Increasing the substitution elasticity can improve VAT compliance and social welfare*

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Forthcoming: *Economic Modelling* 2016

DOI: 10.1016/j.econmod.2016.06.005

Abstract. This paper presents a model of Value Added Tax (VAT) evasion in a monopolistically competitive closed economy. The paper shows that an increase in the intra-brand elasticity of substitution can lower output VAT evasion when under-reporting of final sales and input VAT credits occur jointly. Because of the improvement in VAT compliance, equilibrium prices will fall and VAT revenues will rise both in the short and in the long run. Disentangling the love of variety and the elasticity of substitution utility parameters, it turns out that, in a symmetric general equilibrium solution with free entry and exit of firms, an increase in the substitution elasticity is welfare improving when love of variety is not too strong.

Keywords: Monopolistic competition, VAT evasion.

JEL codes: H26, L11

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* Earlier versions of this paper were presented at the EPCS 2011 (Rennes), SIEP 2011 (Pavia) and Shadow 2011 (Münster) conferences. We thank conference participants and Alessandro Santoro for useful discussions. We thank a reviewer for useful comments. We are responsible for any mistake. We gratefully acknowledge MIUR for funding.

1. Introduction

In recent years, several papers have considered the economic implications of different degrees of product market regulation for the performance of market economies (see Fiori et al., 2012 and the references therein cited). Monopolistic competition is a common modelling framework. The academic view is that, in a monopolistically competitive economy with imperfectly competitive labour markets, product market deregulation can increase outputs and the real wage, while lowering prices and unemployment at the same time (but see Eggertsson et al., 2014, for a different view). However, the short-run and long-run effects of deregulation are different depending on whether this is modelled as a reduction in firms' entry costs or as an increase in the degree of substitutability between products. Blanchard and Giavazzi (2003: 891-892) argue that an increase in the degree of product substitutability has beneficial effects in the short run only. As long as the reduction in price mark-ups is temporary, these effects will be washed away by the reduction in the number of firms entering the economy over time following the reduced profit opportunities. For this reason, attempts of increasing competition following this route, rather than by lowering entry barriers that would permanently reduce market rents, "are likely to be partly self-defeating".

The aim of this paper is to show that, if monopolistically competitive firms optimally choose the amount of commodity tax evasion, an increase in the degree of product substitutability has potentially beneficial effects both in the short and in the long runs. More specifically, when commodity taxation takes the form of a Value Added Tax (VAT) under the credit-invoice method, increasing substitutability could lower a firm's VAT evasion permanently. In turn, this would generate a long-run trade off between lowering entry and increasing VAT compliance. The latter effect would provoke lower firm level prices and higher VAT revenues. Consequently, under some conditions, a welfare improvement would be observed.

The explanation for the VAT compliance effect of an increase in the substitution elasticity, which we believe has not been previously investigated in the literature, is based on the "input tax credit" characteristic of the VAT. Under the credit-invoice method, registered taxpayers are obliged to collect and remit to the tax authority the VAT on their sales of goods and services (named *output VAT*). However, they are entitled to a deduction of the VAT they have paid on their own purchases of intermediate goods (named *input VAT*).[1]

[1] If the VAT chain is unbroken, the tax is levied on final sales to consumers and unregistered businesses. The credit-invoice method is universally adopted, but with few exceptions, such as Japan (Ebrill et al., 2001).

This paper hypothesises that, when choosing to evade the VAT by under-declaring their sales to final consumers, monopolistically competitive firms have to give up simultaneously part of the VAT credit they would be able to claim on their own VAT registered purchases of intermediate inputs. Firms behave this way to avoid signalling their evasion activities to the tax authority. To be sure, the tax authority can use the information generated by the input VAT credit returns for deducing the firm actual output sales. If the tax authority observed marked and persistent inconsistencies between output sales and input purchases from an individual firm's VAT record, namely if the observed sales-input ratio were markedly different from what it would expect from similar firms, it would be warned to investigate further by starting an audit. The anticipation of this possibility induces a firm evading the VAT on its sales to simultaneously under-declaring its input VAT credits. This mode of VAT evasion is most likely to be present in countries like Italy, where crosschecking of VAT records submitted by different firms usually occurs during audits and is not automatically available in electronic form. Italian tax authorities can moreover use analytical-inductive methods, including *Sector Studies* that are based on knowledge of input-output coefficients, to prove VAT evasion in court.[2] However, this firm behaviour is also likely to operate in countries where tax authorities use presumptive methods to assess the VAT tax base (Weichenrieder, 2007) or where they use the sales-input ratio as a proxy for suspicion of evasion (Pomeranz, 2015: 2564, on Chile).

