and having the largest impact on the prescribing behavior, and including phase II trials may help address the endogeneity concerns. Also, I do not account for whether trials were conducted on a specific patient population (beyond the trial type distinction), for instance whether the trial was on pre-treated or treatment-naive patients, adult vs. children, co-infected patients. This could be explored to gain further insights about whether clinical trials by nonprofits are complements or substitutes to those by the firms. Finally, the paper studies a specific market within a single industry which may limit generalizability.

Notwithstanding these limitations, I hope that this paper can provide interesting insights into the interaction between for-profit and nonprofit actors in the context of complementary products. Its findings serve to further our understanding of the ecosystem dynamics by explicitly considering the role of a nonprofit actor in the emergence of complementarities and how the incentives of such actors can shape the evolution of the ecosystem and shifts in the bottlenecks.
6 CONCLUSIONS

In my dissertation I explored strategies towards complements that for-profit and nonprofit actors adopt to maximize value creation and value capture in the contexts where a coalition of firms is needed in order to create value for the final customer (Adner, 2017; Adner and Kapoor, 2010; Jacobides et al., 2018). I focused on the cases when forming such coalitions requires an upfront investment. In the first essay I showed that nonprofit actors can take actions to enable value creation between for-profit actors, and examined how the outcomes of such collaborations depend on firms’ and nonprofits’ characteristics. In the second essay I showed that firms make strategic choices regarding the integration into complementary component and the development of exclusive complements, and these choices shape the evolution of bottlenecks in an ecosystem. Finally, in the third essay I showed that nonprofit actors, by establishing compatibility among complements other than those prioritized by firms, can prompt changes in ecosystem bottlenecks.

Overall, my dissertation suggests that observed complementarities in ecosystems are an outcome of firms’ strategic decisions, and that these decisions affect the shifts in what constitutes a bottleneck in an ecosystem. Furthermore, it suggests that nonprofit actors can spur these shifts by actively engaging in forming the aforementioned complementarities.

Contribution

In this dissertation I sought to tackle the three gaps that I identified as being insufficiently explored in the literature on ecosystems and complements: introducing the trade-offs between value creation and value capture as the drivers of decision-making, endogenizing complementarity, and examining bottleneck shifts in ecosystems. Furthermore, I sought to include nonprofit actors as an integral part of an ecosystem and examine the effect of these actors on the above mentioned issues (see Table 18 for the summary). In addressing these gaps I strive to contribute to the literature on ecosystems and complements, as well as to the literature studying interactions between firms and non-market actors.

By incorporating both value creation and value capture as the drivers of firms’ strategies towards complements (Brandenburger and Nalebuff, 1997) I bridge the gap between the two lit-
Table 18: Summary of main findings

<table>
<thead>
<tr>
<th>Issues identified</th>
<th>Impact of non-profit actors</th>
<th>Main findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value creation and value capture as two drivers of firms’ decisions</td>
<td>Nonprofits have different goals driving their decisions</td>
<td>- Nonprofit actors may have goals that are neither antagonistic, nor aligned with those of the firm, yet need to account for value capture constraint of the firm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Trade-offs between value creation and value capture drive firms’ decision to be exclusively compatible with a certain complement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- These trade-offs imply that firm may integrate into complementary component even when complements are available</td>
</tr>
<tr>
<td>Endogenous complementarity</td>
<td>Nonprofits can facilitate different types of complementarities</td>
<td>- Changes in the focal product value, and the position of the firm’s product in the focal component, drive the decision to be compatible with multiple complements vs. unique complement</td>
</tr>
<tr>
<td>(compatibility among complements)</td>
<td></td>
<td>- Nonprofits can facilitate compatibility among complements that would otherwise be ignored by the firms as providing insufficient value capture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Nonprofits do this both within the existing ecosystem architecture (“filling the voids”) and outside of it (challenging existing bottlenecks)</td>
</tr>
<tr>
<td>Dynamic perspective on ecosystems</td>
<td>Nonprofits can spur the shifts of the bottlenecks</td>
<td>- Firms in a bottleneck position will seek to transform the ecosystem into a vertical supply chain (through integration into complementary component and pursuing exclusivity)</td>
</tr>
<tr>
<td>(evolution of bottlenecks)</td>
<td></td>
<td>- Competitors will try to shift the bottleneck to a different component while relying on other ecosystem participants to create value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Nonprofits, by pursuing compatibility among complements that challenge the existing ecosystem architecture, can pave way for bottleneck shifts in an ecosystem</td>
</tr>
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</table>

...literature streams: the business ecosystems literature that cares about value creation and conducts analysis at the level of a firm (Adner and Kapoor, 2010; Kapoor and Furr, 2015; Kapoor and Lee, 2013), and the industry architecture literature that focuses on value capture but looks at the level of a component, rather than an individual firm (Jacobides et al., 2006; Jacobides et al., 2016; Jacobides and Tae, 2015). Bringing together the two literatures that deal with complements yet developed independently of each other allows to qualify the insights of both. For instance, the second essay showed that due to value capture considerations firms will sometimes choose to integrate into complementary component even when complements are already available, while business ecosystems literature suggests that firms will do so only in the absence of complements (Kapoor and Furr, 2015): integration allows firms to develop complements exclusive to their focal product and thus capture higher value at the expense of the customer. It also showed that, besides between-
component heterogeneity, as in the industry architecture literature, within-component heterogeneity matters: firms will adopt different strategies depending on their product’s position within an ecosystem component.

The important implication is that the availability of complements for the focal product (Adner and Kapoor, 2010; Kapoor and Furr, 2015) is no longer assumed as exogenous, but is a strategic decision by the producer of complements. The second essay showed that firms can choose to seek compatibility with a specific complement as opposed to multiple complements, and this decision is driven, on the one hand, by value creation – value capture trade-off and, on the other hand, by value-creating capabilities of the focal product.

This dissertation also offers insights on how ecosystems evolve over time, in particular, how bottlenecks emerge, persist and change (Baldwin, 2015; Jacobides, MacDuffie, and Tae, 2016). While the industry architecture literature is mainly concerned with the bottleneck shifts across components (Jacobides, MacDuffie, and Tae, 2016; Jacobides and Tae, 2015), I show that a single product within a component can become a bottleneck. Furthermore, firms in that component will adopt different strategies that affect the evolution of an ecosystem: the owner of the bottleneck will integrate into complementary component and, effectively, seek to transform the ecosystem into a vertical supply chain, while the firm with a weaker product will seek to shift the bottleneck to another component, but will keep relying on other ecosystem participants to create value. These findings contribute to the research on the dynamic perspective on ecosystems (Hannah and Eisenhardt, 2018; Kapoor and Agarwal, 2017).

Moreover, by making a nonprofit actor an integral part of an ecosystem, this dissertation offers further insights on how complementarities emerge in an ecosystem (Adner, 2017) and how ecosystems evolve. The first and the third essays showed that because nonprofit actors do not seek to maximize profit, they can enable coalitions of firms or products resulting in value creation when for-profit actors on their own would be deterred by insufficient value capture. Both essays also highlighted the importance of accounting for nonprofits’ goals to understand the outcomes of firm-nonprofit interactions. Importantly, the third essay showed that not only can nonprofits step in to fill
the voids left by for-profit firms within the existing ecosystem architecture, but also challenge this architecture by promoting combinations that eschew the bottleneck-containing component. These findings underscore the importance of accounting for nonprofit actors in the research on business ecosystems as these actors can be instrumental in fostering complementarities and shaping ecosystem evolution.

Finally, this dissertation also contributes to the literature on non-market strategies and stakeholder engagement. It speaks to the growing stream of research on the interplay between public and private actors, and value creation (Cabral et al., 2019; Kivleniece and Quelin, 2012). By examining the behavior of a nonprofit actor that contributes directly to the economic value creation I advance research studying firm-nonprofit interaction through collaborative lens (Dorobantu and Odziemkowska, 2017; Gatignon and Capron, 2016; McDermott, Corredoira, and Kruse, 2009) as opposed to confrontational (e.g., Baron and Diermeier, 2007; McDonnell, King, and Soule, 2015). In line with this research, the first and the third essays showed how a nonprofit can facilitate economic value creation between for-profit actors. The first essay further qualified the conditions under which nonprofits and firms are able to create value, in particular, the constraints that the need for value capture by for-profit actors imposes on nonprofits.

At the same time, I speak to the research on firm-nonprofit competition which is usually restricted to the domain of social goods (e.g., Cabral et al., 2013; Chau and Huysentruyt, 2006; Kaul and Luo, 2018; Luo and Kaul, 2018). Here I extend it to the context where competition is over the provision either of economic value (internalization of the effort by the firms vs. relying on nonprofit in the first essay) or of the social good that, nevertheless, translates directly into economic value for firms (competition over the provision of combinations of complements in the third essay).

Limitations

Naturally, this dissertation has a number of limitations. First, it focuses on the choice of strategy as the dependent variable, but not the outcomes of these strategies, which prevents me from having normative implications.

Another limitation is the absence of information about the quality of combinations – results
of the clinical trials – in the second and the third essays. Including this information in the second essay would help account for the role of drugs’ medical value as opposed to strategic considerations of the firm in choices of complements. In the third essay the information on trials’ results would be important to better understand the patterns of prior trials’ replication: what happens when the trial’s results are negative? Is replication primarily driven by whether the combination performed well in a trial?

While focusing on the choices of the firms active in the focal component, the dissertation doesn’t account for the competition ensuing between these firms integrating into the complementary component and firms originally active in the complementary component. Would the exclusivity strategy pursued by the owner of a stronger focal product incentivize the original producers of complements to work with the owner of the weaker focal product? What would the implications for value creation and value capture by the owner of the stronger product be?

Finally, the empirical context is constrained to a specific industry – anti-HIV drug market – which may limit generalizability to other settings. In particular, in this context products in the focal and in the complementary components require similar capabilities making it relatively easy for the firms in the focal segment to integrate into complementary component. Further research could test whether the findings hold as the entry barriers into complementary component become higher.

**Future research**

In terms of the future research, I intend to continue the line of work on incorporating non-market actors into the ecosystem framework. Possible directions include addressing some of the limitations that I have identified. One way to go forward would be to collect data on the outcomes of clinical trials, which will provide quasi-exogenous variation in the quality of combinations. It would also allow to answer questions regarding the time patterns of innovation: do firms stop when the combination of interest is successful? Do products initially shown as unsuccessful get tried in different combinations afterwards, and are there differences in this respect between firms and nonprofits? The latter could be particularly interesting to better understand how firms and nonprofits
build on each others’ knowledge. It could also provide insights as to how a less successful product may still survive in an ecosystem.

Another interesting direction that I intend to pursue is to look at the impact of firms’ and nonprofits’ strategies on performance of drugs and combinations in the market. By using the dataset of individual-level consumption of anti-HIV drugs I can explore how clinical trials’ results translate into drug consumption. It would allow to examine the impact of nonprofits’ strategies on firms’ performance and whether firms can free-ride on nonprofits’ efforts. It would also be particularly interesting to explore whether there is heterogeneity in the impact of for-profit and nonprofit actions.

To conclude, this dissertation helps advance research on business ecosystems by developing a better understanding of firms’ strategies towards complements and by accounting for the role of nonprofit actors in shaping these ecosystems. It also contributes to the research on the interaction between firms and non-market actors by furthering research on the role of non-market actors in economic value creation.
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Appendix A  Essay 1

A.1 Baseline model: investment area

![Figure 19: Boundary between investment (above the surface) and non-investment sets of parameters](image)

A.2 Proofs

Proof of Lemma 1.

Omitted. The expressions are easily derived from the formulas for the NGO’s utility and the firm’s profit.

Proof of Proposition 2.

The thresholds $\alpha_F^{\min}$ and $\alpha_F^{opt}$ are derived from the expressions for the critical levels of effort. The NGO makes no effort when $e^{ub} < e^{collab}$. Solving it in $\alpha_F$ yields $\alpha_F < \frac{2IF\mu^2\bar{V}^3}{(\mu\bar{V}(V-1)+1+\sqrt{1+2\mu\bar{V}(V-1)})^2}$. We will denote this expression as $\alpha_F^{\min}$.

The NGO makes its first best effort $\hat{e}$ when $e^{collab} \leq \hat{e}$. Solving it in $\alpha_F$ yields $\alpha_F \geq \frac{2IF\mu^2\bar{V}^3}{(\mu\bar{V}(V-1)+1)^2}$. We will denote this expression as $\alpha_F^{opt}$. Since the NGO makes
participation-inducing effort $e^{collab}$ when $e^{ub} \leq e^{collab} < \hat{e}$, it is straightforward that the NGO makes $e^{collab}$ when $\alpha_F^{min} \leq \alpha_F < \alpha_F^{opt}$.

Proof of Proposition 4.

First, we take the derivative of $\hat{e}_F$ in $\bar{V}$:

$$\frac{\partial \hat{e}_F}{\partial \bar{V}} = \frac{\alpha_F (\mu - \alpha_F)}{(\mu \bar{V} - \alpha_F)^2} > 0,$$

as $\mu > \alpha_F$ to fulfill the condition for $\hat{e}_F < 1$ (otherwise the analysis becomes trivial). Therefore, for the range of $\mu$ interesting for the analysis, the optimal level of effort for the firm $\hat{e}_F$ increases in $\bar{V}$.

Secondly, we derive the expressions for the critical values $\alpha_F^a (\pi_F(\hat{e}_F) = 0)$ and $\alpha_F^b (\pi_F(\hat{e}_F) = \pi_F(\hat{e}))$ assuming $\mu = \mu$:

$$\alpha_F^a = \frac{2\mu \bar{V} I_F}{2 I_F + \mu (V - 1)^2},$$

$$\alpha_F^b = \frac{\mu \bar{V} (2\mu \bar{V} (V - 1) + 1)}{(\mu \bar{V} (V - 1) + 1)^2}.$$

However, the order of the critical values $\alpha_F^{min}$, $\alpha_F^{opt}$, $\alpha_F^a$ and $\alpha_F^b$ depends on the parameters $I_F$, $\bar{V}$ and $\mu$. While we do know from Proposition 2 that $\alpha_F^{min} < \alpha_F^{opt}$, the location of the critical values $\alpha_F^a$ and $\alpha_F^b$ relative to the NGO’s thresholds and to each other depends on the aforementioned parameters. For these reasons we formulated the proposition in a more general way and relied on graphical representation under different values of $I_F$ and $\bar{V}$ for illustration (Figure 3).

