Taxation of a Monopolist Digital Platform*

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Abstract

This paper investigates the consequences of taxation on the choice of business model of a digital two-sided monopolistic platform that provides services to users and offers targeted advertising possibilities to sellers, based on the collection of users' personal data. The paper investigates in particular the proposal of a tax on data collection, which has been proposed in the French context by Collin & Colin (2013), and proves that a tax competition effect between this tax and the VAT prevents from increasing fiscal revenues for high values of the VAT rate. The paper shows that under a supermodularity condition on the platform's profit function absent any tax, any specific tax faces the same limitation while *ad valorem* taxes may increase fiscal revenues irrespective of the VAT rate.

1 Introduction

Besides its role as the source of technical and organizational changes and as one of the main engines of growth, what is known as the Digital Economy has also become a major concern for governments, in particular public and fiscal authorities. The major companies in the digital economy are as of today the most profitable firms in the global economy. In 2014, Google earned revenues of $16.52 billion, a 20% rise over 2013. Facebook's stock value has more than doubled since its initial public offering in 2012, reaching $215 billion in January 2015. Yet, these giant companies are well-known for their low effective rate of taxation and for their ability to design worldwide fiscal strategies to exploit fiscal competition internationally and evade taxation.

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Following the financial crisis, governments faced with severe budget constraints have launched several initiatives to be able to capture a larger part of the digital value creation. OECD published a report on the Base Erosion and Profit Shifting Project, whose aim was to prevent the transfer of profits to low corporate tax entities.[1] As of January 2015, VAT on e-services will follow the destination principle.[2] More specifically, in 2013, a French expert mission on the taxation of the digital economy, known as the Colin-Collin report (2013), has drawn a tax project on data tracking.

As it appears in the OECD report, "*the digital economy and its business models present some key features which are potentially relevant from a tax perspective. These features include mobility, reliance on data, network effects, the spread of multi-sided business models, a tendency toward monopoly or oligopoly and volatility.*" Our paper proposes a model of the digital economy that takes explicitly into account several of these features: platforms have two-sided business models, they rely critically on data collection and they have market power. This model is then used to assess some impacts of a various taxes that have been proposed so as to target implicitly dominant digital platforms, in particular we will evaluate the possibility of a tax on data collection in the spirit of Colin-Collin (2013).

We develop a model in which a dominant (monopolistic) digital platform provides services to users and sell advertising slots to online sellers. Web-users get potential benefits from being targeted with relevant advertising, that is, advertising for products that meet their needs. Online sellers benefit from the large audience of the platform, particularly when this platform relies on personal data, collected on each user, that help it provide a better targeting technology and therefore more efficient advertising campaigns for sellers. These features characterize a two-sided business model.[3]

Many observers suggest that this type of business model implies that most of the value created by a digital platform comes from the data input that is provided by users, an input that is free for the platform. This view has led Colin-Collin (2013) to propose specific taxes on data collection and usage. Indeed, a small tax on data collection borne

[1] See OECD (2014).

[2] See, among others, the reports written for the French Conseil National du Numérique (2013), for the EC (Gaspar et al., 2014), and for HM Treasury (2014).

[3] General references on two-sided markets include Caillaud and Jullien (2003), Rochet and Tirole (2003) and Armstrong (2006). Papers more specifically focused on advertising-based business models include Anderson and Coate (2005) and Peitz and Valletti (2008).

by the platform has no direct impact on the "price of data", which is equal to zero; the fiscal base is insensitive to the tax rate and a tax on data would seem to be adequate to capture part of the platform's profits. However, taking into account the two-sided nature of platforms changes the picture radically and we show how a tax on data collection impacts the market for advertising and ultimately reduces the volume of transactions generated by targeted advertising. As a result, a tax competition effect kicks in between a tax on data and VAT proceeds. Moreover, platforms who charge users for their base services may also respond to a tax on data by changing users' registration or subscription fees.

Since advertising is the main source of revenue of major digital platforms, it may also be legitimate to consider a tax on online advertising revenues, a possibility that has been much fought against by professionals in advertising. An *ad valorem* tax on advertising seems to be superior to a tax on data since it is actually neutral in a model where the platform is free for users and does not support significant variable costs. But if the platform follows a more balanced business model, charging a subscription fee on users and a price on advertising, the same tax competition effect arises for all types of taxes whenever the platform responds to the tax by increasing prices on both sides of its activities. The critical point, however, is that even if the platform's objective function is well behaved, i.e., supermodular with respect to its prices, it may react to the introduction of an *ad valorem* tax on advertising by decreasing either the advertising price, or subscription fees, or even both. In such a case, the tax competition effect disappears and *ad valorem* taxes dominate other forms of taxes with respect to fiscal revenues.