VAT evasion in Italy is huge. According to official estimates, it amounts to €38 billion yearly on average for the years 2007-2011. This is roughly 29% of potential VAT revenue according to the tax law and around 2.2% of GDP (*Corte dei Conti*, 2012: 8) against EU-15 averages of 16% and 1.45%, respectively, in 2011 (Taxud, 2013: 29). Nearly 64% of VAT evasion in Italy is due to hidden sales to final consumers (NENS, 2015: 26). Part of this evasion is associated with simultaneous under-declaration or missed registration of input purchases. Official VAT records indeed document a €51 billion gap between taxable sales and taxable purchases in 2011. This difference gives support to the hypothesis that VAT registered businesses under-declare their input purchases, thus giving up part of their input VAT credits as well. The Italian government in fact interprets these data as largely the result of deliberate behaviour by firms willing to hide their output VAT evasion (MEF, 2014: 90; NENS, 2015: 4-7; Santoro, 2015).

[2] For example, Italian tax authorities can produce laundry bills (using the so-called *tovagliometro* or napkin-meter and *lenzuolometro* or bedsheet-meter) in court in order to infer actual business turnover of restaurants and hotels. Since 1993, *Sector Studies* have provided a benchmark to third parties as regards various dimensions of business activity (such as turnover and inputs) for medium and small-sized enterprises (Santoro, 2008).

In this paper, the assumption that monopolistically competitive firms evade their output VAT by simultaneously under-declaring their final sales and their input purchases implies that they will face a trade-off between the benefits from under-reporting (i.e. higher net-of-tax revenues) and the corresponding costs (including the cost of unrecovered VAT on registered input purchases). As we shall see below, an increase in the substitution elasticity will alter the firm's trade-off by raising the cost of unrecovered input VAT. More specifically, for each unit of under-declared final sales, it will turn out that the cost of unrecovered input VAT is proportional to the real producer price of intermediates (namely, the input price-output price ratio). In turn, this real price is an increasing function of the elasticity of substitution. Thus, as the elasticity rises, the firm will report truthfully a larger share of its final sales.

As regards welfare effects, following Bénassy (1996) this paper introduces a distinction between love of variety and substitution elasticity by considering two separate preference parameters in the CES consumption index for differentiated goods of a representative household. From a benevolent government's point of view, it turns out that increasing substitutability unambiguously improves social welfare provided love of variety is not too strong, meaning its parametric value is fixed at or below the one implied by the Dixit-Stiglitz specification of the CES index.

The rest of the paper is organised as follows. Section 2 presents a review of the related literature. Section 3 outlines the model. Section 4 considers the VAT evasion decision by monopolistically competitive firms under free entry and exit, and how increasing the intra-brand substitution elasticity affects this choice, equilibrium and welfare. Section 5 analyses the optimal tax rate with VAT evasion. Section 6 concludes.

2. Related literature

The aim of this section is to review the VAT evasion literature, focussing on those papers that show how the credit-invoice method used to collect the VAT can affect firm choices on tax evasion and compliance. Under the credit-invoice method, at each stage of the production process firms remit to the tax authority the difference between the VAT they have applied on their sales (their "VAT debt" or output VAT) and the VAT they have paid on their input purchases (their "VAT credit" or input VAT). Several authors have shown that this method affects VAT evasion and compliance in different directions, depending on the government's information set, market structure, firm characteristics and VAT design (for example, the presence of registration thresholds). Keen (2008), Boadway and Sato (2009), and de Paula and Scheinkman (2010) present models of competitive economies comprising a formal and an informal sector. Firms operating in the formal sector are VAT compliant, whereas informal sector firms evade the VAT undetected by the tax authorities. The credit-invoice method implies that the VAT on intermediate goods acts as an input tax for informal sector firms. Whereas formal sector firms obtain a VAT credit on their input costs when remitting their output VAT, informal sector firms cannot receive any input VAT credit. More specifically, de Paula and Scheinkman (2010) develop a model with an upstream industry, producing intermediate goods, and a downstream industry, producing final goods.[3] In each industry, low productivity firms choose to operate informally, whereas high productivity firms are VAT compliant. The credit-invoice method stimulates the creation of production chains in which all firms involved are either formal or informal. This is because a client of an informal firm cannot claim input VAT credits, while informal buyers cannot use credits from formal suppliers. The authors test their model on Brazilian data. Their main result is that clients or suppliers of formal firms are more likely to be formal as well. They also find that, when the VAT is charged at a single upstream stage of production and on large-sized formal firms (e.g. producers paying the VAT on tires), smaller downstream firms (e.g. retailers) are more likely to be formal as well.