We can identify three possible sequences of these thresholds depending on $I_F$, $\bar{V}$ and $\mu$. First, let use see how the firm’s thresholds $\alpha_F^a$ and $\alpha_F^b$ together are located with respect to $\alpha_F^{opt}$. Solving
inequalities $\alpha_F^{opt} > \alpha_F^a$ and $\alpha_F^{opt} > \alpha_F^b$ yields:

$$\alpha_F^{opt} > \alpha_F^a \text{ if } I_F > 1 - \frac{1}{V} - \frac{1}{2\mu V},$$

$$\alpha_F^{opt} > \alpha_F^b \text{ if } I_F > 1 - \frac{1}{V} - \frac{1}{2\mu V}.$$

In other words, either both firm’s thresholds $\alpha_F^a$ and $\alpha_F^b$ are below NGO’s threshold for its optimal effort $\alpha_F^{opt}$ (when $I_F > 1 - \frac{1}{V} - \frac{1}{2\mu V}$), or both thresholds are above $\alpha_F^{opt}$ (when $I_F < 1 - \frac{1}{V} - \frac{1}{2\mu V}$). Furthermore, we can also see how the the firm’s thresholds are located with respect to each other. Solving inequality $\alpha_F^b > \alpha_F^a$ yields $I_F < 1 - \frac{1}{V} - \frac{1}{2\mu V}$, which is exactly the condition for $\alpha_F^{opt} < (\alpha_F^a, \alpha_F^b)$. This implies that there are two possible sequences of thresholds $\alpha_F^{opt}$, $\alpha_F^a$, and $\alpha_F^b$:

$$\alpha_F^b < \alpha_F^a < \alpha_F^{opt} \text{ if } I_F > 1 - \frac{1}{V} - \frac{1}{2\mu V},$$

$$\alpha_F^{opt} < \alpha_F^a < \alpha_F^b \text{ if } I_F < 1 - \frac{1}{V} - \frac{1}{2\mu V}.$$

Given $\alpha_F^{min} < \alpha_F^{opt}$ and the firm’s and NGO’s incentives to invest depending on thresholds we can come up with three scenarios of thresholds’ location and firm’s strategy:

1. If $I_F > 1 - \frac{1}{V} - \frac{1}{2\mu V}$ and $\alpha_F^b < \alpha_F^a < \alpha_F^{min} < \alpha_F^{opt}$: then for $\alpha_F < \alpha_F^a$, the effort is not viable neither through the NGO nor through the internalization resulting in $e^* = 0$ and $e_F^* = 0$; for $\alpha_F \geq \alpha_F^a$, the firm can do the effort internally and earn positive profits, making internalization superior to the collaboration with the NGO. Indeed, for $\alpha_F < \alpha_F^{min}$ the effort is prohibitively costly for the NGO; for $\alpha_F^{min} \leq \alpha_F < \alpha_F^{opt}$ the NGO is able to make $e^* = e_{collab}$, however the firm will get $\pi_F = 0$ making this option inferior to internalization (which yields positive profits); for $\alpha_F \geq \alpha_F^{opt}$ the NGO can do its first best $\hat{e}$, but since $\alpha_F^{opt} > \alpha_F^b$ the firm will get higher profits with internalization. Therefore, in this scenario the firm will eschew the collaboration with the NGO altogether and make $e_F^* = \hat{e}_F$ once $\alpha_F \geq \alpha_F^a$ (this scenario corresponds to the top right part of Figure 3a)
2. If \( I_F > 1 - \frac{1}{V} - \frac{1}{2\mu V} \) and \( \alpha_F^{\text{min}} < \alpha_F^a < \alpha_F^{\text{opt}} \) (in this scenario we are ambiguous as to the exact location of \( \alpha_F^b \), we only know that \( \alpha_F^b < \alpha_F^a \)) then for \( \alpha_F < \alpha_F^{\text{min}} \) the effort is not viable for either player and we have both \( e^* = 0 \) and \( e_F^* = 0 \). For \( \alpha_F^{\text{min}} \leq \alpha_F < \alpha_F^a \) the firm cannot have positive profits by internalizing the effort and sets \( e_F^* = 0 \), while the NGO sets \( e^* = e^{\text{collab}} \) with the firm getting \( \pi_F = 0 \) (consistent with Proposition 2). Once \( \alpha_F \) is above \( \alpha_F^a \) the firm is able to have positive profits by doing the effort itself, and because in this scenario \( \alpha_F^b < \alpha_F^a < \alpha_F^{\text{opt}} \) it implies that for \( \alpha_F \geq \alpha_F^b \) the firm will prefer to internalize the effort and set \( e_F^* = \hat{e}_F \) rather than collaborate with the NGO. We should note that in this scenario there is no range of \( \alpha_F \) where the firm prefers to collaborate with the NGO under the NGO’s first best \( \hat{e} \) (this sequence corresponds to the middle parts of Figures 3b and 3c).

3. If \( I_F < 1 - \frac{1}{V} - \frac{1}{2\mu V} \) and \( \alpha_F^{\text{min}} < \alpha_F^{\text{opt}} < \alpha_F^a < \alpha_F^b \): then, as explained above, for \( \alpha_F < \alpha_F^{\text{min}} \) neither player makes the effort; for \( \alpha_F^{\text{min}} \leq \alpha_F < \alpha_F^{\text{opt}} \) the effort is too costly for the firm (because both thresholds are below \( \alpha_F^a \)) while the NGO is able to make \( e^* = e^{\text{collab}} \). Then for \( \alpha_F^{\text{opt}} \leq \alpha_F < \alpha_F^b \), consistent with Proposition 2, the NGO is able to make its first best \( \hat{e} \) and the firm earns positive profits making the collaboration the firm’s preferred option. Once \( \alpha_F \geq \alpha_F^b \), however, the firm has higher profits from internalizing the effort than from collaborating with the NGO, therefore the firm chooses internalization with \( e_F^* = \hat{e}_F \). This scenario corresponds to the lower parts of Figures 3b and 3c.

Putting the three scenarios together yields Proposition 4. The first part of the proposition unites the insights from all scenarios on the situations when both \( e^* = 0 \) and \( e_F^* = 0 \), and accounts for the location of \( \alpha_F^{\text{min}} \) and \( \alpha_F^a \) with respect to each other.

The second part of the proposition consolidates scenarios 2 and 3 to describe the cases where the firm will set \( e_F^* = 0 \) while the NGO makes participation-inducing effort \( e^* = e^{\text{collab}} \) accounting for different sequences of \( \alpha_F^{\text{opt}} \), \( \alpha_F^a \), and \( \alpha_F^b \). We should note that when \( \alpha_F^a < \alpha_F^{\text{min}} \) there is no range of \( \alpha_F \) where the firm will choose to collaborate with the NGO under \( e^* = e^{\text{collab}} \) (the top right part of Figure 3a).
The third part of the proposition refers to scenario 3 to identify the range of $\alpha_F$ where the firm chooses to partner with the NGO who makes $e^* = \hat{e}$. We should note that when $\alpha_F < \alpha_F^{opt}$ there is no range of $\alpha_F$ when the firm chooses to collaborate with the NGO under $\hat{e}$.

Finally, the fourth part of the proposition puts together all three scenarios to define the cases when the firm chooses to internalize the effort and make $e^*_F = \hat{e}_F$ rather than collaborate with the NGO.

**Proof of Proposition 5.**

Part one of Proposition 5 is straightforward: when $\alpha_F < \alpha_F^{min}$ NGO exerts the effort $e^* = 0$ resulting in $U_{NGO} = 0$ (as we have assumed that $U_{NGO}(e = 0) = 0$), and $\pi_F = 0$ and $\pi_S = 0$ (as we have assumed that the firm is not investing when $e = 0$).

For the second part of Proposition 5 we need to take $e^{collab}$ and plug it into the expressions for $U_{NGO}$. Differentiating $U_{NGO}$ with respect to $\alpha_F$ and $\mu$ yields

$$\frac{\partial U_{NGO}}{\partial \alpha_F} = \frac{I_F}{\alpha_F \sqrt{2I_F V \alpha_F}} \left( \mu V (1 - \sqrt{\frac{2I_F V}{\alpha_F}}) - 1 \right),$$

$$\frac{\partial U_{NGO}}{\partial \mu} = -\frac{1}{2} (1 - \sqrt{\frac{2V I_F}{\alpha_F}})^2 < 0,$$

$$\frac{\partial^2 U_{NGO}}{\partial \mu \partial \alpha_F} = \frac{V I_F}{\alpha_F^b} - \frac{\sqrt{V I_F (V - 1)}}{\alpha_F \sqrt{2 \alpha_F}}.$$

Derivative $\frac{\partial U_{NGO}}{\partial \alpha_F}$ is positive when $\mu V (1 - \sqrt{\frac{2I_F V}{\alpha_F}}) - 1 > 0$, which can be re-written as $1 - \sqrt{\frac{2I_F V}{\alpha_F}} > \frac{1}{\mu V}$. The right-hand side of the inequality is the expression for $e^{collab}$, while the left-hand side is the expression for $\hat{e}$, which transforms the inequality into $e^{collab} > \hat{e}$. Being in the scenario $\alpha_F^{min} \leq \alpha_F < \alpha_F^{opt}$ implies that $e^{collab} > \hat{e}$. Therefore, in this scenario the condition for $\frac{\partial U_{NGO}}{\partial \alpha_F} > 0$ will always be fulfilled, and $U_{NGO}$ is increasing in $\alpha_F$.

Cross-partial derivative $\frac{\partial^2 U_{NGO}}{\partial \mu \partial \alpha_F}$ is positive when $\alpha_F < \frac{2V I_F}{(V-1)^2}$. Since we are in the scenario where $\alpha_F > \alpha_F^{opt}$ it implies that $\alpha_F < \frac{2I_F \mu^2 V^3}{(1+\mu V(V-1))^2}$ (see the proof for Proposition 2), which can be re-written as $\alpha_F < \frac{2I_F V}{(\frac{1}{\mu V} + (V-1))}$. Because $\frac{1}{\mu V} > 0$ we have $\frac{2I_F V}{(\frac{1}{\mu V} + (V-1))} < \frac{2V I_F}{(V-1)^2}$, which means that if $\alpha_F < \alpha_F^{opt}$ then $\alpha_F < \frac{2V I_F}{(V-1)^2}$, or, in other words, in this scenario the condition for
Because in this scenario $\pi_F = 0$, $\frac{\partial}{\partial \alpha_F} = 0$.

For the third part of Proposition 5 we take $\hat{e}$ and plug it in the expressions for $\pi_F$ and $U_{NGO}$.

Differentiating $\pi_F$ with respect to $\alpha_F$ and $\mu$ yields

$$\frac{\partial \pi_F}{\partial \alpha_F} = \frac{1}{2\bar{V}}(\bar{V} + \frac{1}{\mu\bar{V}} - 1)^2 > 0,$$

$$\frac{\partial \pi_F}{\partial \mu} = -\frac{\alpha_F}{V^2\mu^2}(\bar{V} - 1 + \frac{1}{\mu\bar{V}}) < 0,$$

$$\frac{\partial^2 \pi_F}{\partial \alpha_F \partial \mu} = -\frac{1}{V^2\mu^2}(\bar{V} - 1 + \frac{1}{\bar{V}\mu}) < 0,$$

since $\bar{V} > 1$.

Plugging the expression for $\hat{e}$ in the expression for the NGO’s utility yields $\frac{\bar{V} + \frac{1}{\mu\bar{V}} - 1}{\bar{V} - 1 + \frac{1}{\bar{V}\mu}}$. It is straightforward to see that the NGO’s utility does not depend on $\alpha_F$ at the margin.

### A.3 NGO-firm matching process

We seek to find weakly stable one-to-one matchings within a population of $m$ firms and $m$ NGOs. Such matching that are weakly stable, i.e., individually rational and not blocked by any pair of agents (Roth and Sotomayor, 1992). Individual rationality means that an agent is better off with its partner in the matching than if not matching at all. A pair of agents can block a matching if they would both prefer to be together rather than with the partner assigned to them in the matching. Following Irving (1994), we strictly rank arbitrarily (by random draw) the partners an agent is indifferent to, and then use Gale and Shapley’s (1962) deferred acceptance algorithm to find weakly stable matchings.

Firms’ and NGOs’ preferences are based on Proposition 5. Consider first NGO’s preferences. An NGO prefers to match with firms with a bargaining power that is high enough so that it can optimally exert effort $\hat{e}$, i.e., with $\alpha_F > \alpha_F^{opt}$ but the NGO is indifferent between all the firms in that category. We will assume a random preference ordering within that first category. Failing to match with a firm with a higher $\alpha_F$, an NGO would fall back to firms with an intermediate
level of $\alpha_F \ (\alpha_F^{opt} > \alpha_F > \alpha_F^{min})$. However, the NGO will strictly prefer firms with a higher $\alpha_F$ as they enable the NGO to reduce its effort towards its most favorable level. The NGO’s least preferred set of firms include those with which no collaboration can enable strictly positive utility (i.e., $\alpha_F < \alpha_F^{min}$).

Turning to the firms, we see that a firm’s first choice is to match with an NGO with a low $\mu$ such that the NGO’s effort is equal to $\hat{e}$. This guarantees positive profits for the firm, which decrease in $\mu$. Given the choice, the firm will thus strictly prefer to match with NGOs with lower $\mu$. A firm’s second choice is to match with an NGO that will make effort $e^{collab}$, implying a higher $\mu$ while keeping $\alpha_F$ constant. However, the firm will be indifferent among all those NGOs as they all guarantee the firm the same minimal profit. We will assume a random ordering within that category. Failing to match with any of the above NGOs, a firm elects not to collaborate.

These preferences do not change depending on which other matches are realized, i.e., there are no, or negligible externalities due to matching so that, a firm’s benefit from matching with an NGO is not affected by whether other firms are themselves matching or not with NGOs. This means that firms are not direct competitors in the product market, either due to geographical separation or because their products are sufficiently horizontally differentiated, even though they are figuratively competing in an input market.\footnote{We know of few studies that account for how competitive interactions in the product market feed into the equilibrium in the upstream market. An exception is Chatain’s (2014) paper on factor market competition.}

For our computations, we create preference orderings for 200 firms, whose confidence indices are evenly spread in $[0,1]$, and 200 NGOs, whose efficiency parameter is evenly spread between $1/V$ and $3V$, setting $I_F = 0.4$ and $V = 2.5$. This number of firms and organizations is chosen to ensure a fine-grained coverage of the parameter space. By construction, the parameters $\alpha_F$ and $\mu$ are uncorrelated. We then run the deferred acceptance algorithm to get a stable matching. We ran it with either the firms or the NGOs starting the process. We repeat this operation 1,000 times to account for the randomization used to break ties within categories.
A.4 Firm and NGO cross-subsidization

So far we have assumed that the firm and the NGO fully bear the cost of the investment and the effort, respectively. Yet in collaborative initiatives we can sometimes observe firms transferring funds to NGOs (e.g., Dunkin’ Donuts gave $260,000 to Rainforest Alliance to train coffee and tea farmers in several developing countries\(^{50}\)), and vice versa—for instance, a nonprofit IECD co-invested with Bel Group (best known for its “Laughing Cow” brand) to create a special business school to train street vendors in Vietnam in the distribution of Bel Group’s products (Guesné and Ménascé, 2014).

We extended our analysis to allow cash transfers between parties to find when such transfers are mutually beneficial in our model as well as their direction. For instance, at intermediate levels of the firm’s bargaining power the NGO may be better off transferring cash to the firm in order to relax the firm’s participation constraint and reduce the level of its effort. On the other hand, at high levels of the firm’s bargaining power the firm can benefit from a higher effort by the NGO.

Interestingly, we find that the firm never finds it profitable to subsidize the NGO while the NGO may often have an interest to motivate the firm’s participation through a direct cash transfer rather than through improvement in the value creation potential of the suppliers. The intuition is that cash transfers can be more efficient than improving the suppliers’ value creation because some of improvements in value creation leaks into value captured by suppliers in inverse relationship with \(\alpha_F\), while at the same time the NGO is reaching diminishing returns in improving supplier quality.