Our paper contributes to clarify the effects of various forms of taxation in a two-sided economy. To our knowledge, there exists no formal analysis of a tax on data collection. Kind et al. (2008), (2010a) and (2010b) are the first articles that analyze taxation in a two-sided setting. They show that *ad valorem* taxes do not necessarily dominate unit taxes as they do in a standard environment in terms of tax revenues or of welfare. By contrast, our model suggests that *ad valorem* taxes may indeed dominate other taxes in terms of tax revenues because they may mitigate the tax competition effect with the VAT. Second, they show most interestingly that the price of a good may decrease with the *ad valorem* tax rate, which is precisely why *ad valorem* taxes may avoid the tax competition effect with the VAT in our model.

The model is presented in Section 2 in some details as it is of independent interest and tractable. In Section 3, we analyze the case of a platform whose access is provided for free to users while in Section 4, we study the more general case in which the platform also charges users a subscription fee. Section 5 proposes an example that illustrates our findings.

2 A platform model relying on personal data

A monopolistic Internet platform, say a dominant content provider, collects personal data on heterogeneous users to provide valuable personalized services to these users and offer the possibility of targeted advertising to a heterogeneous population of sellers. Users care about the amount and the relevance of the ads they receive, and advertisers care about the platform's audience: i.e., this is a two-sided platform. In this economy, all economic activities are subject to a value-added tax (VAT). We will study the introduction of other fiscal instruments: an infinitesimally small tax on data collection, in the spirit of Colin-Collin (2013), as well as more standard (infinitesimally small) specific or *ad valorem* taxes on users' subscription to the platform or on advertising.

Users. Let $x \in [0, X] \subset \mathbb{R}_+$ denote the quantity of personal data that a user (she) decides to disclose to the platform. This quantity is perfectly controlled by the user: it can correspond to the personal information she willingly provides or uploads on the platform, the authorization she gives for her geo-location to be known or for cookies to be used by the platform, the comments and ratings she writes, and more generally her past browsing history on the platform.

The platform offers the consumer a service of value $v(x)$, where $v(.)$ is increasing concave and $v(0) \geq 0$. Moreover, data help the platform perform targeted advertising: we summarize the quality of this service by $\lambda(x)$, the probability per active seller that the user under scrutiny is reached by a relevant ad from this seller, with $\lambda(.)$ increasing concave and $\lambda(0) \geq 0$. By "relevant ad", we mean an ad that induces the user to click, and that can potentially generate a transaction between the seller and the user. We let σ denote the user's expected net surplus of transaction associated with a relevant ad. Users are indexed by θ, their marginal disutility of increasing the amount of personal data they let the platform collect, which we will call the marginal utility of privacy. We assume that θ is distributed according to the c.d.f. $F(.)$, with density $f(.)$, on $[0,1]$.

Online sellers. Online sellers benefit from a relevant match as they can make a transaction with the users who click on their ad. Online sellers pay the platform on a pay-per-click basis, assuming for simplicity that all relevant matches translate into a click, at a unit net price equal to a, with $a \geq 0$.[4] They are characterized by a cost parameter c that determines $\pi(c) = r(c) - \gamma(c)$, the seller's profit in a transaction, equal to the difference between the seller's revenue and the seller's cost, and $s(c)$, the user's net surplus from the transaction. We assume that $\pi(c)$ is decreasing in c.[5] Finally, we assume that the cost parameter c is distributed according to the c.d.f. $G(.)$, with density $g(.)$, on $\mathbb{R}_+$.

Letting t denote the VAT rate, the expected profit of each seller per relevant ad generated is given by $(\pi(c)-a)/(1+t)$, since advertisers are able to reclaim the VAT proceeds on their intermediate consumption (advertising and production costs). It follows that the set of participating sellers on the platform is given by $[0, \bar{c}(a)]$ such that: $\pi(\bar{c}(a)) = a$, so that $\bar{c}(.)$ is decreasing provided that $a < \pi(0)$.

Users' participation. We can now turn to users' participation to the platform. Users' expected surplus of transaction is given by:

$$\sigma(a) = \int_0^{\bar{c}(a)} s(c) dG(c),$$

a decreasing function of a for $a < \pi(0)$. When she participates in the platform, a user of type θ chooses the quantity of data to be collected such that:

$$x(\theta; a) \equiv \arg \max_{0 \leq x \leq X} \left\{ v(x) - \theta x + \lambda(x)\sigma(a) - A \right\},$$

assuming that the platform charges the user a subscription fee $A \geq 0$.[6] Our assumptions

[4]The ad price is non-negative to prevent sellers from generating revenues by fake clicks.

[5]A possible foundation for this model is the following. Users derive utility $u(q) - pq$ when they buy q units at price p in the transaction; their individual demand function is then $d(p) = (u')^{-1}(p)$. A seller will face such a demand whenever it is matched with a user and will charge a monopoly price $p^M(c) = \arg\max_p (p-c)d(p)$. Then, we have $r(c) = p^M(c)d(p^M(c))$, $\gamma(c) = cd(p^M(c))$, $\pi(c) = \max_p (p-c)d(p)$ decreasing in c (envelope theorem), and $s(c) = u(d(p^M(c))) - p^M(c)d(p^M(c))$.

[6]We will normalize subscription charges to be non-negative. In principle, they could be negative to the extent that the platform could provide users with a free additional service. In this model, however, negative subscription fees do not increase the flow of data compared to a null subscription fee. Hence,

imply that $x(0;a) > 0$. We will moreover assume that a user with maximal marginal utility for privacy does not accept maximal collection of her personal data, i.e., $v'(X) + \lambda'(X)\sigma(0) < X$, so that $x(1;a) < X$. Given our assumptions, $x(\theta;a)$ is unique and, when interior, it decreases in both its arguments. The maximized utility is a decreasing function of θ by the envelope theorem so that we let $\bar{\theta}(A,a)$ denote the maximal element of the set of participating users $[0, \bar{\theta}(A,a)]$, for which the utility of participation is non-negative; whenever interior, $\bar{\theta}(A,a)$ is a decreasing function of both its arguments.

Platform. Let $X(A,a) \equiv \int_0^{\bar{\theta}(A,a)} x(\theta;a)dF(\theta)$ denote the aggregate amount of data collected by the platform, and $\Lambda(A,a) \equiv \int_0^{\bar{\theta}(A,a)} \lambda(x(\theta;a))dF(\theta)$ the total amount of relevant ads and of valuable clicks per participating seller. Note that $G(\bar{c}(a))\Lambda(A,a)$ represents the total amount of ad-generated transactions in the economy. Given the previous assumptions, $X(A,a)$, $\Lambda(A,a)$, $G(\bar{c}(a))\Lambda(A,a)$ and $F(\bar{\theta}(A,a))$ are all decreasing functions of both price instruments in the domain $(A,a) \in (0,1) \times (0,\pi(0))$.

Assuming that the operating costs of the platform are negligible (or independent of the amount of data collected and the number of ads proposed), the platform's profits are given by:

$$\Pi^P(A,a;\phi) = \frac{1}{1+t}\int_0^{\bar{\theta}(A,a)} \left[A + aG(\bar{c}(a))\lambda(x(\theta;a))\right] dF(\theta) - \phi\int_0^{\bar{\theta}(A,a)} x(\theta;a)dF(\theta),$$

where ϕ is the small tax rate on the amount of collected data, that we assume is paid by the platform. It will be convenient to use $\psi = (1+t)\phi$ and

$$\Pi^0(A,a) \equiv AF(\bar{\theta}(a,A)) + aG(\bar{c}(a))\Lambda(A,a), \tag{1}$$

so that the platform's objective function, normalized by $(1+t)$, can be written as: $(1+t)\Pi^P(A,a;\psi) = \Pi^0(A,a) - \psi X(A,a)$.

When considering other forms of taxation paid by the platform, its normalized profits are easily obtained as the difference between $\Pi^0(A,a)$ and the additional fiscal burden equal respectively to $\alpha(1+t)F(\bar{\theta}(A,a))$ for a specific tax on subscriptions, $\tau AF(\bar{\theta}(A,a))$ for an *ad valorem* tax on subscriptions, $\zeta(1+t)G(\bar{c}(a))\Lambda(A,a)$ for a specific tax on advertising and $\beta aG(\bar{c}(a))\Lambda(A,a)$ for an *ad valorem* tax on advertising.

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we discard this possibility.

Fiscal revenues. In order to assess the performance of fiscal instruments, we characterize the total tax proceeds that accrue to the fiscal authority, which are given by:

$$
\begin{aligned}
T &= \frac{t}{1+t}\int_0^{\bar\theta(A,a)} \left[A + R(a)\lambda(x(\theta;a))\right] dF(\theta) + \phi\int_0^{\bar\theta(A,a)} x(\theta;a)dF(\theta) \\
&\equiv \frac{1}{1+t}\left[tB^0(A,a) + \psi X(A,a)\right],
\end{aligned}
$$

where we let $R(a) \equiv \int_0^{\bar{c}(a)} r(c)dG(c)$ denote the total revenue of sellers generated through online advertising, which is a decreasing function of a provided that $a < \pi(0)$, and $B^0(A,a) \equiv AF(\bar\theta(A,a)) + R(a)\Lambda(A,a)$ denote the users' total spending on subscriptions and purchase of goods.