Specifically, the opportunity to improve its utility through a cash transfer is viable for less capable NGOs and NGOs partnering with less powerful firms. The reason is that the lower the NGO’s capabilities, the more important the difference in marginal cost for the NGO (which is consistent with the results of the section 3.5 where less capable NGOs were more interested in having \(e^{\text{collab}}\) reduced). Similarly, the lower the firm’s \(\alpha_F\), the further the firm’s constraint \(e^{\text{collab}}\) from the NGO’s first best \(\hat{e}\), and the more important it is for the NGO to reduce its effort. We provide the formal analysis below.

Let us assume that there is a potential monetary transfer $t$ between the firm and the NGO. We also assume that such a transfer is contingent on the firm actually investing to collaborate, if the firm is a recipient, and on the NGO improving the distribution of the suppliers’ type, if the NGO is the recipient. Taking into account that NGO’s capabilities will affect the NGO’s ability to raise funds, the firm’s profit and the NGO’s utility are modified as follows:

$$\pi_{F, \text{sponsor}} = \alpha_F \frac{(\bar{V} + e - 1)^2}{2\bar{V}} - I_F + t,$$

$$U_{\text{NGO, sponsor}} = \frac{\bar{V} + e - 1}{\bar{V}} - \mu \frac{(\max(0, e + t))^2}{2}.$$

The transfer $t$ can be positive or negative. $t < 0$ means that the firm transfers money to the NGO, while $t > 0$ means that the NGO subsidizes the firm. If the NGO receives funds ($t < 0$), these funds will be used to reduce the total effort of resource mobilization, but not below 0.$^{51}$

We have the following proposition:

**Proposition 6** Assume $I_S = 0$, and the firm is not investing in collaboration if $e = 0$. Then,

1. If $e^\ast = e_{\text{collab}}$, there are combinations of parameters $\mu$, $\alpha_F$, $\bar{V}$, and $I_F$, such that $\frac{\partial U_{\text{NGO, sponsor}}(t)}{\partial t} |_{t=0} > 0$, i.e. the NGO has higher utility at the margin if it transfers cash to the firm rather than devote more resources to its effort. Moreover, the set of parameters such as $\frac{\partial U_{\text{NGO, sponsor}}(t)}{\partial t} |_{t=0} > 0$ increases in $\mu$ and decreases in $\alpha_F$.

2. If $e^\ast = \hat{e}$, then it is never the case that $\frac{\partial \pi_{F, \text{sponsor}}(t)}{\partial t} |_{t=0} < 0$ (such that $e^\ast < 1$), i.e. the firm can never have higher profit at the margin by transferring cash to the NGO.

Proposition 6 says that for a certain range of parameters the NGO is better off transferring cash to the firm when the NGO makes the participation-inducing effort $e_{\text{collab}}$. On the other hand, within the range of parameters that we analyze (i.e. $e^\ast < 1$) it is always the case that the firm does not benefit from subsidizing the NGO.

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$^{51}$In the proof we also show that when the NGO makes a transfer $t$ to the firm it will not exceed $I_F$, i.e. we can interpret it as the NGO reducing the firm’s investment cost, but not below 0.
Let us first look at the situation when $e^* = e^{collab}$. As we have seen in previous sections when the NGO has to make $e^{collab}$ it prefers to have it reduced in order to get closer to its first best $\hat{e}$. A positive transfer from the NGO to the firm increases the latter’s profit, thereby reducing the requirement for the participation-inducing effort to $e^{collabSponsor}$, $e^{collabSponsor} < e^{collab}$.

The new $e^{collabSponsor}$ implies that the NGO will have a lower marginal cost of effort leading to a better cost-benefit combination than with the original $e^{collab}$. If the ensuing increase in the NGO’s utility outweighs the cost of transfer $t$ then the NGO benefits from subsidizing the firm. In other words, rather than making the effort $e^{collab}$ and incurring high marginal cost, the NGO has an option to make a lower effort $e^{collabSponsor}$ and give cash to the firm directly to compensate for the difference in the effort requirement.

Figure 20 provides an intuition to understand under which conditions we can observe the NGO benefitting from such a transfer. To do so we map the areas where the derivative $U_{NGO}^{sponsor'}(t)$ at $t = 0$ is negative (dark grey-shaded area) and positive (light grey-shaded area) as a function of $\alpha_F$ and $\mu$ when $e^* = e^{collab}$. The light-grey shaded area shows the combinations of $\alpha_F$ and $\mu$ where the NGO’s utility increases in $t$ at the margin, i.e. the NGO can improve its utility by transferring cash to the firm, while the dark grey-shaded area is where the NGO’s utility is decreasing at margin in $t$. We add the thresholds from Figure 4 to indicate the areas of scenarios $e^* = e^{collab}$ and $e^* = \hat{e}$ (thick black lines).52 Concentrating on the area of $e^* = e^{collab}$, which lies between the $\alpha_F^{min}$ and $\alpha_F^{opt}$ lines, we can see that a large part of this area is where the NGO’s utility is increasing in $t$, indicating that the NGO indeed has an opportunity to improve its situation by directly giving cash to the firm.

Furthermore, the area where the NGO’s utility increases in $t$ is itself expanding in $\mu$ and contracting in $\alpha_F$. In other words, the opportunity to benefit from the cash transfer is more valuable for NGOs with lower capabilities, and for NGOs working with the less powerful firms.

Because in this scenario the firm’s profits remain zero and making a positive transfer to the NGO would further reduce the firm’s profits, the firm gains nothing from subsidizing the NGO and

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52 Similarly to Figure 4, Figure 20 has $\mu > \frac{1}{V}$ to guarantee $\hat{e} = \frac{1}{\mu V}$ below 1.
would thus not make a transfer.

Consider now the case where at \( t = 0 \) we have \( e^* = \hat{e} \). For small values of \( t \), the firm’s participation is ensured, and as a result the NGO has no interest in sending cash to the firm. For the firm, transferring cash to the NGO is not paying off because the marginal increase of value creation is limited, and the firm will only gain a share \( \alpha_F \) of such increase in value creation. In other words, the only way to have the firm benefit from making a cash transfer to the NGO at the margin is by having the NGO’s capabilities high enough to make \( e^* > 1 \), in which case there is no uncertainty linked to the supplier’s quality, and relying on the supplier always dominates the firm’s outside option.

The implication is that rather than stretching their resources in order to meet the firm’s participation constraint less capable NGOs and NGOs working with less powerful firms can be better off giving cash directly to the firm, for instance, in the form of co-funding (e.g., the case of IECD and Bel Group). Complex arrangements can be equivalent to a transfer of funds from the NGO to the firm. For instance, the NGO can secure a lower price of input for the firm (the firm then gets more money) while compensating the suppliers for this discount, effectively subsidizing the suppliers in return for the suppliers allowing more value capture by the firm.\(^{53}\) These funds come from extra fundraising efforts and resource mobilization in addition to the effort \( e \) towards suppliers.

**Proof of Proposition 6.**

For the first part of Proposition 6 solving \( \pi_F^{spon} = 0 \) gives us the new participation-inducing level of effort for the firm \( e_{collabSponsor} = 1 - \hat{V} + \sqrt{2\hat{V}(I_F - t) / \alpha_F} < e_{collab} \) (since \( t > 0 \)). Note that in this case \( t \leq I_F \), i.e. the transfer of funds from the NGO to the firm will not reduce the firm’s investment below 0. Plugging \( e_{collabSponsor} \) into the expression for \( U_{NGO}^{spon} \) and differentiating it

\(^{53}\)We thank an anonymous referee for suggesting this equivalent, yet more practical, transaction structure.
Figure 20: Values of $\frac{\partial U_{NGO}^{\text{sponsor}}(t)}{\partial t}$ if $e^* = e^{\text{collab}}$

with respect to $t$ yields:

$$U_{NGO}^{\text{sponsor}}(t) = -\mu t + \mu(\bar{V} - 1 + \frac{\bar{V}}{\alpha_F}) - \mu \sqrt{\frac{2\bar{V}(I_F - t)}{\alpha_F}} + \frac{1}{\sqrt{2V\alpha_F(I_F - t)}}(\mu t\bar{V} - \mu\bar{V}(\bar{V} - 1) - 1),$$

$$U_{NGO}^{\text{sponsor}}(t) \mid_{t=0} = \mu(\bar{V} - 1 + \frac{\bar{V}}{\alpha_F}) - \mu \sqrt{\frac{2\bar{V}I_F}{\alpha_F}} - \frac{1}{\sqrt{2V\alpha_F I_F}}(\mu\bar{V}(\bar{V} - 1) + 1).$$

Rather than directly solving $U_{NGO}^{\text{sponsor}}(t)\mid_{t=0} > 0$ (which is mathematically challenging, whilst providing results difficult to interpret) we map the derivative as a function of parameters $\alpha_F, \mu, I_F,$ and $\bar{V}$ (see Figure 20).

In this scenario the firm will not make a transfer $t$ because $\pi_F^{\text{sponsor}} = 0$ resulting in the absence of any gain for the firm.

For the second part of Proposition 6 maximizing $U_{NGO}^{\text{sponsor}}$ in $c$ gives the new first best level of effort for the NGO $\hat{c}^{\text{sponsor}} = \frac{1}{\mu V} - t > \hat{c}$ (since $t < 0$). Plugging $\hat{c}^{\text{sponsor}}$ into the equation for the
firm’s profit and differentiating it in $t$ yields:

$$
\pi_{F,\text{sponsor}}^{\prime}(t) = 1 - \frac{\alpha_F}{\bar{V}} (\bar{V} - 1 + \frac{1}{\mu \bar{V}} - t),
\pi_{F,\text{sponsor}}^{\prime}(t) |_{t=0} = 1 - \frac{\alpha_F}{\bar{V}} (\bar{V} - 1 + \frac{1}{\mu \bar{V}}).
$$

Because $t < 0$ we are interested in the situation when the firm’s profit decrease in $t$ (i.e. if the firm makes transfer $t$ it will get higher profit than with $t = 0$). Solving $\pi_{F,\text{sponsor}}^{\prime}(t)|_{t=0} < 0$ gives us the condition $\alpha_F > \frac{\bar{V}}{\bar{V} - 1 + \frac{1}{\mu \bar{V}}}$. Since by definition $0 \leq \alpha_F \leq 1$ we need to compare this condition with 1. We find that $\frac{\bar{V}}{\bar{V} - 1 + \frac{1}{\mu \bar{V}}} < 1$ iff $\mu < \frac{1}{\bar{V}}$. However, we have imposed that $\mu$ has to be high enough to guarantee that $e^{*}$ is below 1, which translates into the condition $\mu > \frac{1}{\bar{V}}$. Therefore, the only way to have $\pi_{F,\text{sponsor}}^{\prime}(t)|_{t=0} < 0$ and to keep $\alpha_F$ within the viable limits (i.e., $\alpha_F \leq 1$) is to have $\mu < \frac{1}{\bar{V}}$, which implies $e^{*} = \hat{\mu} > 1$.

The NGO will not sponsor the firm in this scenario because if $t > 0$ then $\hat{e}^{\text{Sponsor}} < \hat{\mu}$, and therefore $U_{NGO}^{\text{Sponsor}}(e^{*} = \hat{e}^{\text{Sponsor}}) = \frac{\bar{V} + \frac{1}{\mu \bar{V}} - t - 1}{\bar{V}} - \frac{\mu}{2} \left( \frac{1}{\mu \bar{V}} - t + t \right)^2 = \frac{\bar{V} + \hat{\mu} - t - 1}{\bar{V}} - \frac{\mu \hat{\mu}^2}{2} < U_{NGO}(e^{*} = \hat{\mu})$.

**A.5 Supplier not fully subsidized**

So far we have assumed that either the supplier’s investment is negligible or that the firm can fully subsidize the supplier and ensure the investment is made (in both cases, $I_S = 0$). As a robustness check, we now relax this assumption and have the supplier invest $I_S > 0$ in the co-specialized asset simultaneously with the firm. As a result, the supplier will incur losses from the collaboration if its value capture is insufficient to recoup the cost of investment. We can explore the implications of this constraint for the area of collaboration and the level of improvement exerted by the NGO.

Now the NGO needs to provide sufficient improvement to ensure that the supplier captures enough value to recover its investment and be willing to collaborate. With $e^{\text{collabS}}$ denoting the smallest strictly positive level of effort at which the supplier’s profit is non-negative ($\pi_S \geq 0$), we
have:

$$e^{collabS} = \max \left( 0, 1 - \bar{V} + \sqrt{\frac{2I_S V}{1 - \alpha_F}} \right).$$

With $\alpha_F^{optS}$ denoting the level of $\alpha_F$ at which $\hat{e} = e^{collabS}$ and $\alpha_F^{max}$ the level at which $e^{collabS} = e^{ub}$, we can now fully characterize the NGO’s effort level.

**Proposition 7** Assume $I_S > 0, I_F > 0$, and that the firm or the supplier are not investing in collaboration if $e = 0$. Then,

1. At the extremes of the firm’s bargaining power $\alpha_F$ the NGO’s effort is zero ($e^* = 0$) and there is no collaboration between the firm and the supplier (i.e., if $\alpha_F < \alpha_F^{min}$ or $\alpha_F^{max} < \alpha_F$).

2. At intermediate levels of $\alpha_F$, the NGO’s effort exhibits a U-shaped relationship with respect to the firm’s bargaining power ($e^* = \max(e^{collab}, \hat{e}, e^{collabS})$), and the first best $\hat{e}$ may only be achieved at moderate levels of $\alpha_F$.

The NGO is now constrained by both the firm’s and the supplier’s needs. When at least one of the players is too powerful (which is the case at the lowest and the highest levels of the firm’s bargaining power) the participation-inducing effort for the counterpart is too costly for the NGO, and the collaboration does not happen. Conversely, when there is little imbalance in the bargaining power between the firm and the supplier (which happens at moderate levels of $\alpha_F$), the requirements in terms of the improvement level are also balanced, enabling the NGO to exert its first best effort level $\hat{e}$.

When at least one player requires a level of improvement higher than $\hat{e}$, the NGO’s effort will depend on whose need is the greatest. At lower levels of $\alpha_F$ the firm will represent the constraint, while at higher levels of $\alpha_F$ it will be the supplier’s constraint. The implication for the NGO is that it would prefer to work with firms that have more balanced level of bargaining power vis-à-vis their suppliers.

**Proof of Proposition 7.**
Thresholds $\alpha_F^{optS}$ and $\alpha_F^{max}$ are derived from the expressions for the critical levels of effort in a manner similar to Proposition 2. Let us consider for the moment only the supplier’s side (or, in other words, $I_F = 0$). The NGO will make no effort when $e^{ub} < e^{collabS}$. Solving it in $\alpha_F$ yields $\alpha_F > 1 - \frac{2I_F V^3}{(\mu V(V-1)+1+2\mu V(V-1))^2}$. We will denote this expression as $\alpha_F^{max}$.