For other forms of taxation, fiscal revenues are equal to the sum of the VAT proceeds and of the additional platform's fiscal burden written explicitly above in the different cases.

3 A users-free platform

Major content-providing platforms such as Google or Yahoo are purely financed by advertising and their access is free for web-browsers. We start our analysis by taking the form of this business model as given and assume that $A = 0$; that is, the platform only generates revenues by charging sellers for their online advertisements.

Note first that given that all users may simply choose not to upload any data, we can consider w.l.o.g. that all of them participate, i.e., $\bar\theta(0,a) = 1$. If it is active, the platform chooses the price of advertising so as to maximize its expected profits net of taxes, so that:

$$a^*(\phi) = \arg\max_{0\le a\le \pi(0)} \left\{aG(\bar{c}(a))\Lambda(0,a) - \psi X(0,a)\right\}. \tag{2}$$

For small enough tax rates, our assumptions guarantee an interior solution and, by Topkis' theorem, $a^*(\psi)$ is an increasing function of the tax rate on data collection, for ψ in a neighborhood of 0. Our first proposition characterizes the effectiveness of a tax on data collection to generate additional fiscal revenues.

Proposition 1 *: In the case of a users-free platform, there exists a critical threshold $\bar t$ for the VAT rate such that the introduction of a small tax on data collection generates* *additional fiscal revenues if and only if $t < \bar{t}$.*

Proof. Computing the effect of an increase in ψ on the fiscal revenues, evaluated at $\psi = 0$, we obtain:

$$(1+t)\left.\frac{dT}{d\psi}\right|_{\psi=0} = X(0, a^*(0)) + t.\frac{\partial a^*}{\partial \psi}(0).\frac{d}{da}\left[B^0(0,a)\right]_{a^*(0)}. \tag{3}$$

Given that $R(a)$ and $\Lambda(0, a)$ are both positive decreasing in a, $\frac{d}{da}\left[B^0(0,a)\right]_{a^*(0)} < 0$ and the result follows since $a^*(\psi)$ increases in ψ, with

$$\bar{t} \equiv X(0, a^*(0)) \left[-\frac{\partial a^*}{\partial \psi}(0).\frac{d}{da}\left[R(a)\Lambda(0,a)\right]_{a^*(0)}\right]^{-1}. \tag{4}$$

■

This result shows that a tax on data collection competes with the VAT, which limits the effectiveness of the introduction of this specific tax to raise fiscal revenues. When the VAT rate is high, this tax competition effect dominates the direct effect on fiscal revenues. The main point is that the tax competition effect does not come from substitution effects within consumers' behavior as is usual in the literature on taxation, but rather from the platform's modified behavior due to its two-sided nature.

Suppose, as a benchmark, that σ were perceived by users as independent of a, i.e., suppose users do not care about the sellers' behavior. Then, users' decisions of participation and of data uploading would be independent of a as well. It follows that, faced with a tax on data collection, the platform would have no means to reduce its tax burden by inducing users to limit their data uploading. In other words, a tax on data collection would not induce any real change in the economy, neither on the volume of data collected, nor on the volume of advertising or on the volume of transactions. A tax on data collection, an inelastic and isolated activity, would then be a good idea.

However, users care about the sellers' behavior on the platform and sellers' behavior is affected by the price of advertising. So, in response to a tax on data collection, the platform can now dissuade users from uploading too many data by increasing the price on advertising, i.e., on the other side of the market. The mechanics is simple: an increase in the price of advertising reduces the number of advertising sellers, hence it reduces the value of uploading data on the platform for users, thereby reducing the volume of data collected, and the number of ad-generated transactions, thereby reducing the VAT proceeds. Therefore, users' participation is now elastic, although in an indirect way, with respect to the tax rate on data collection because of the cross-externality between users and sellers through the platform.

Are there easier ways to raise additional fiscal revenues? First, data not being monetized, there is no other tax base related to data collection that could be used. A specific tax on advertising leads to a similar analysis as the specific tax on data collection: it induces the platform to charge a price for ads that increases with the relevant tax rate and the local effect of the introduction of either taxes exhibits a positive direct effect and the same tax competition effect as in (3) with $\frac{\partial a^*}{\partial \alpha}\Big|_{\alpha=0}$ instead. A large VAT rate makes the introduction of this tax counter-productive in terms of fiscal revenues. When the platform is purely financed by advertising revenues, the last possibility is an *ad valorem* tax on advertising and it induces the platform to maximize a normalized profit equal to $(1-\beta)aG(\bar{c}(a))\Lambda(0,a)$. Consequently, an *ad valorem* tax on advertising is neutral: it does not affect advertising prices, nor the amount of transactions in the economy, and it generates additional fiscal revenues without tax competition effects.

4 Two-sided financing of the platform

Although many major players online have adopted an advertising-financed business model, this is by no means the general rule. Platforms such as Netflix extract revenues from users and platforms such as Spotify extract revenues both from advertisers and from users. Indeed, the choice of a business model should be viewed as endogenous and depending on the business line and the type of services provided, a platform may find it optimal to charge users a subscription fee or to prevent from charging them such a fee. This has been discussed in the literature on two-sided platforms and we have not much to add to it. What we want to illustrate, however, is that both business models exhibit different responses to the introduction of specific taxes on data or on advertising. So, in this section, we will assume that the platform charges users a subscription fee A, on top of charging sellers for advertising, and that the market characteristics are such that the platform find it optimal to have $A > 0$.

With a positive subscription fee, not all users will participate in the platform in general and $\bar{\theta}(A,a)$ may be interior. If it is active, the platform now chooses its prices $(A^*(\psi), a^*(\psi))$ in order to maximize its normalized expected profits $(1+t)\Pi^P(A,a;\psi) = \Pi^0(A,a) - \psi X(A,a)$, where $\Pi^0(A,a)$ is given by (1).

For a small enough tax rate ψ, the platform can guarantee positive profits, which implies that it fixes prices so that there is some users' participation: $\bar{\theta} > 0$. Then, it follows that in a neighborhood of $(A^*(0), a^*(0))$ and $\psi = 0$, $\Pi^P(A,a;\psi)$ has strictly increasing differences in prices (A,a) and ψ. If $\Pi^P(A,a;\psi)$ were supermodular in (A,a) for any ψ in this neighborhood, Topkis' theorem would imply that the platform's optimal prices $(A^*(\psi), a^*(\psi))$ are increasing in the tax rate locally. This remark leads to the following proposition that generalizes Proposition 1.

Proposition 2 *: In the general case of two-sided financing, if the platform charges a subscription fee on users and an advertising price that both increase (at least one of them strictly) in the tax rate ψ, there exists a critical threshold $\bar{t}_\psi$ for the VAT rate such that the introduction of a small tax on data collection generates additional fiscal revenues if and only if $t < \bar{t}_\psi$. A sufficient condition is that the platform's profit function at $\psi = 0$, $\Pi^0(A,a)$, is supermodular in (A,a) in a neighborhood of $(A^*(0), a^*(0))$.*

Proof. Computing the local change in fiscal revenues from the introduction of a small tax on data collection, we obtain:

$$\begin{aligned}(1+t)\frac{dT}{d\psi} \mid_{\psi=0} &= X(A^*(0), a^*(0)) + t.\frac{da^*}{d\psi}(0).\frac{\partial}{\partial a}\left[B^0(A,a)\right]_{A^*(0),a^*(0)} \\ &+ t.\frac{dA^*}{d\psi}(0).\frac{\partial}{\partial A}\left[B^0(A,a)\right]_{A^*(0),a^*(0)}.\end{aligned}$$

Given our assumptions, note first that $B^0(A,a)$ decreases in a so that $\frac{\partial}{\partial a}\left[B^0(A,a)\right]_{A^*(0),a^*(0)} < 0$. Moreover, the FOC for profit maximization by the platform at $\psi = 0$ implies:

$$\frac{\partial}{\partial A}[AF(\bar{\theta}(A,a))]\bigg|_{A^*(0),a^*(0)} = -a^*(0)G(\bar{c}(a^*(0)))\frac{\partial \Lambda}{\partial A}(A,a) \mid_{A^*(0),a^*(0)}.$$

So,

$$\frac{\partial}{\partial A}\left[B^0(A,a)\right]_{A^*(0),a^*(0)} = \left[R(a^*(0)) - a^*(0)G(\bar{c}(a^*(0)))\right]\frac{\partial \Lambda}{\partial A}(A,a) \mid_{A^*(0),a^*(0)}.$$

The sign of this term therefore depends on:

$$R(a^*(0)) - a^*(0)G(\bar{c}(a^*(0))) = \int_0^{\bar{c}(a^*(0))} [r(c) - a^*(0)]dG(c).$$