The NGO will make its first best effort $\hat{e}$ when $e^{collabS} \leq \hat{e}$, which when solved in $\alpha_F$ gives the condition $\alpha_F \leq 1 - \frac{2I_F V^3}{(1+2\mu V(V-1))^2}$. We will denote this expression as $\alpha_F^{opt}$, $\alpha_F^{opt} < \alpha_F^{max}$. It is straightforward that the NGO will make $e^{collabS}$ when $\alpha_F^{opt} < \alpha_F \leq \alpha_F^{max}$.

Coming back to the situation when $I_F > 0$ and $I_S > 0$ we can characterize the NGO’s effort. It is straightforward that $e^* = 0$ when $0 \leq \alpha_F < \alpha_F^{min}$ or $\alpha_F^{max} < \alpha_F \leq 1$. For $\alpha_F \in [\alpha_F^{min}, \alpha_F^{max}]$ we have $e^* = \max(e^{collab}, \hat{e}, e^{collabS})$. More specifically, if $\alpha_F^{opt} < \alpha_F^{optS}$ we have:

$$
e^* = \begin{cases} 
0 & \text{if } 0 \leq \alpha_F < \alpha_F^{min} \text{ or } \alpha_F^{max} < \alpha_F \leq 1, \\
 e^{collab} & \text{if } \alpha_F^{min} \leq \alpha_F < \alpha_F^{opt}, \\
 \hat{e} & \text{if } \alpha_F^{opt} \leq \alpha_F \leq \alpha_F^{optS}, \\
 e^{collabS} & \text{if } \alpha_F^{optS} < \alpha_F \leq \alpha_F^{max}. 
\end{cases}
$$

Since $e^{collab}$ decreases in $\alpha_F$, $e^{collabS}$ increases in $\alpha_F$, while $\hat{e} < e^{collab}$, and $\hat{e} < e^{collabS}$, we have a U-shaped relationship between $e^*$ and $\alpha_F$ when $e^* > 0$.

We should note that the NGO will be able to make its first best $\hat{e}$ only if $\alpha_F^{opt} < \alpha_F^{optS}$. If $\alpha_F^{opt} > \alpha_F^{optS}$ (which is the case, for instance, when $I_F$ and $I_S$ are high) then the equilibrium effort will be equal to:

$$
e^* = \begin{cases} 
0 & \text{if } 0 \leq \alpha_F < \alpha_F^{min} \text{ or } \alpha_F^{max} < \alpha_F \leq 1, \\
 e^{collab} & \text{if } \alpha_F^{min} \leq \alpha_F < \frac{I_F}{I_F+I_S}, \\
 e^{collabS} & \text{if } \frac{I_F}{I_F+I_S} < \alpha_F \leq \alpha_F^{max}, 
\end{cases}
$$

where $\frac{I_F}{I_F+I_S}$ is the value of $\alpha_F$ at which $e^{collab} = e^{collabS}$.

Since $e^{collab}$ is decreasing in $\alpha_F$ and $e^{collabS}$ is increasing in $\alpha_F$ the U-shaped relationship between $e^*$ and $\alpha_F$ will still be preserved. ■
A.6 Comparison with the socially optimal effort benchmark

We will now consider the level of effort that would maximize social welfare in a world without an NGO, rather than the utility of the NGO, and then compare it to the equilibrium level of effort exerted by the NGO. The socially optimal effort from the view point of an agency would be the one that maximizes the sum of profits by the firm and the supplier given the investment and the cost of effort $c(e)$. Denote this level as $\hat{e}$. We have

$$\hat{e} = \frac{\bar{V}}{\mu V - 1}.$$ 

Let us define a critical value $\alpha_{F}^{**}$ such that $e^{\text{collab}} > \hat{e}$ when $\alpha_F < \alpha_{F}^{**}$ and $\hat{e}^{\text{collab}} < \hat{e}$ when $\alpha_F > \alpha_{F}^{**}$.

In addition, we define a threshold $K_{FB}$ such that $\hat{e} = 0$ if $K_{FB} \leq I_F + I_S$ (in other words, we want to ensure that it is worth investing at all into the improvement of the suppliers’ value creation potential). For all $K_{FB} > I_F + I_S$ the public actor will choose to exert $\hat{e} > 0$.

We also impose that $\mu > \frac{1}{\bar{V}}$ to ensure that the NGO’s first best level $\hat{e}$ does not exceed $1$ to preserve the uncertainty around the collaboration.

Comparing the socially optimal level of effort $\hat{e}$ with the effort that the NGO exerts under each of the three regimes in Proposition 2 yields the following proposition:

**Proposition 8** Assume $\mu > \frac{1}{\bar{V}}$, $K_{FB} > I_F + I_S$, $I_S = 0$ and that the firm is not investing in collaboration if $e = 0$. Then for $\alpha_F < \alpha_{F}^{min}$ the NGO’s equilibrium effort is zero, and the NGO underinvests compared to the benchmark $\hat{e}$. For $\alpha_{F} \geq \alpha_{F}^{min}$ the comparison between $\hat{e}$ and $e^{*}$ depends on the location of $\hat{e}$ relative to $e^{ub}$ and $\hat{e}$:

1. If $\hat{e} > e^{ub}$ then $e^{*} < \hat{e}$ for $\alpha_{F} \geq \alpha_{F}^{min}$,

2. If $\hat{e} < \hat{e} < e^{ub}$ then $e^{*} > \hat{e}$ when $\alpha_{F}^{min} \leq \alpha_{F} < \alpha_{F}^{**}$ and $e^{*} < \hat{e}$ when $\alpha_{F}^{**} < \alpha_{F} \leq 1$.

We have $K_{FB} = \frac{(V-1)^2}{2V} \left(1 + \frac{1}{\mu V - 1}\right)$, where $\frac{(V-1)^2}{2V}$ is the value creation in the absence of the NGO. Given the assumption $\mu > \frac{1}{\bar{V}}$ to ensure that $\hat{e} < 1$, $K_{FB}$ is higher than the value creation in the absence of the NGO. We can also express the condition in terms of $\mu$: $\hat{e} > 0$ when $\mu < \mu_{FB}$ if $\mu_{FB} > 0$ and under all $\mu > 0$ if $\mu_{FB} < 0$, where $\mu_{FB} = \frac{2(I_F + I_S)}{2V(I_F + I_S) - (V-1)^2}$.
3. If \( \hat{e} < \hat{e} \) then \( e^* > \hat{e} \) for \( \alpha_F \geq \alpha_F^{\min} \).

Since we impose that \( K^{FB} > I_F + I_S \) then \( \hat{e} > 0 \). Because \( e^* = 0 \) when \( \alpha_F < \alpha_F^{\min} \) it is straightforward that at \( \alpha_F < \alpha_F^{\min} \) the NGO will always underinvest compared to the socially optimal benchmark. For the remaining part of the proposition the intuition is the following.

In the first case the socially optimal benchmark \( \hat{e} \) is so high that it exceeds the NGO’s maximum effort \( e^{ub} \). Since the latter is the maximum level that the NGO is able to do, the NGO will always underinvest compared to the socially optimal outcome (see Figure 21a).

In the second case \( \hat{e} \) falls between \( e^{ub} \) and \( \hat{e} \) and thus has to be compared to \( e^{collab} \). While the public actor is not concerned with the distribution of the value created, the firm’s requirement for the quality improvement \( e^{collab} \) depends on its ability to capture value from the collaboration. This results in a situation when under \( e^* = e^{collab} \) the NGO who wants to meet the firm’s constraint will over-invest compared to the benchmark \( \hat{e} \) at lower level of the firm’s bargaining power, while at higher level of the firm’s bargaining power the NGO will underinvest because the constraint is low. Since \( \hat{e} < e^{collab} \) when the NGO exerts \( e^* = \hat{e} \) it will also be below the socially optimal benchmark (see Figure 21b).

The third case is a foil to the first one: here the socially optimal benchmark is low, so that \( \hat{e} < \hat{e} \). Therefore, if the NGO exerts a positive equilibrium effort it will always over-invest compared to \( \hat{e} \) (see Figure 21c).

However, among the three cases the second one is by far the most common. Figure 22 maps the areas of the three scenarios described above depending on the values of \( \mu \) and \( \bar{V} \). The dark grey-shaded area is what is where \( \mu < \frac{1}{\bar{V}} \) meaning \( e^* > 1 \) and no uncertainty linked to the supplier’s quality. The dashed line represents the maximum \( \mu \) to satisfy condition \( K^{FB} > I_F + I_S \). We can see that in most cases we will observe \( \hat{e} < \hat{e} < e^{ub} \) while the other two cases are constrained to a limited range of \( \mu \) and \( \bar{V} \). It means that it is more likely to be in the situation in which the NGO will underinvest compared to the socially optimal benchmark unless the firm’s constraint is high.

The intuition behind these results is the following. The “upward” potential of the NGO’s first best effort level \( \hat{e} \) depends on the \textit{probability} that the expected value creation meets the threshold
of 1 (which is the firm’s outside option). In contrast, $\hat{e}$ is driven by the expected value creation itself. The implication is that when the supplier’s ex ante quality is sufficiently high, the NGO does not need to make a large effort, while the public actor still benefits from exerting a higher effort. This results in the most frequently observed situation when the NGO’s first best $\hat{e}$ is below the socially optimal $\hat{e}$. The opposite (i.e. $\hat{e} < \hat{e}$ ) happens only when the supplier’s ex ante quality is low. In this case the supplier needs a lot of help from the NGO to increase its chances to enter, however, the value created remains not very high. The NGO who wants the supplier to enter will then exert a higher effort than a public actor who cares about the total payoffs, leading the NGO to over-invest compared to the socially optimal benchmark (scenario 21c).

The NGO’s maximum level of effort $e^{ub}$, on the other hand, will in most cases be above the socially optimal benchmark, except when the agent has particularly high capabilities (low $\mu$) leading to scenario 21a with $\hat{e} > e^{ub}$. However, we should note that for such $\mu$ the socially optimal benchmark $\hat{e}$ is above 1, which eliminates the uncertainty associated with the collaboration.

The main insight is that the NGO whose goal is to increase the probability of the supplier’s inclusion will in most cases underinvest compared to the welfare maximizing level of effort. A public actor who cares about the total value creation will therefore prefer the firm to have a higher constraint in order to push the NGO to exert higher effort. However, when the ex ante quality of the supplier is very low the NGO will do more than a public actor who will make either a low effort, or no effort at all.

**Proof of Proposition 8.**

First we explain the calculation of the threshold $K^{FB} > I_F + I_S$, which is the condition for $\hat{e} > 0$. We plug $\hat{e}$ into the expression for the social welfare to find the condition for the total value creation to exceed the total investment given the cost of effort. We have $\frac{(\tilde{V} - 1)^2}{2\tilde{V}} (1 + \frac{1}{\mu \tilde{V} - 1}) > I_F + I_S$, where we denote the left-hand side $K^{FB}$. Solving the inequality in $\mu$ and given that we imposed

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55 We should also note that a large part of this area lies above the line delineating the condition $K^{FB} > I_F + I_S$, which means that in these cases the NGO’s effort does not, actually, maximize welfare.
(a) $\hat{e} > e^{ub}$

(b) $\hat{e} < \hat{e} < e^{ub}$

(c) $\hat{e} < \hat{e}$

Figure 21: Comparison of the NGO’s level of effort to the socially optimal benchmark
\[ \mu > \frac{1}{\bar{V}} \] we have:

\[
K^{FB} > I_F + I_S \begin{cases} 
\text{when } \mu > \frac{1}{\bar{V}} \text{ if } 2\bar{V}(I_F + I_S) - (\bar{V} - 1)^2 < 0, \\
\text{when } \frac{1}{\bar{V}} < \mu < \frac{2(I_F + I_S)}{2\bar{V}(I_F + I_S) - (\bar{V} - 1)^2} \text{ if } 2\bar{V}(I_F + I_S) - (\bar{V} - 1)^2 > 0.
\end{cases}
\]

Alternatively, solving \( 2\bar{V}(I_F + I_S) - (\bar{V} - 1)^2 > 0 \) in \( 1, \bar{V} \), and bearing in mind that \( \bar{V} > 1 \), we can express the condition as

\[
K^{FB} > I_F + I_S \begin{cases} 
\text{when } \mu > \frac{1}{\bar{V}} \text{ if } \bar{V} > I_F + I_S + 1 + \sqrt{(I_F + I_S)(I_F + I_S + 2)}, \\
\text{when } \frac{1}{\bar{V}} < \mu < \frac{2(I_F + I_S)}{2\bar{V}(I_F + I_S) - (\bar{V} - 1)^2} \text{ if } \bar{V} < I_F + I_S + 1 + \sqrt{(I_F + I_S)(I_F + I_S + 2)},
\end{cases}
\]

which means all \( \mu > \frac{1}{\bar{V}} \) and below the dashed line on Figure 22.

Given these conditions, we need to compare the socially optimal \( \hat{\hat{e}} \) with \( \hat{e}, e^{ub}, \) and \( e^{collab} \), taking into account that the NGO makes the effort iff \( \hat{\hat{e}} \leq e \leq e^{ub} \).

Because \( \hat{\hat{e}} \) is independent of \( \alpha_F \) and \( \hat{\hat{e}} > 0 \) it is straightforward that when \( e = 0, \hat{\hat{e}} > e \), i.e. the NGO’s effort is below \( \hat{\hat{e}} \).
Comparing $\hat{e}$ to $\hat{\hat{e}}$ yields that $\hat{e} < \hat{\hat{e}}$ when $\mu > \max(\frac{1}{V}, \frac{1}{V(2-V)})$, provided that $\bar{V} < 2$. This corresponds to the upper light grey-shaded area on Figure 22 and panel 21c on Figure 8. By construction, in this case $\hat{e} < e^{ub}$. For other combinations of $\mu$ and $\bar{V}$ we have $\hat{e} > \hat{\hat{e}}$.

Comparing $\hat{e}$ to $e^{ub}$ yields that $e^{ub} < \hat{e}$ when $\mu > \frac{\bar{V} \sqrt{(V-2)(2-V)}}{\mu V-1}$. Solving the inequality gives that $e^{ub} < \hat{e}$ when

$$
\begin{cases}
\frac{1}{V} < \mu < \min(\frac{\bar{V}+1}{2V}, \frac{1}{V(2-V)}) & \text{when } V < 2, \\
\frac{1}{V} < \mu < \frac{\bar{V}+1}{2V} & \text{when } V > 2,
\end{cases}
$$

which corresponds to the lower light-grey shaded area on Figure 22 and panel 21a on Figure 8. Otherwise $\hat{e} < e^{ub}$.

Therefore, $\hat{e} < \hat{\hat{e}} < e^{ub}$ when

$$
\begin{cases}
\frac{\bar{V}+1}{2V} < \mu < \frac{1}{V(2-V)} & \text{when } V < 2, \\
\mu > \frac{\bar{V}+1}{2V} & \text{when } V > 2,
\end{cases}
$$

This corresponds to the white area on Figure 22, and panel 21b on Figure 21. Because in this case the socially optimal effort $\hat{e}$ is located between the two NGO’s critical thresholds, we compare $\hat{e}$ with $e^{collab}$. Solving $\hat{e} > e^{collab}$ in $\alpha_F$ yields $\alpha_F > \frac{2l_F(\mu V-1)^2}{(V-1)^2\mu^2 V^2}$, which we denote $\alpha_F^{**}$.