For participating sellers, it has to be that $r(c)$ is larger than the price-per-click, so that the term above is positive. It follows that :

$$\frac{\partial}{\partial A}\left[B^0(A,a)\right]_{A^*(0),a^*(0)} < 0$$

because $\Lambda(A,a)$ decreases in A. ■

The intuition is very similar to that of Proposition 1. An increase in, say, the tax on data collection induces on the one hand, an increase in the subscription fee so as to reduce users' participation, hence data uploading, and on the other hand, an increase in the price of advertising so as to decrease the users' benefits from targeted advertising and therefore, again, data uploading. Both effects reinforce each other. In the end, they imply an unambiguous decline in the volume of ad-generated transactions and then, a reduction in VAT proceeds. When the VAT rate is high enough, this tax competition effect annihilates the direct tax revenue effect of the introduction of a small tax on data collection.

It should be rather immediate to notice that the introduction of a small tax on subscriptions or on advertising, be it specific or *ad valorem*, gives rise to the same trade-off. If the subscription fee and the advertising price respond positively to an increase in any of these (small) tax rates, there is a tax competition effect that reduces and possibly reverses the positive direct effect of an additional tax.

The key is, however, that in a full two-sided model, the platform's price response may not be monotonically increasing in any tax rate, even assuming $\Pi^0(A,a)$ exhibits strict supermodularity in (A,a). Small specific taxes on advertising or on subscriptions give rise to a platform's profit function that is supermodular in (A,a) and has increasing differences in any of the prices and the tax rate.[7] Proposition 2 therefore has some bite and the sufficient condition therein extends immediately. *Ad valorem* taxes, however,

[7]For a specific tax on advertising, the platform's additional tax burden is equal to $\alpha F(\bar{\theta}(A,a))$ and for the specific tax on subscriptions, it is equal to $\zeta G(\bar{c}(a))\Lambda(A,a)$; in both cases, the cross derivative with respect to one of the prices and the tax rate is negative, so that Π^P has increasing differences in any of the prices and the tax rate.

may trigger different responses by the platform, as seen in the previous section.[8] In the full two-sided platform model, an *ad valorem* tax will not be neutral anymore in general; it may actually induce a decrease in price. In fact, we have:

Claim 3 *: For an ad valorem tax on advertising, the platform's profit function has decreasing differences in a and β (but increasing differences in A and β) around the optimum. For an ad valorem tax on subscriptions, the platform's profit function has decreasing differences in A and τ (but increasing differences in a and τ) around the optimum. Therefore, even if $\Pi^0(A,a)$ were supermodular in (A,a), it may be that the introduction of a small ad valorem tax increases fiscal revenues for any value of the VAT rate t.*

Proof. For an *ad valorem* tax on advertising, we have

$$(1+t)\Pi^P(A,a;\beta) = AF(\bar{\theta}(A,a)) + (1-\beta)aG(\bar{c}(a))\Lambda(A,a).$$

At the optimum, the FOC yields:

$$(1-\beta)\frac{\partial}{\partial a}\left[aG(\bar{c}(a))\Lambda(A,a)\right]_{A^*(\beta),a^*(\beta)} = -A^*(\beta)f(\bar{\theta}(A^*(\beta),a^*(\beta)))\frac{\partial\bar{\theta}}{\partial a}\mid_{A^*(\beta),a^*(\beta)} > 0.$$

It follows that:

$$(1+t)\frac{\partial^2}{\partial\beta\partial a}\left[\Pi^P(A,a;\beta)\right]_{A^*(\beta),a^*(\beta)} = -\frac{\partial}{\partial a}\left[aG(\bar{c}(a))\Lambda(A,a)\right]_{A^*(\beta),a^*(\beta)} < 0.$$

A similar proof holds for the case of a tax on subscriptions.

The possibility evoked in the last part of the proposition is proved by way of the example that follows. ■

In both cases of *ad valorem* taxes, it may therefore be the case that both prices increase, or decrease, or one of them increases while the other decreases with the corresponding tax rate. When the price decrease is strong enough or when both prices decrease, these forms of taxation may generate additional fiscal revenues even for large values of the VAT rate: with respect to public finance, they may therefore be preferable to a tax on data collection.[9] Below, we develop an example in which we can compute precisely and compare these effects.

[8] As noted by Kind *et al.* (2010a) and (2010b).

[9] In case where an *ad valorem* tax induces a price decline so powerful that the volume of uploads increases, this tax also implies an increase in social welfare compared to a tax on data collection.