A.7 NGO seeking to maximize supplier profits

Let us now look at the situation when the NGO’s objective is to maximize the profits of the supplier, which in our paper is identical to the welfare of the supplier. The objective function of the NGO is modified as follows:

$$
U_{NGO} = \gamma \pi_S - \frac{\mu}{2} e^2 = \gamma \left(\frac{1}{2V} - \frac{\alpha_F}{2V} (\bar{V} + e - 1)^2 - I_S\right) - \frac{\mu}{2} e^2,
$$
where $\gamma \pi_S$ is the new $z(e)$, and $\gamma$ is a scaling parameter indicating the importance of the supplier’s welfare to the NGO, $\gamma \in (0, 1)$.

The first best effort level for the NGO in this case is equal to

$$\hat{e}_{Aligned} = \frac{\gamma(1 - \alpha_F)(\bar{V} - 1)}{\mu \bar{V} - \gamma(1 - \alpha_F)}.$$  

NGO’s utility is non-negative when $e_{lbAligned} \leq e \leq e_{ubAligned}$, where $e_{ubAligned} = \hat{e}_{Aligned} + \delta$, $e_{lbAligned} = \hat{e}_{Aligned} - \delta$, and $\delta = \sqrt{\gamma \bar{V}(\mu(1-\alpha_F)\bar{V} - 1)^2 + 2Is(\gamma(1-\alpha_F) - \mu \bar{V})}$. The NGO will have positive utility when the effort is anywhere between $e_{ubAligned}$ and $e_{lbAligned}$. Because $e_{lbAligned} \leq \hat{e}_{Aligned} \leq e_{ubAligned}$ by definition let us define $\alpha_F^{Aligned}$ the critical value of $\alpha_F$ such that $e_{lbAligned} = \hat{e}_{Aligned} = e_{ubAligned}$ if $\alpha_F = \alpha_F^{Aligned}$. Then if $\alpha_F > \alpha_F^{Aligned}$ we have $U_{NGO} < 0$.

Figure 23 shows the equilibrium effort for the NGO in this model. The curves $e^{collab}$ and $e^{collabS}$ represent the participation constraints of the firm and the supplier, respectively; there are the curves for $\hat{e}_{Aligned}$ and $e_{ubAligned}$, indicating the first best NGO’s effort level and the upper boundary of the NGO’s effort level.

We can now see the key differences with the main model. First, the NGO’s first best effort $\hat{e}_{Aligned}$ is decreasing in $\alpha_F$, and at high levels of $\alpha_F$ it becomes only marginally different from 0. Indeed, because the NGO’s utility depends now on the supplier’s payoff, the NGO is reluctant to incur high cost to make a large effort when the firm is going to appropriate the most of it.

Secondly, the NGO’s equilibrium effort is no longer U-shaped in $\alpha_F$. Rather than trying to meet the supplier’s constraint $e^{collabS}$ the NGO sets its equilibrium effort to 0 beyond $\alpha_F^{Aligned}$ (at which the NGO is indifferent between making the effort and not making the effort). As we can see on Figure 23, in contrast to the the main model, $e_{ubAligned}$ is decreasing in $\alpha_F$ and becomes equal to $\hat{e}_{Aligned}$ at $\alpha_F^{Aligned}$. At this point the NGO whose utility is linked to the supplier’s profit, cannot both incur the cost necessary to meet the supplier’s constraint $e^{collabS}$ and still have positive utility. In other words, beyond $\alpha_F^{Aligned}$ the value appropriation by the supplier (and, by extension, the “upward” part of the NGO’s utility $z(e)$) is too low to justify the cost of effort for the NGO.
Figure 23: Equilibrium effort when the NGO seeks to maximize the welfare of the supplier

Note that at $\alpha = \alpha_{aligned}$ the NGO’s is still making an effort $\hat{e}_{aligned}$ above $e_{collab}$. The reason is that in order to have positive utility the NGO needs the supplier to have positive profits, therefore the NGO always needs to make an effort beyond $e_{collab}$ (at which $\pi_S = 0$, implying $z(e) = 0$ and $U_{NGO} = -\frac{\mu}{2}e^2 < 0$). In other words, $\alpha_{aligned}$ is lower than $\alpha_{opt}$ from Proposition 7 holding $\bar{V}$, $I_F$, $I_S$, and $\mu$ constant.

Mathematically we can show this result by calculating $\alpha_{aligned}$. This is the level of $\alpha_F$ where the three NGO’s curves — $\hat{e}_{aligned}$, $e_{ubaligned}$, and $e_{lbaligned}$ — intersect. We have $\hat{e}_{aligned} = e_{ubaligned} = e_{lbaligned}$ at $\alpha_{aligned} = 1 - \frac{2I_S\mu\bar{V}}{2I_S\gamma + \mu(\bar{V}-1)^{\gamma}}$. For $\alpha_F > \alpha_{aligned}$ the NGO sets the equilibrium effort equal to 0. We can easily see that when $I_S = 0$ then $\alpha_{aligned}$ is equal to 1 (i.e. the NGO can make a positive $e^{*} = \hat{e}_{aligned}$ even at the highest levels of $\alpha_F$, because in this case the supplier can never lose money), while when $I_S > 0$, then $\alpha_{aligned} < 1$.

A.8 Contrast between this paper and related literatures
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### APPENDIX B  ESSAY 2

#### B.1 HIV treatment

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<td>Viread</td>
<td>Tenofovir Disoproxil</td>
<td>NRTI (base)</td>
<td>2001</td>
<td>2002</td>
<td>2002</td>
<td>Gilead Sciences</td>
<td></td>
</tr>
<tr>
<td>Vemldy</td>
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<td>2016</td>
<td>2017</td>
<td></td>
<td>Gilead Sciences</td>
<td>Approved as standalone drug only for Hepatitis B. For HIV approved only as a combination</td>
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<tr>
<td></td>
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<td>2005</td>
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<td>NRTI (base combo)</td>
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<td>2005</td>
<td>2005</td>
<td>Gilead Sciences</td>
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<tr>
<td>Descovy</td>
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<td>2016</td>
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<tr>
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<td>Lamivudine</td>
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<td>1995</td>
<td>1996</td>
<td>before 2001</td>
<td>GlaxoSmithKline/ ViiV Healthcare</td>
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<tr>
<td>Emtriva</td>
<td>Emtricitabine</td>
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<td>2003</td>
<td>2004</td>
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<td>1996</td>
<td>1998</td>
<td>before 2001</td>
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<td>Pfizer</td>
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<td>1999</td>
<td>2001</td>
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</tr>
<tr>
<td>Intelence</td>
<td>Etravirine</td>
<td>NNRTI</td>
<td>2008</td>
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<td>2011</td>
<td>2011</td>
<td>2012</td>
<td>Janssen</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>under development</td>
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<td>Saquinavir</td>
<td>PI</td>
<td>1995</td>
<td>1996</td>
<td>before 2001</td>
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<td>Indinavir</td>
<td>PI</td>
<td>1996</td>
<td>1996</td>
<td>before 2001</td>
<td>Merck &amp; Co</td>
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<td>Nelfinavir</td>
<td>PI</td>
<td>1997</td>
<td>1998</td>
<td>before 2001</td>
<td>Agouron Pharmaceuticals/ Pfizer</td>
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</tr>
<tr>
<td>Agenerase</td>
<td>Amprenavir</td>
<td>PI</td>
<td>1999</td>
<td>2000</td>
<td>before 2001</td>
<td>GlaxoSmithKline/ ViiV Healthcare</td>
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<tr>
<td>Kaletra</td>
<td>Lopinavir + Ritonavir (booster)</td>
<td>PI</td>
<td>2000</td>
<td>2001</td>
<td>2001</td>
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</tr>
</tbody>
</table>

---

56 Bristol-Myers Squibb is a licensee and the owner of the FDC pill including efavirenz.
57 The owner is Tibotec Pharmaceuticals which was bought by Johnson & Johnson in 1994, and was merged into its Janssen division in 2002.
58 Id.
59 The owner is Vertex Pharmaceuticals, while GlaxoSmithKline is a licensee who conducted phase III trials.
<table>
<thead>
<tr>
<th>Brand name</th>
<th>Molecule</th>
<th>Class</th>
<th>FDA approval year</th>
<th>EMA approval year</th>
<th>France commercialization year</th>
<th>Main developer</th>
<th>Notes</th>
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<td>Fosamprenavir</td>
<td>PI</td>
<td>2003</td>
<td>2004</td>
<td>2004</td>
<td>GlaxoSmithKline/ViiV Healthcare</td>
<td>60 The owner is Tibotec Pharmaceuticals which was bought by Johnson&amp;Johnson in 1994, and was merged into its Janssen division in 2002</td>
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<td>Reyataz</td>
<td>Atazanavir</td>
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<td>Tipranavir</td>
<td>PI</td>
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<td>Darunavir</td>
<td>PI</td>
<td>2006</td>
<td>2007</td>
<td>2007</td>
<td>Janssen</td>
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<td>Booster</td>
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<td>1996</td>
<td>before 2001</td>
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<td></td>
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<tr>
<td>Tybost</td>
<td>Cobicistat</td>
<td>Booster</td>
<td>2013</td>
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<td>Gilead Sciences</td>
<td>Generally used as a part of an FDC pill</td>
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<td>FI</td>
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<tr>
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<td>Maraviroc</td>
<td>CCR5 antagonist</td>
<td>2007</td>
<td>2007</td>
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<td>Maraviroc</td>
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<td>CCR5 antagonist</td>
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<td>Schering-Plough/Merck &amp; Co</td>
<td>development discontinued</td>
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<td>Maraviroc</td>
<td>CCR5 antagonist</td>
<td></td>
<td></td>
<td></td>
<td>GlaxoSmithKline/ViiV Healthcare</td>
<td>development discontinued</td>
</tr>
<tr>
<td>Isentress</td>
<td>Raltegravir</td>
<td>IN</td>
<td>2007</td>
<td>2007</td>
<td>2008</td>
<td>Merck &amp; Co</td>
<td>Withdrawn in 2016. In France available as an FDC pill only</td>
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<td>Viteka</td>
<td>Elvitegravir</td>
<td>IN</td>
<td>2014</td>
<td>2013</td>
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<tr>
<td>Tivicay</td>
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<td>IN</td>
<td>2013</td>
<td>2014</td>
<td>2014</td>
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<td>Bictegravir</td>
<td>Dolutegravir</td>
<td>IN</td>
<td></td>
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<td>Gilead Sciences</td>
<td>Available only as a part of an FDC pill</td>
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<tr>
<td>Cabotegravir</td>
<td>Dolutegravir</td>
<td>IN</td>
<td></td>
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<td>ViiV Healthcare</td>
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<tr>
<td>Stribild</td>
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<td>IN combo</td>
<td>2012</td>
<td>2013</td>
<td>2014</td>
<td>Gilead Sciences</td>
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<tr>
<td>Genvoya</td>
<td>Elvitegravir + Tenofovir Alafenamide + Emtricitabine + Cobicistat</td>
<td>IN combo</td>
<td>2015</td>
<td>2015</td>
<td>2016</td>
<td>Gilead Sciences</td>
<td></td>
</tr>
<tr>
<td>Biktarvy</td>
<td>Bictegravir + Tenofovir Alafenamide + Emtricitabine + Cobicistat</td>
<td>IN combo</td>
<td>2018</td>
<td></td>
<td></td>
<td>Gilead Sciences</td>
<td></td>
</tr>
<tr>
<td>Triumeq</td>
<td>Dolutegravir + Abacavir + Lamivudine</td>
<td>IN combo</td>
<td>2014</td>
<td>2014</td>
<td>2015</td>
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</tr>
<tr>
<td>Juluca</td>
<td>Dolutegravir + Rilpivirine</td>
<td>IN combo</td>
<td>2017</td>
<td></td>
<td></td>
<td>ViiV Healthcare</td>
<td></td>
</tr>
<tr>
<td>Cabotegravir + Rilpivirine</td>
<td>IN combo</td>
<td></td>
<td></td>
<td></td>
<td>ViiV Healthcare</td>
<td>under development</td>
<td></td>
</tr>
</tbody>
</table>

60 id.
61 The owner is Tibotec Pharmaceuticals which was bought by Johnson&Johnson in 1994, and was merged into its Janssen division in 2002
62 In February 2016 sold to ViiV Healthcare
<table>
<thead>
<tr>
<th>Brand name</th>
<th>Molecule</th>
<th>Class</th>
<th>FDA approval year</th>
<th>EMA approval year</th>
<th>France commercialization year</th>
<th>Main developer</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atripla</td>
<td>Efavirenz + Tenofovir Disoproxil + Emtricitabine</td>
<td>NNRTI combo</td>
<td>2006</td>
<td>2007</td>
<td>2009</td>
<td>Gilead Sciences</td>
<td></td>
</tr>
<tr>
<td>Eviplera</td>
<td>Rilpivirine + Tenofovir Disoproxil + Emtricitabine</td>
<td>NNRTI combo</td>
<td>2011</td>
<td>2011</td>
<td>2012</td>
<td>Gilead Sciences/Janssen</td>
<td></td>
</tr>
<tr>
<td>Odefsey</td>
<td>Rilpivirine + Tenofovir Alafenamide + Emtricitabine</td>
<td>NNRTI combo</td>
<td>2016</td>
<td>2016</td>
<td>2018</td>
<td>Gilead Sciences</td>
<td></td>
</tr>
<tr>
<td>Prezobix</td>
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<td>PI combo</td>
<td>2015</td>
<td>2014</td>
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<td></td>
</tr>
<tr>
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<td>PI combo</td>
<td>2015</td>
<td>2015</td>
<td></td>
<td>Bristol-Myers Squibb/Gilead Sciences</td>
<td></td>
</tr>
<tr>
<td>Symtuza</td>
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<td>PI combo</td>
<td>2017</td>
<td></td>
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<td>Gilead Sciences/Janssen</td>
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</tr>
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</table>

Table 19: List of anti-HIV drugs (approved drugs and investigational drugs)

**B.2 Model solution**

Following Brandenburger and Stuart (2007) we use the core. In order to find the range of players’ payoffs at the core we apply the method proposed by Montez, Ruiz-Aliseda, and Ryall (2017) by finding the minimum payoffs guaranteed to the players by the competition. Montez et al. (2017) propose to identify the range of payoffs at the core by using the concepts of first order competitive intensity and second order competitive intensity. The first order competitive intensity guarantees a minimum payoff for actor $i$ which is a part of a certain coalition equal to actor $i$’s maximum added value if she joins another coalition, or, in other words, actor $i$ cannot get less than what she can add to another coalition. At the same time $i$ will have to pay to other actors in her coalition at least what other actors can create with other coalitions. Thus the capability of the actor $i$ to create value with other coalitions provides a lower boundary on $i$’s payoff range, while the capability of other actors in actor $i$’s coalition to create value with other coalitions provide the upper boundary for $i$.

The second order competitive intensity allows to further refine the payoff interval by considering the substitution by $i$ of an actor in another coalition. Actor $i$ cannot get less than its added value if she substitutes another actor in another coalition net of the substituted actor’s net benefit to that coalition. In other words, it represents the maximum amount that another coalition is willing to
pay to substitute one of its actors by \( i \). Similarly, \( i \)'s second order competitive intensity determines \( i \)'s minimum payoff, while competitive intensity for other actors determines \( i \)'s maximum payoff.

**B.2.1 Base model solution**

In the model we have five players: \( b_1 \) and \( b_2 \) in the base component with products \( B_1 \) and \( B_2 \), respectively; \( a_1 \) and \( a_2 \) in the add-on component with products \( A_1 \) and \( A_2 \), respectively; and a mass of customers distributed along Hotelling line \( x \in [0, 1] \). We assume that each firm has the capacity to serve the whole market. For notations we will use the products to refer to the payoffs. Given that \( B_2 \) is not compatible with customers located at \( 0 < x < a \) the indifferent customer is \( x^* = 1/(2 - a) \), customers located to the left of \( x^* \) prefer \( B_1 \), while customers to the right of \( x^* \) prefer \( B_2 \). Thus we will have 2 coalitions: coalition 1 comprising \( B_1, A_2 \), and customer \( x < x^* \), coalition 2 comprising \( B_2, A_2 \), and customer \( x > x^* \), and coalition 3 comprising \( A_1 \). The value created by each coalition is the following:

\[
\begin{align*}
v_1 &= v\{B_1, A_2, C'^{x<x^*}\} = \int_0^{x^*} V(1 + R)(1-x)dx = V(1 + R) \frac{3 - 2a}{2(2 - a)^2}, \\
v_2 &= v\{B_2, A_2, C'^{x>x^*}\} = \int_{x^*}^{1} V(1 + R) \frac{(x-a)}{1-a} dx = V(1 + R) \frac{(3 - 2a)(1-a)}{2(2 - a)^2}, \\
v_3 &= v\{A_1\} = 0.
\end{align*}
\]

Based on Montez et al. (2017), the first order competitive intensity of actor \( i \) is determined as:

\[
w^*_i = av_i(C'^*_i),
\]

where \( C'^*_i \) is a coalition other than \( i \)'s focal coalition where \( i \) adds the most value. \( w^*_i \) determines the lower boundary of \( i \)'s payoff, while \( w^*_{-i} \) determines the upper boundary of the \( i \)'s payoff, where

\[
w^*_{-i} = \min(v\{i, j\} - \sum_{j \neq i} w^*_j, av_i),
\]

where \( j \) stands for actors in \( i \)'s coalition, and \( v\{i, j\} \) represents the value created by \( i \)'s coalition.
The upper boundary $w^*_{i}$ implies the $i$ will have to pay to other actors in its coalition what is their due according to the first order competitive intensity, but not more than $i$’s added value in its coalition.

We will thus determine $w^*_{i}$ for each actor in each coalition in our model. Let us start with coalition 1. Adding any actor from coalition 1 to coalition 3 (comprising of $A_1$) will not create any value because $v\{A_j\} = 0$ (add-on and base cannot create value without customer, and add-on cannot create value for customer without a base). Adding $B_1$ to coalition 2 results in $AV(B_1) = 0$ because customer $x > x^*$ prefers $B_2$. Since $A_2$ is already in coalition 2 there is no additional value created either. By contrast, adding customer $x < x^*$ to coalition 2 does create value. Specifically, $B_2$ cannot create value with $x < a$, but, together with $A_2$ it can create $V(1+R)\frac{x-a}{1-a}$ for $a < x < x^*$. Therefore we have

$$w^*_{C\in[0,x^*]} = \int_0^a 0dx + \int_a^{x^*} V(1+R)\frac{x-a}{1-a}dx = V(1+R)\frac{(1-a)^3}{2(2-a)^2}. $$

For coalition 1 we have:

$$w^*_{C\in[0,x^*]} = V(1+R)\frac{(1-a)^3}{2(2-a)^2},$$

\[
\begin{align*}
    w^*_{B_1} &= 0,
    w^*_{B_A} &= 0,
    w^*_{-C\in[0,x^*]} = min[\{v1 - (w^*_{B_1} + w^*_{A_2}), av_{C\in[0,x^*]}\}] = V(1+R)\frac{3-2a}{2(2-a)^2},
    w^*_{-B_1} = min[\{v1 - (w^*_{-C\in[0,x^*]} + w^*_{A_2}), av_{B_1}\}] = V(1+R)\frac{1+a-a^2}{2(2-a)},
    w^*_{-A_2} = min[\{v1 - (w^*_{-C\in[0,x^*]} + w^*_{B_1}), av_{A_2}\}] = V(1+R)\frac{1+a-a^2}{2(2-a)}.\end{align*}
\]

We do a similar exercise with coalition 2. Adding either $B_2$ or $A_2$ to coalition 1 does not lead to any added value by either actor. Adding customer $x > x^*$ to coalition 1 allows to create
\[ V(1 + R)(1 - x). \] Thus we have

\[ w^*_C \in [x^*,1] = \int_{x^*}^{1} V(1 + R)(1 - x) \, dx = V(1 + R) \frac{(1 - a)^2}{2(2 - a)^2}. \]

Thus for coalition 2 we have:

\[ w^*_C \in [x^*,1] = V(1 + R) \frac{(1 - a)^2}{2(2 - a)^2}, \]

\[ w^*_{B_2} = 0, \]

\[ w^*_{A_2} = 0, \]

\[ w^*_{-C} \in [x^*,1] = \min[v2 - (w^*_{B_2} + w^*_{A_2}), av_C \in [x^*,1]] = V(1 + R) \frac{(3 - 2a)(1 - a)}{2(2 - a)^2}, \]

\[ w^*_{-B_2} = \min[v2 - (w^*_{C} \in [x^*,1] + w^*_{A_2}), av_{B_2}] = V(1 + R) \frac{1 - a}{2(2 - a)}, \]

\[ w^*_{-A_2} = \min[v2 - (w^*_C \in [x^*,1] + w^*_{B_2}), av_{A_2}] = V(1 + R) \frac{1 - a}{2(2 - a)}. \]

Finally, it is obvious that adding \( A_1 \) to any coalition will not result in added value as \( A_2 \) will always be preferred.

Summing up, we have

\[ w^*_C = V(1 + R) \frac{(1 - a)^2}{2(2 - a)}, \]

which is the amount that the customer is guaranteed to appropriate, whereas other players do not have anything guaranteed based on the first order competitive intensity:

\[ 0 < \pi_{B_1} < V(1 + R) \frac{1 + a - a^2}{2(2 - a)}, \]

\[ 0 < \pi_{B_2} < V(1 + R) \frac{1 - a}{2(2 - a)}, \]

\[ V(1 + R) \frac{(1 - a)^2}{2(2 - a)} < \pi_C < V(1 + R) \frac{3 - 2a}{2(2 - a)}, \]

\[ \pi_{A_1} = 0. \]
Note that the upper limits for $B_1$ and $B_2$ correspond to the their added value in the overall coalition.

Calculating second order competitive intensity does not yield any interesting results for the following reason. In Montez et al. (2017) the second order competitive intensity is calculated as the maximum possible

$$s_i^* = av_i(i \cup X \setminus j) - [av_j(X) - \max(w_j^*, v\{j\})].$$

The first part is the added value that $i$ brings to coalition $X$ if $i$ substitutes $j$ in coalition $X$. Yet this amount needs to be net of the net benefit that $j$ brings to other actors in $X$. This is the second part of the formula: the added value of $j$ to the network $X$ net of what actors in $X$ will have to pay at the very least to $j$ (which is either what is due to $j$ from its first order competitive intensity, or what $j$ can create on its own). From the formula we can see that even if $i$ adds less value to $X$ compared to $j$, but $X$ has to pay to $j$, then $s_i$ can be positive. In other words, $s_i$ represents what $X$ will be willing to pay to $i$ in order for $i$ to substitute $j$ given value creating capabilities of $i$ and the payment that $X$ has to make to $j$.

From the above we know that the actors from other coalitions have lower added value compared to the actors that they substitute. For coalition 2 substituting $B_2$ with $B_1$ will result in $av_{B_1} < av_{B_2}$ in that coalition; similarly, $av_{B_2} < av_{B_1}$ in coalition 1. Given that $w_{B_1}^* = 0$ and $v\{B_1\} = 0$ we have $s_{B_1}^* = s_{B_2}^* = 0$.

Because $A_2$ is already present in both coalitions 1 and 2 we cannot substitute it. Substituting customer from coalition 2 with customer from coalition 1 will result in $av_{C \in [0,x^*]} = V(1 + R)\frac{a}{1-a}$, which is precisely $w_{C \in [0,x^*]}^*$. Given that $v\{C\} = 0$ and $w_C^* > 0$ we will have

$$s_{C \in [0,x^*]}^* = w_{C \in [0,x^*]}^* - (av_{C \in [x^*,1]} - w_{C \in [x^*,1]}^*) < w_{C \in [0,x^*]}^*,$$

because $av_{C \in [x^*,1]} - w_{C \in [x^*,1]}^* > 0$.

For these reasons we cannot get further insights with second order competitive intensity.
Value split between the base and the add-on

We have now determined how the value is split between the customer and the bundles $A_2B_1$ and $A_2B_2$. We will now calculate the payoffs of each product in the base and the add-on component. From the first order intensity analysis we know the minimum payoff guaranteed to the customer. The remaining part is to be bargained between the customer, the base and the add-on. Let us assume that the customer’s confidence index (or customer’s bargaining power) $\alpha_C$ is equal to 0, i.e. the customer will be able to capture only the minimum payoff, and the rest is to be split between the add-on and the respective base. We will further assume that the customer is available in the network with $A_1$, which is equal to the assumption that bases $B_1$ and $B_2$ have the option to create value with $A_1$. This way we can concentrate on the dynamic between $A_2$, $B_1$, and $B_2$. Essentially we need to understand how much value capture can be guaranteed to $B_1$ and $B_2$ due to the competition from $A_1$ assuming that the customer gets only the minimum payoff.

We have 3 coalitions: $B_1$ and $A_2$, $B_2$ and $A_2$, and $A_1$. We assume that the customer is available in all coalitions. We have the following value creation (equal to the value that the base and the add-on have to split):

$$v\{B_1, A_2\} = V(1 + R)\frac{1 + a - a^2}{2(2 - a)},$$

$$v\{B_2, A_2\} = V(1 + R)\frac{1 - a}{2(2 - a)},$$

$$v\{A_1\} = 0.$$

If $B_1$ joins $A_1$ for the customer range of $0 < x < x^*$ we will have the following situation. $B_1$ and $A_1$ can create $V(1 - x)$ while $B_2$ and $A_2$ can create $V(1 + R)(x - a)/(1 - a)$. This means that the customer indifferent between $B_1$ and $B_2$ is now located at $x'' = \frac{1 + aR}{2 - a + R}$. The easiest way

---

63This is a reasonable assumption in B2C markets where each individual customer is too small to be able to negotiate with the firm.
to calculate the added value that $B_1$ bring is
\[
w_{B_1}^* = \int_0^{x''} V(1-x)dx + \int_{x''}^1 V(1+R)\frac{x-a}{1-a}dx - \int_a^1 V(1+R)\frac{x-a}{1-a}dx = \frac{V(1+a(1-a+R(2-a)))}{2(2-a+R)}.
\]

Alternatively we can calculate this amount as
\[
w_{B_1}^* = \int_0^a V(1-x)dx + \int_a^{x''} V(1-x) - V\frac{x-a}{1-a}dx.
\]

This way we directly take into account that there is no alternative for $B_1$ for customer $0 < x < a$ and that for $a < x < x''$ the added value of $B_1$ has to take into account the competition from $B_2$. What is left for $A_2$ in coalition 1 is
\[
w_{B_1}^* = v\{B_1, A_2\} - w_{B_1}^* = \frac{VR(3 + R + a(R - 2 - aR))}{2(2 - a)(2 - a + R)}.
\]

Doing a similar exercise with $B_2$ we have the new indifferent customer $x' = \frac{1 + R - ar}{2 + R - a(1 + R)}$. To find the added value of $B_2$ if paired with $A_1$ we have
\[
w_{B_2}^* = \int_0^{x'} V(1+R)(1-x)dx + \int_{x'}^1 V\frac{x-a}{1-a}dx - \int_0^1 V(1+R)(1-x)dx = \frac{V(1-a)}{2(2-a+R(1-a))}.
\]

Or we can take into account the competition of $B_2$ directly and calculate
\[
w_{B_2}^* = \int_{x'}^1 V\frac{x-a}{1-a} - V(1+R)(1-x)dx.
\]

This leaves for $A_2$
\[
w_{B_2}^* = v\{B_2, A_2\} - w_{B_2}^* = \frac{VR(1-a)(3 + R - a(2 + R))}{2(2 - a)(2 - a + R(1-a))}.
\]
To sum up, we have the following range of payoffs in the core:

\[ V(1 + R) \frac{(1-a)^2}{2(2-a)} < \pi_C < V(1 + R) \frac{3-2a}{2(2-a)}, \]

\[ \pi_{A_1} = 0, \]

\[ 0 < \pi_{A_2} < \frac{VR(2 - a^2 + \frac{(1-a)^3}{2-a+R} + \frac{(1-a)^2}{2-a+R(1-a)})}{2(2-a)}, \]

\[ 0 < \pi_{B_1} < V(1 + R) \frac{1+a-a^2}{2(2-a)}, \]

\[ 0 < \pi_{B_2} < V(1 + R) \frac{1-a}{2(2-a)}. \]

If \( \alpha_C = 0 \) then we will have:

\[ \pi_C = V(1 + R) \frac{(1-a)^2}{2(2-a)}, \]

\[ \pi_{A_1} = 0, \]

\[ 0 < \pi_{A_2} < \frac{VR(2 - a^2 + \frac{(1-a)^3}{2-a+R} + \frac{(1-a)^2}{2-a+R(1-a)})}{2(2-a)}, \]

\[ \frac{V(1 + a(1-a + R(2-a)))}{2(2-a+R)} < \pi_{B_1} < V(1 + R) \frac{1+a-a^2}{2(2-a)}, \]

\[ \frac{V(1-a)}{2(2-a+R(1-a))} < \pi_{B_2} < V(1 + R) \frac{1-a}{2(2-a)}. \]

B.2.2 The choice of the add-on producer to be compatible with both bases vs. one base

Using the payoffs calculated in the previous section we can now focus on the decision of \( A_2 \) to be exclusive for \( B_1 \) base. We assume \( \alpha_C = 0 \), and that the customer appropriates only what is guaranteed by the competition, \( \pi_C = V(1 + R) \frac{(1-a)^2}{2(2-a)} \). We further assume that the confidence index of the add-on \( A_2 \) is the same \( \text{vs-à-vis} \) \( B_1 \) and \( B_2 \) (i.e., \( \alpha_{A_2 \text{vs} B_1} = \alpha_{A_2 \text{vs} B_2} \)). We further assume that the cost of being compatible with \( B_1 \) and \( B_2 \) is the same (i.e., \( I_{B_1} = I_{B_2} \)).