5 A linear example

This example illustrates the above claim. Assume, on the users' side, that: $v(x) = vx$ and $\lambda(x) = \lambda x$ for $x \in [0,1]$, and that $F(.)$ is uniform on $[0,1]$. For online sellers, assume that consumers have unit demand, that the transaction price $\bar{p}$ is fixed and exogenous. Users obtain the gross surplus $s \leq \bar{p}$ from transacting, and sellers are heterogeneous with respect to their cost c, uniformly distributed on $[0,s]$. It follows that $\pi(c) = \bar{p} - c$ and $\bar{c}(a) = \bar{p} - a$; the number of participating sellers is $n^S(a) \equiv G(\bar{c}(a)) = (\bar{p} - a)/s$ and $\sigma(a) = (s - \bar{p})n^S(a)$.

Since $v(.)$ and $\lambda(.)$ are linear, a participating user θ uploads the maximum amount of data ($x = 1$) if $v - \theta + \lambda\sigma(a) \geq 0$, and no data ($x = 0$) otherwise. A consumer that uploads no data does not obtain any utility, and therefore does not participate. A consumer that uploads the maximum amount of data participates if and only if $v - \theta + \lambda\sigma(a) \geq A$. Therefore, all participating users choose $x(\theta; a) = 1$ and the number of participating users is $n^U(A,a) \equiv \bar{\theta}(A,a) = v + \lambda\sigma(a) - A$.

The platform's profits are given by:

$$\Pi^P(A, a; \psi, \beta) = \frac{n^U(A,a)}{1+t}\left[A - \psi + \lambda a(1-\beta)n^S(a)\right].$$

Focusing on an interior solution, the optimal prices[10] are then

$$\begin{aligned} a^* &= \frac{(2-\beta)\bar{p} - s}{2(1-\beta)}, \\ A^* &= \frac{1}{2}\left[v + \psi + \frac{\lambda(s - \beta\bar{p})}{4s(1-\beta)}\left(3s - (4-\beta)\bar{p}\right)\right]. \end{aligned}$$

This optimum is interior in the neighborhood of $\psi = \beta = 0$ if $\bar{p} \geq s/2$ and $v \in [\lambda(\bar{p} - 3s/4), 2 - \lambda s/4]$.

It is immediate that a^* is independent of ψ but decreases in β, while A^* increases in ψ and also increases in β in the neighborhood of $\beta = 0$. Note that $n^S(a^*) = \frac{(s-\beta\bar{p})}{2s(1-\beta)}$ increases in β while $n^U(A^*, a^*) = \frac{v}{2} + \frac{\lambda(s-\beta\bar{p})^2}{8s(1-\beta)}$ decreases in β: a small *ad valorem* tax on advertising induces an increase in advertisers' participation but a reduction in users' participation and, therefore, in the volume of data collected.

Computing the variations of fiscal revenues with respect to a tax on data and an *ad*

[10]The Hessian matrix is negative definite in the neighborhood of $\psi = \beta = 0$.

valorem tax on advertising in the neighborhood of $\psi = \beta = 0$, we obtain:

$$T(\psi, \beta) = \frac{n^U(A^*, a^*)}{1+t} \left[\psi + \lambda a^* \beta n^S(a^*) + t(A^* + \lambda n^S(a^*)\bar{p})\right]$$

and $\partial T/\partial \psi \leq 0$ for $t \geq \bar{t} = 1 + 4v/(s\lambda)$, as expected from our proposition:[11] a small tax on data collection does not generate additional fiscal revenues for t large enough. Moreover, we obtain:[12]

Claim 4 *: In the example, $\partial T/\partial \beta \geq 0$ for all t if $\bar{p} \leq \frac{8v+3\lambda s}{8v+4\lambda s} s$, i.e. a small ad valorem tax on advertising unambiguously increases tax revenues.*

A small *ad valorem* tax on advertising induces the platform to change the balance of its business model: it reduces revenue extraction from sellers, as advertising revenues are taxed, hence inducing more advertisers' participation on the platform (higher n^S) and higher benefits for users from targeted advertising (higher $\sigma(a^*)$), and it compensates by extracting more surplus from users, which is profitable as targeted advertising has made users more eager to join the platform. Overall, the platform's profits decrease of course, users participate less (smaller n^U) and so fewer data are collected; but more sellers advertise on the platform, which limits the reduction in transactions and in users' welfare.

The VAT proceeds consist of the VAT collected on subscriptions (equal to $\frac{t}{1+t} A^* n^U$) and the VAT collected on transactions (equal to $\frac{t}{1+t} \lambda n^S n^U \bar{p}$). The increase in the subscription fee is partially compensated by the increase in benefits from advertising for users so that $A^* n^U$ actually increase in β; on the other hand, the number of transactions $\lambda n^U n^S$ increases for low values of $\bar{p}$ and decreases for high values of $\bar{p}$,[13] so that overall VAT proceeds always increase when a sizable part of these proceeds comes from VAT on subscriptions, i.e., when $\bar{p}$ is not too large.

[11] More precisely, $\left.\frac{\partial T}{\partial \psi}\right|_{\psi=\beta=0} = \frac{\lambda s + 4v - t\lambda s}{8t+8}$.

[12] We have:

$$\left.\frac{\partial T}{\partial \beta}\right|_{\psi=\beta=0} = \frac{\lambda(2\bar{p} - s)(\lambda s + 4v) + \lambda t\left[s(3\lambda s + 8v) - 4\bar{p}(\lambda s + 2v)\right]}{32(1+t)}.$$

As $2\bar{p} - s \geq 0$ from the assumptions on the interior equilibrium, the term independent of t is positive. Now, the coefficient of t is decreasing in $\bar{p}$, and positive if and only if: $\bar{p} < \frac{8v+3\lambda s}{8v+4\lambda s} s$.

[13] The variations of the number of transactions w.r.t. β are given by:

$$\left.\frac{\partial(n^U n^S)}{\partial \beta}\right|_{\psi=\beta=0} = \frac{1}{16}\left(-3\lambda \bar{p} + v\left(4 - \frac{4\bar{p}}{s}\right) + 2\lambda s\right),$$

which is decreasing in $\bar{p}$, positive for low values of $\bar{p}$ and negative for high values of $\bar{p}$ (and negative at the cutoff $\frac{8v+3\lambda s}{8v+4\lambda s} s$).

6 Conclusion

In this paper, we study the impact on fiscal revenues of taxing a two-sided monopolistic platform offering personalized services to users and targeted advertising possibilities to sellers, based on the collection of users' personal data. We show that the introduction of a small tax on data collection fails to increase fiscal revenues if the VAT rate is high enough, due to a tax competition effect between the tax on data and the VAT. Under a supermodularity condition on the platform's profit function, this result generalizes to any specific tax. However, an *ad valorem* tax on subscriptions or on advertising can raise fiscal revenues, irrespective of the VAT rate.

We have analyzed the impact of taxation on a monopolistic platform. A natural extension would be to introduce platform competition within our framework. For example, an interesting question would be to study the effect of taxation on the market structure of the two-sided market.

References

Anderson, S. and S. Coate (2005): "Market Provision of Broadcasting: a Welfare Analysis", *Review of Economic Studies,* 72(4), 947-972.

Armstrong, M. (2006): "Competition in Two-sided Markets", *RAND Journal of Economics,* 34, 309-328.

Caillaud, B. and B. Jullien (2003): "Chicken and Egg: Competition among Intermediation Service Providers", *RAND Journal of Economics,* 37, 668-691.

Colin, N. and P. Collin (2013): *Mission d'expertise sur la fiscalité de l'économie numérique.*

Conseil National du Numérique (2013): *Concertation sur la fiscalité du numérique,* Report 2013-03.

Gaspar, V., Collin, P., Devereux, M.P., Snabe, J.H., Varrak, T., Walsh, M., and B. Westberg (2014): *Commission Expert Group on Taxation of the Digital Economy Report.*

HM Treasury (2014): "Finance Bill 2015: Diverted Profits Tax", HM Revenue and Custom, December.

Kind, H.J., Koethenbuerger, M. and G. Schjelderup (2008): "Efficiency Enhancing Taxation in Two-sided Markets", *Journal of Public Economics,* 92(5-6), 1531-1539.

Kind, H.J., Koethenbuerger, M. and G. Schjelderup (2010a): "Tax Responses in Platform Industries", *Oxford Economic Papers,* 62(4), 764-783.

Kind, H.J., Koethenbuerger, M. and G. Schjelderup (2010b): "On Revenue and Welfare Dominance of *Ad Valorem* Taxes in Two-sided Markets", *Economics Letters, 104(2),* 86-88.

OECD (2014): "Report on the Tax Challenges of the Digital Economy", Center for Tax Policy and Administration, Committee on Fiscal Affairs, June.

Peitz, M. and T. Valletti (2008): "Content and Advertising in the Media: Pay-TV versus Free-to-air", *International Journal of Industrial Organization,* 26(4), 949-965.

Rochet, J.C. and J. Tirole (2003): "Platform Competition in Two-sided Markets", *Journal of the European Economic Association,* 1, 990-1029.