We can re-write previous solution using confidence index notation to get a point estimate of
the payoffs of $B_1$, $B_2$, and $A_2$ ($A_1$ gets 0). The payoffs in the first coalition are

$$v\{B_1, A_2\} = V(1 + R) \frac{1 + a - a^2}{2(2 - a)},$$

$$\pi_{B_1} = \frac{V(1 + a(1 - a + R(2 - a)))}{2(2 - a + R)} + \alpha_{B_1} \frac{VR(3 + R + a(R - 2 - aR))}{2(2 - a)(2 - a + R)},$$

$$\pi_{A_2} = (1 - \alpha_{B_1}) \frac{VR(3 + R + a(R - 2 - aR))}{2(2 - a)(2 - a + R)}.$$

For the second coalition value creation and value capture is

$$v\{B_2, A_2\} = V(1 + R) \frac{1 - a}{2(2 - a)},$$

$$\pi_{B_2} = \frac{V(1 - a)}{2(2 - a + R(1 - a))} + \alpha_{B_2} \frac{VR(1 - a)(3 + R - a(2 + R))}{2(2 - a)(2 - a + R(1 - a))},$$

$$\pi_{A_2} = (1 - \alpha_{B_2}) \frac{VR(1 - a)(3 + R - a(2 + R))}{2(2 - a)(2 - a + R(1 - a))}.$$

We will now calculate the payoffs if $A_2$ decides to pursue compatibility with only one base. From prior analysis we know that $A_2$ can create higher value with $B_1$. Assuming that the bargaining power of $A_2$ is similar with both bases then, intuitively, if $A_2$ decides to be compatible with only one base it will be with $B_1$. In other words, the decision for $A_2$ is whether to invest in compatibility with both bases, or with $B_1$ only.

Calculation of payoffs is similar to the scenario where $A_2$ is compatible with both bases. Now $B_1$ and $A_2$ can create $V(1 + R)(1 - x)$ while $B_2$ is paired with $A_1$ and can create only $V(x - a)/(1 - a)$. The customer indifferent between $B_1$ and $B_2$ is denoted by $x' = \frac{1 + R - aR}{2 + R - a(1 + R)}$. We have again two coalitions: $B_1$, $A_2$, and customer $x < x'$ creating

$$v\{B_1, A_2, C^{x < x'}\} = V(1 + R) \frac{(1 + R(1 - a))(3 + R - a(2 + R))}{2(2 - a + R(1 - a))^2},$$

and $B_2$, $A_1$ and customer $x > x'$ creating

$$v\{B_2, A_2, C^{x > x'}\} = V \frac{(1 - a)(3 + 2R - 2a(1 + R))}{2(2 - a + R(1 - a))^2}.$$
Similarly to the baseline scenario calculation we calculate the minimum payoffs guaranteed by the first order competitive intensity for each player. It is equal to 0 for $B_1$ and $B_2$ because if added to another coalition they will be inferior to the other base. For customer in coalition 1 (with $B_1$ and $A_2$) we have

$$w^*_{C \in [0,x']} = \int_0^a 0 dx + \int_a^{x'} V(1 + R) \frac{x - a}{1 - a} dx = V(1 + R)^2 \frac{(1 - a)^3}{2(2 - a + R(1 - a))^2},$$
$$w^-_{C \in [0,x']} = \min[v1 - (w^*_{B_1} + w^*_{A_2}), av_{C \in [0,x']} ] = V(1 + R) \frac{1 + R + a(1 - a - R)}{2(2 - a + R(1 - a))}.$$

For customer in coalition $B_2$ and $A_1$ we have:

$$w^*_{C \in [x',1]} = \int_{x'}^1 V(1 + R)(1 - x) dx = V(1 + R)^2 \frac{(1 - a)^3(3 - a + R(1 - a))}{2(2 - a + R(1 - a))^2},$$
$$w^-_{C \in [x',1]} = \min[v2 - (w^*_{B_2} + w^*_{A_1}), av_{C \in [x',1]} ] = V(1 + R) \frac{(1 - a)(3 + 2R - 2a(1 + R))}{2(2 - a + R(1 - a))}.$$

We will now calculate the payoff of $A_2$ in this scenario. Assuming that the customer only captures what is guaranteed by the competition, what is left in coalition 1 to be split between $B_1$ and $A_2$ is

$$v\{B_1, A_2\} = V(1 + R) \frac{1 + R + a(1 - a - R)}{2(2 - a + R(1 - a))}.$$

Because $B_1$ can also create value with $A_1$, then $B_1$ will be able to capture at least

$$w^*_{B_1} = \int_0^a V(1 - x)dx + \int_a^{x^*} V(1 - x) - V \frac{x - a}{1 - a} dx = \frac{V(1 + a - a^2)}{4 - 2a}.$$

This leaves for $A_2$ the maximum of

$$w^*_{-C \in [0,x']} - w^*_{B_1} = VR \frac{(3 - 2a + R(2 - a)(1 - a))}{2(2 - a)(2 - a + R(1 - a))}.$$
Therefore, the payoffs in coalition 1 would be:\footnote{\textsuperscript{64}We have assumed that since $A_2$ has not invested in compatibility with $B_2$ it can only create 0 if added to $B_2$ network. However, if the decision is taken before the investment is made on can argue that $A_2$ may threaten $B_1$ to invest instead in the compatibility with $B_2$ and thus the added value that $A_2$ brings to the coalition with $B_2$ (the difference between the value creation with $A_2$ and with $A_1$) will be the minimum guaranteed payoff to $A_2$ by $B_1$. If this is the case then the incentives for $A_2$ to be exclusive are higher, even in the absence of investment requirement. In this case it is similar to $A_2$ having limited capacity.}

$$\pi_{B_1} = \frac{V(1 + a - a^2)}{4 - 2a} + \alpha_{B_1}VR\frac{(3 - 2a + R(2 - a)(1 - a))}{2(2-a)(2-a + R(1-a))},$$

$$\pi_{A_2} = (1 - \alpha_{B_1})VR\frac{(3 - 2a + R(2 - a)(1 - a))}{2(2-a)(2-a + R(1-a))}.$$

Therefore $A_2$ will need to compare its payoffs from the two scenarios:

$$\pi_{A_2}^{\text{Compatible with both}} = (1 - \alpha_{B_1})VR\frac{(3 + R + a(R - 2 - aR))}{2(2-a)(2-a + R)} + (1 - \alpha_{B_2})\frac{VR(1 - a)(3 + R - a(2 + R))}{2(2-a)(2-a + R(1-a))} - I_{B_1} - I_{B_2},$$

$$\pi_{A_2}^{\text{Exclusive to } B_1} = (1 - \alpha_{B_1})VR\frac{(3 - 2a + R(2 - a)(1 - a))}{2(2-a)(2-a + R(1-a))} - I_{B_1}.$$

Let us denote $\pi_{A_2}^{\text{with } B_2} = \frac{VR(1-a)(3-R-a(2+R))}{2(2-a)(2-a+R(1-a))}$. Then $(1 - \alpha_{B_2})\pi_{A_2}^{\text{with } B_2} - I_{B_2}$ is the net benefit of $A_2$ from being compatible with $B_2$ in addition to $B_1$, and what $A_2$ would forgo should it decide to be compatible with $B_1$ only. This is what we call the effect on value creation.

Let us denote $b = VR\frac{(3-2a+R(2-a)(1-a))}{2(2-a)(2-a+R(1-a))} - VR\frac{(3+R+a(R-2-aR))}{2(2-a)(2-a+R)} = VR\frac{(1-a)(3-R-a(2+R))}{2(2-a)(2-a+R(1-a))}$, which is the difference in the maximum payoffs that $A_2$ can get in the coalition with $B_1$ when being exclusive to $B_1$ as opposed to being compatible with both $B_1$ and $B_2$. This benefit of exclusivity exists because being exclusive to $B_1$ deprives customers who prefer $B_1$ of the viable substitute bundle ($\{A_2, B_2\}$). This results in a lower value capture by the customers and higher value capture by the bundle $\{A_2, B_1\}$, a portion of which $A_2$ appropriates. This is what we call the effect on value capture.

We can now rewrite the decision of $A_2$: $A_2$ is better off being exclusive if

$$(1 - \alpha_{B_1})b > (1 - \alpha_{B_2})\pi_{A_2}^{\text{with } B_2} - I_{B_2},$$
where \((1 - \alpha_{B_1})^b\) is the effect on value capture, and \((1 - \alpha_{B_2})\pi_{A_2}^{\text{max}(\text{with } B_2)} - I_{B_2}\) is the effect on value creation.

Taking the derivative of the first one (value capture effect) in \(a\) yields

\[
-\frac{VR^2(1-a)^2(1-\alpha_{B_1})(2+R)(3(2+R)^2+(3+R(3+R))(a^2-4a))}{2(2-a)^2(2-a+R)^2(2-a+R(1-a))^2},
\]

and the derivative of the second one (value creation effect) in \(a\) yields

\[
-\frac{(1-\alpha_{B_2})VR(8+R(5+R)-a^2(3+R(3+R))-2a(5+R(4+R)))}{2(2-a)^2(2-a+(1-a)R)^2}.
\]

Solving the equations is complicated, therefore, we provide the solution graphically. Figure 24a shows the derivatives of both effects graphically. We see that both derivatives are negative (in general, for the relevant range of parameters \(V, R, \alpha_{B_1}, \alpha_{B_2},\) and \(a\) the derivatives are negative). This means that both effects are decreasing in \(a\), albeit at a different speed. Specifically, at higher levels of \(a\) the effect on value creation decreases faster than the effect on value capture. This leads to the result observed in the top panels of Figure 7 – at higher levels of \(a\) value capture effect dominates value creation effect, and the producer of \(A_2\) chooses to keep \(A_2\) exclusive to \(B_1\).

At lower levels of \(a\) the effect on value capture decreases faster than the effect on value creation, which explains the convex shape of the former and concave shape of the latter observe in the top panels of Figure 7. This also explains that when the compatibility cost \(I_{B_2}\) increases, therefore pushing the curve of the value creation effect downwards, there is an area when at very low levels of \(a\) value capture effect dominates value creation effect (Figure 7b).

B.2.3 The choice of the broad base producer to develop an exclusive add-on

Let us look now at the choice of the base producers if they can develop their own add-on drugs. We shall start with the producer of the broad base \(B_1\). Let us assume that the producer \(b_1\) of \(B_1\) can also produce an add-on \(A_2\) at the cost \(I\). Then \(b_1\) faces the choice similar to the producer of \(A_2\) in the previous section: should it make \(A_2\) compatible with \(B_1\) only or with both \(B_1\) and \(B_2\). I
will first compare calculate these payoffs, and then compare these payoffs to the case where \( A_2 \) is developed by the add-on producer \( a_2 \).

If \( b_1 \) makes \( A_2 \) compatible with \( B_1 \) only, then we will have the situation as in the previous section when the producer of \( A_2 \) chose to be exclusive with \( B_1 \): coalition 1 with \( B_1, A_2 \), and customer \( x < x' \), and coalition 2 with \( B_2, A_1 \) and customer \( x > x' \). Based on the calculations in the prior section and assuming that the customer gets only what is guaranteed by the competition the value left to \( B_1 \) and \( A_2 \) is

\[
v\{B_1, A_2\} = V(1 + R) \frac{1 + R + a(1 - a - R)}{2(2 - a + R(1 - a))},
\]

however, now that \( b_1 \) produces both \( B_1 \) and \( A_2 \) this value is entirely captured by \( b_1 \), i.e., this is \( \pi_{b_1} \).

If \( b_1 \) makes \( A_2 \) compatible with both \( B_1 \) and \( B_2 \) then we will have the situation as in the previous section when the producer of \( A_2 \) chose to be compatible with both bases: coalition 1 with \( B_1, A_2 \), and customer \( x < x^* \), coalition 2 with \( B_2, A_2 \) and customer \( x > x^* \), and coalition 3 with \( A_1 \). Producer \( b_1 \) will be able to extract the full value left to \( B_1 \) and \( A_2 \) from coalition 1 and a portion of the value creation by \( A_2 \) and \( B_2 \) in coalition 2. From the calculations in the baseline scenario we know that \( b_1 \) will be able to capture in coalition 1 the amount of \( V(1 + R) \frac{1 + a - a^2}{2(2 - a)} \), and from the calculations in previous section we know that \( b_1 \) will be able to capture in coalition 2 a portion of value created with \( B_2 \) equal to \((1 - \alpha_{B_2}) \frac{VR(1 - a)(3 + R - a(2 + R))}{2(2 - a)(2 - a + R(1 - a))}\). Taking into account the cost of compatibility with each base we need to compare the following payoffs for \( b_1 \):

\[
\begin{align*}
\pi_{b_1}^{\text{Compatible with both}} &= V(1 + R) \frac{1 + a - a^2}{2(2 - a)} + (1 - \alpha_{B_2}) \frac{VR(1 - a)(3 + R - a(2 + R))}{2(2 - a)(2 - a + R(1 - a))} - I_{B_1} - I_{B_2}, \\
\pi_{b_1}^{\text{Exclusive to } B_1} &= V(1 + R) \frac{1 + R + a(1 - a - R)}{2(2 - a + R(1 - a))} - I_{B_1}.
\end{align*}
\]

As in the previous section, we shall denote \( \pi_{A_2}^{\text{with } B_2} = \frac{VR(1 - a)(3 + R - a(2 + R))}{2(2 - a)(2 - a + R(1 - a))} \) making \((1 - \alpha_{B_2})\pi_{A_2}^{\text{with } B_2} - I_{B_2}\) the effect on value creation (it is the same as in the previous section). Let
us denote the difference in value capture in coalition 1 as

\[ b' = V(1 + R) \frac{1 + R + a(1 - a - R)}{2(2 - a + R(1 - a))} - V(1 + R) \frac{1 + a - a^2}{2(2 - a)} = \frac{VR(1 + R)(1 - a)^3}{2(2 - a)(2 - a + R(1 - a))}, \]

that represents the effect on value capture. Intuitively, \( b' > b \), as \( b' - b = VR \frac{(1-a)^3}{2(2-a)(2+R-a)} > 0 \).

Then \( b_1 \) will choose to develop \( A_2 \) as exclusive to \( B_1 \) if

\[ b' > (1 - \alpha_{B_2}) \pi^{\text{with } B_2}_A - I_{B_2}. \]

From the previous section we know the derivative of the value creation effect in \( a \). Taking the derivative of \( b' \) in \( a \) yields

\[ -\frac{VR(1-a)^2(1+R)(8+3R+a(6-a+R(4-a)))}{2(2-a)^2(2-a+R(1-a))^2} < 0, \]

as \( 0 < a < 1 \).

Mapping the two derivatives results in a picture similar to the case of the add-on producer (Figure 24b): both effects decrease in \( a \), but the effect on value creation decreases faster.

**B.2.4 The choice of the narrow base producer to develop an exclusive add-on**

Now we shall look at the choice of base producer \( b_2 \) who is the owner of the narrow base \( B_2 \). Let us assume that producer \( b_2 \) of \( B_2 \) can also produce an add-on \( A_2 \) at the cost \( I \). The choice is whether to make it exclusive to the base \( B_2 \) or compatible with both \( B_1 \) and \( B_2 \).

If \( b_2 \) develops an exclusive \( A_2 \) then \( B_1 \) and \( A_1 \) will only be able to create \( V(1-x) \), while \( B_2 \) and \( A_2 \) will be able to create \( V(1+R)(x-a)/(1-a) \). The customer indifferent between \( B_1 \) and \( B_2 \) is denoted by \( x'' = \frac{1+ar}{2-a+R} \). We have two coalitions: coalition 1 with \( B_1, A_1 \) and customer \( x < x'' \) creating

\[ v\{B_1, A_1, C^{x<x''}\} = V \frac{(1+aR)(3+2R-a(2+R))}{2(2-a+R)^2}, \]
and $B_2$, $A_2$, and customer $x > x''$ creating

$$v\{B_2, A_2, C^{x>x''}\} = V(1 + R)^2 \frac{(1 - a)(3 + R - 2a)}{2(2 - a + R)^2}.$$  

We calculate the the minimum payoffs guaranteed to the customer by the first order competitive intensity. For $B_1$ and $B_2$ this is 0 because if added to another coalition they will be inferior to the other base. For customer in coalition 1 (with $B_1$ and $A_1$) we have

$$w^*_{C \in [0,x''']} = \int_0^a 0dx + \int_a^{x''} V(1 + R) \frac{x - a}{1 - a} dx = V(1 + R) \frac{(1 - a)^3}{2(2 - a + R)}.$$  

$$w^{-C}_{C \in [0,x''']} = \min [v1 - (w^*_{B_1} + w^*_{A_2}), av_{C \in [0,x''']} ] = V(1 + aR)(3 + 2R - a(2 + R)) \frac{(1 - a)(3 + R - 2a)}{2(2 - a + R)^2}.$$  

For customer in coalition $B_2$ and $A_2$ we have:

$$w^*_{C \in [x'',1]} = \int_{x''}^1 V(1 - x) dx = V(1 + R)^2 \frac{(1 - a)^2}{2(2 - a + R)^2},$$  

$$w^-_{C \in [x'',1]} = \min [v2 - (w^*_{B_2} + w^*_{A_2}), av_{C \in [x'',1]} ] = V(1 + R)^2 \frac{(1 - a)(3 + R - 2a)}{2(2 - a + R)^2}.$$  

Assuming that the customer only captures what is guaranteed by the competition, what is left for $B_2$ and $A_2$ is

$$v\{B_2, A_2\} = V(1 + R)^2 \frac{(1 - a)}{2(2 - a + R)},$$  

which will be fully captured by $b_2$ as the sole producer of both $B_2$ and $A_2$.

If $b_2$ chooses to develop $A_2$ as compatible with both $B_1$ and $B_2$ the situation will be similar to that of the baseline case: coalition 1 with $B_1$, $A_2$ and customer $x < x^*$, coalition 2 with $B_2$, $A_2$ and customer $x > x^*$, and coalition 3 with $A_1$. Producer $b_2$ will be able to extract the full value left to $B_2$ and $A_2$ in coalition 2, and a portion of the value left to $B_1$ and $A_2$ in coalition 1. From the calculations in the baseline scenario we know that $b_2$ will be able to capture in coalition 2 the amount of $V(1 + R)^2 \frac{1-a}{2(2-a)}$, and it will be able to capture a portion of value creation with $B_1$ equal to $(1 - \alpha B_1) \frac{VR(3+R+a(R-2-aR))}{2(2-a)(2-a+R)}$. Taking into account the cost of compatibility with each base we
need to compare the following payoffs for \( b_2 \):

\[
\pi_{b_2}^{\text{Compatible with both}} = V(1 + R) \frac{1 - a}{2(2 - a)} + (1 - \alpha_{B_1}) \frac{V R(3 + R + a(R - 2 - aR))}{2(2 - a)(2 - a + R)} - I_{B_1} - I_{B_2},
\]

\[
\pi_{b_2}^{\text{Exclusive to } B_1} = V(1 + R)^2 \frac{(1 - a)}{2(2 - a + R)} - I_{B_2}.
\]

As in the previous sections, we shall denote \( \pi_{A_2}^{\text{with } B_1} = \frac{V R(3 + R + a(R - 2 - aR))}{2(2 - a)(2 - a + R)} \) making \( (1 - \alpha_{B_2})\pi_{A_2}^{\text{with } B_1} - I_{B_1} \) the effect on value creation (what \( b_2 \) can make from the coalition 1). Let us denote the difference in value capture in coalition 2 as

\[
b'' = V(1 + R)^2 \frac{1 - a}{2(2 - a + R)} - V(1 + R) \frac{1 - a}{2(2 - a)} = V R \frac{(1 + R)(1 - a)^2}{2(2 - a)(2 - a + R)}.
\]

Then \( b_2 \) will choose to develop \( A_2 \) as exclusive to \( B_2 \) if

\[
b'' > (1 - \alpha_{B_1})\pi_{A_2}^{\text{with } B_1} - I_{B_1}.
\]

Taking the derivative of \( b'' \) (value capture effect) in \( a \) yields

\[
- \frac{V R(1 + R)(1 - a)(4 - 2a + R(3 - a))}{2(2 - a)^2(2 - a + R)^2} < 0,
\]

as \( 0 < a < 1 \). Taking the derivative of \( (1 - \alpha_{B_2})\pi_{A_2}^{\text{with } B_1} - I_{B_1} \) (value creation effect) in \( a \) yields

\[
\frac{(1 - \alpha_{B_1}) V R(1 - a)(4 - 2a + R(3 - a))}{2(2 - a)^2(2 - a + R)^2} > 0,
\]

as \( 0 < a < 1 \). Therefore, value capture effect decreases in \( a \) while value creation effect increases in \( a \). This explains why when mapping each effect (Figure 7d) at high levels of \( a \) value creation effect dominates value capture effect.
Figure 24: Derivatives of value creation effect and value capture effect in $a$

B.3 Product data analysis

We use the sample of 893 patients over 2004-2016. For each patient we constructed a choice set of 186 potential drug combinations resulting in 138,999 patient-combination dyads (choice set is smaller for earlier years as a number of drugs were not available then). We constructed the choice set by using all combinations mentioned in the French medical guidelines since 2002. We assigned the remaining combinations that patients consumed to several categories depending on the base drug.

Dependent variable. Our dependent variable is Choice, a binary variable taking a value of 1 if the patient chose the given combination, and 0 otherwise.

Independent variables. An attractive feature of the French HIV market is the existence of national HIV guidelines, which are developed by a group of medical experts based on the evidence from clinical trials and are frequently updated. They identify a set of recommended combinations of drugs based on the comparative efficacy and safety. We use these recommendations as proxies for value creation by the combination. During the period of our sample the guidelines were updated in 2004 (the update of 2002 guidelines), 2006, 2008, 2009, 2010, 2013, and 2014. The two main independent variables are HighValue, a binary variable equal to 1 if the combination is rec-
ommended by the guidelines relevant for the given year, and HighValueAddOn, a binary variable equal to 1 if the combination contains an add-on drug that is a part of at least one combination recommended by the guidelines relevant for the given year (i.e. the add-on drug is recommended by the guidelines, but together with a different base drug). We know the year and the month of the guidelines publication, and we assume that the information is known in the month following the month of the publication.

We then create three indicator variables for each of the three main bases: TenoEmtri, AbaLami, and ZidoLami, which take the value of 1 if the combination contains the corresponding base drugs.

Control variables. We use control variables at the patient and the combination level.

Combination-level controls: we control for the cases when all drugs in the combination are owned or developed by the same firm, as firms may exercise higher marketing effort to convince prescribers to use all their drugs as combination. Originally we create two indicator variables: SameFirmMarketAuth equal to 1 if all drugs in a given combination have the same market authorization holder in France (in other words, the firm that commercializes the drug in France), and SameFirmDeveloper equal to 1 if all drugs in a given combination were developed by the same firm (i.e. the same firm conducted clinical trials on all drugs in the combination). The former variable reflects marketing effort, while the latter reflects portfolio considerations of the firms.\textsuperscript{65} However, we found that the two variables have an extremely high correlation (0.934), therefore we chose to include only SameFirmMarketAuth in order to account for the marketing effort.

We control for the cases when two of three drugs are integrated into a single pill with IntegratedTriplet equal to 1 if the whole combination is a single pill, and IntegratedDuplet equal to 1 if the two base drugs in the combination are a single pill. We also control for drug uptake, with NewDrug equal to 1 if at least one drug in a combination has been approved in France for commercialization in a given year or in a previous year (assume 2 years needed for drug uptake). Finally,

\textsuperscript{65}In case of combinations containing generic drugs, there are two combinations that consist of drugs produced by the same firm (Mylan), and for these combinations both variables are coded as 1 (while Mylan, naturally, did not conduct clinical trials on the molecules, the idea of SameFirmDeveloper variable is to reflect portfolio ownership, rather than trial experience). All other combinations containing generic drugs do not have same ownership in any form.
with *GenericDrug*, we control for whether in the given year at least one drugs in the combination is generic.

*Patient-level controls:* The choice of treatment is highly patient-specific. The doctor narrows down the list of potential drugs by taking into account the other pathologies that the patient might have (especially, co-infection), side effects, and patient lifestyle. We thus attempt to account for the major patient-level characteristics which affect the likelihood of selection of certain anti-HIV drugs. Using the data on drug consumption data and diagnostic tests for the HIV patients in our sample we control for patients having Hepatitis B, Hepatitis C, depression and cardiovascular risk.

*Econometric model.* Our unit of observation is patient-combination-year, and the dependent variable is binary. We use conditional logistic regression grouping observations at patient level, with errors clustered at prescriber level.

**B.3.1 Results**

Table 20 shows the results of yearly logistic regression models. We find that in 2004-2006 the coefficient on *HighValueAddon* is actually negative, meaning that the combination is less likely to be chosen if it contains a recommended add-on drug. Then in 2007-2010 the coefficient becomes positive, but largely non-significant, until a “jump” in 2011 when is becomes positive, significant, and of size comparable to other coefficients within the respective models. We interpret this change as the evolution of guidelines: in earlier years virtually all add-on drugs were included in the recommended set, therefore being recommended provided little differentiation, while in late 2000 only a few selected add-on drugs (mostly second and third generation drugs) were recommended. In Figure 25a we map the average marginal effects of *HighValueAddon* on the probability of the combination to be selected for each of the yearly logistic regressions, and we can clearly observe the upward trend, and the “bump” that occurs in 2011. It shows that, in a manner of speaking, it became more valuable to be a high-value add-on after 2011.
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**Standard errors clustered at prescriber’s level in parentheses, *p < 0.1, **p < 0.05, ***p < 0.01**
Table 20 also allows to observe the evolution of the consumption of different base drugs. Coefficient for *zidovudine+lamivudine* is positive and significant for 2006-2007 (although not necessarily different from the coefficients for other bases), then it becomes quite small compared to other coefficients and loses its significance, while in the most recent years it has significant negative coefficient, likely reflecting the complete abandonment of the molecule in favor of *tenofovir+emtricitabine* and *abacavir+lamivudine*. *Tenofovir+emtricitabine* experiences the uptake in 2004-2006 (already in 2006 the coefficient is positive, significant, and comparable to that for *zidovudine+lamivudine*), and since then it is consistently positive, significant and large compared to other coefficients within the respective models. Comparing coefficients for *tenofovir+emtricitabine* with those for *abacavir+lamivudine*, the latter is usually smaller and often not statistically significant, notably after 2013. Figure 25 graphs average marginal effects for *tenofovir+emtricitabine* (right-hand panel) and *abacavir+lamivudine* (left-hand panel) on the probability of the combination to be selected for each regression (we exclude the year 2004 as no patient in that year used either *tenofovir+emtricitabine* or *abacavir+lamivudine* as their first choice). We can see that across the years combinations that included *tenofovir+emtricitabine* had in the range of 20% -30% higher likelihood to be selected as the first choice treatment, whereas for *abacavir+lamivudine* the effect was more around 10% across the years, in most cases it was not statistically significant. Overall, these results support our premise that *zidovudine+lamivudine* used to be a superior actor in earlier years, with that role taken over by *tenofovir+emtricitabine*, while *abacavir+lamivudine* remained a weaker base, especially in recent years.

We obtained similar results when we used *HighValue* instead of *HighValueAddon*. 
Figure 25: Average marginal effects on the probability of drug combination choice in naive patients across years

(a) HighValueAddon

(b) tenofovir+emtricitabine

(c) abacavir+lamivudine
Titre : La stratégie d'écosystème dans l'ombre des acteurs à but non lucratif

Mots clés : Écosystème; compléments; non lucratif; la création de valeur; capture de valeur; pharmaceutique

Résumé : Ma thèse porte sur les questions liées à la création de valeur et à la capture de valeur dans les écosystèmes d'entreprise. J'explore comment les acteurs à but non lucratif et à but lucratif façonnent ces écosystèmes et leur évolution à travers la conception de relations avec des compléments clés. Le premier chapitre utilise un modèle formel pour étudier comment un acteur à but non lucratif, en interagissant de manière stratégique avec les entreprises, peut faciliter la création de valeur dans les chaînes d'approvisionnement verticales. Le deuxième chapitre étudie les stratégies utilisées par les entreprises pour façonner l'écosystème dans lequel elles se font concurrence et maximiser la capture de valeur. Plus précisément, j'examine la décision des entreprises de rendre leur produit compatible avec de multiples compléments ou de le garder exclusif d'un complément spécifique dans le contexte du marché des médicaments anti-VIH. J'utilise un ensemble de données exclusif sur la consommation de médicaments au niveau individuel, obtenu auprès de l'assurance maladie nationale française, ainsi que des données collectées manuellement sur les essais cliniques de médicaments anti-VIH.

Le troisième chapitre jette un pont entre les deux premiers chapitres et explore la manière dont les acteurs à but non lucratif façonnent activement l'écosystème en comparant les essais cliniques sur les médicaments anti-VIH parrainés par des entreprises et par des organismes à but non lucratif. Pour conclure, je cherche à comprendre comment les entreprises peuvent maximiser la création de valeur et la capture de valeur dans les contextes où les produits complémentaires sont importants. Je m'efforce d'inclure les acteurs à but non lucratif en tant que partie intégrante de l'écosystème et de comprendre comment les actions d'acteurs qui ne cherchent pas à maximiser leurs profits affectent les stratégies des acteurs à but lucratif vis-à-vis de leurs compléments.

Title : Ecosystem Strategies in the Shadow of Nonprofit Actors

Keywords : Ecosystem; complements; nonprofit; value creation; value capture; pharmaceutical

Abstract : My thesis focuses on issues related to value creation and value capture in business ecosystems. I explore how nonprofit and for-profit actors shape these ecosystems and their evolution through the design of relationships with key complements. The first chapter uses a formal model to study how a nonprofit actor, by strategically interacting with firms, can facilitate value creation in vertical supply chains. The second chapter studies the strategies that firms employ to shape the ecosystem they compete in and maximize value capture. Specifically, I look at firms’ decision regarding whether to make their product compatible with multiple complements or keep them exclusive for a specific complement in the context of anti-HIV drug market.

I use a proprietary individual-level dataset on drug consumption obtained from the national French healthcare insurance and hand-collected data on clinical trials of anti-HIV drugs. The third chapter bridges the first two chapters and explores how nonprofit actors actively shape the ecosystem by comparing firm-sponsored and nonprofit-sponsored clinical trials on anti-HIV drugs. To conclude, I seek to understand how firms can maximize value creation and value capture in the contexts where complementary products are important. I strive to include nonprofit actors as an integral part of the ecosystem and understand how the actions of actors who do not seek to maximize profit affect the strategies of for-profit actors towards their complements.