By taking a different perspective, Pomeranz (2015) tests on Chilean data the idea, which is widely held among practitioners and policy analysts, that the credit-invoice method facilitates tax enforcement relatively to a sales tax because it motivates firms to ask their suppliers for VAT receipts. As long as this generates a paper trail that can be used for tax enforcement, the credit-invoice method should be associated with a "preventive deterrence effect". Namely, firms should evade less with the VAT than a retail sales tax, other things being equal, because they expect that tax evasion is easier to detect when there is a paper trail This "self-enforcing" property of the credit-invoice VAT, however, is absent in business-to-consumer (B2C) transactions, as long as consumers have no incentive to ask for a tax receipt.[4] Thus, if the preventive deterrence effect holds true, one would expect that a credible announcement of an increase in tax monitoring would improve compliance as regards B2C transactions only, not business-to-business transactions, as long

[3] Keen (2008) and Boadway and Sato (2009) focus on the problem of the choice of the commodity tax system for small open developing economies, by comparing the VAT and trade taxes. This analysis is beyond the scope of our paper.

[4] In Italy, consumers are obliged to ask sellers for VAT receipts to avoid fines. However, tax authorities must catch the consumer on the spot. Marchese (2009) discusses the implications of providing different incentives to consumers.

as the former are not covered by a paper trail. Pomeranz (2015: 2560-2562) finds indeed evidence of the preventive deterrence effect. This gives support to the idea that the VAT paper trail acts as a substitute for a firm's own audit probability. Moreover, the evidence shows that an increase in the audit probability on firms suspected of evasion has strong spill-overs of enforcement up the production chain, given that it significantly improves VAT compliance from their input suppliers as well (Pomeranz, 2015: 2564-2565). In other words, considering the whole production chain, the paper trail acts as a complement to the audit probability. This implies that effective VAT enforcement requires the interaction between information generated by the paper trail and deterrence provoked by an increased audit probability.

Liu and Lockwood (2015) study instead the determinants of VAT registration in the presence of a business turnover threshold below which no VAT is legally payable. The threshold creates a "tax notch". This means that, when a firm's business turnover exceeds the threshold, its tax liability jumps discontinuously from zero to a positive amount, given that the VAT rate is applied on all of its sales. These authors consider the UK case, where firms are legally exempted from applying the VAT if they report a yearly business turnover below £82,000 (roughly €114,000) in 2015. They show that the joint phenomena, which are empirically observed in the UK, of voluntary VAT registration for firms with business turnover below the threshold and of bunching of firms producing below the threshold to avoid registration are explained by two features: the share of inputs in total costs (or the cost of inputs relatively to sales) and the proportion of B2C sales over total sales. For given compliance costs, the larger is the share of inputs in total cost or the smaller is the proportion of B2C sales, the more likely is voluntary registration and the less likely is bunching to avoid registration. The former effect occurs because the cost of unrecovered input VAT in case of no registration gets bigger as the share of VAT creditable inputs in total costs increases. The latter effect is explained by the fact that the output VAT cannot be passed through on to non-registered buyers under their model assumptions. But if firms with a large B2C sales share were facing a lower preventive deterrence incentive, one would expect they would evade the VAT to avoid registration as well.

Although the production chain and the "self-enforcing" effects are real-world transmission mechanisms through which the credit-invoice VAT affects tax evasion and compliance, the current paper abstracts from these effects and takes a different approach. This paper focuses on a mechanism influencing VAT evasion at the intensive margin as regards imperfectly competitive firms and for the part of evasion that is associated with simultaneous under-reporting of sales and costs. This specific form of VAT evasion, as already discussed in the introduction, is of policy concern in Italy. The paper posits that all firms are legally registered for the VAT. However, only monopolistically competitive firms can partially evade it. Their competitive input suppliers are fully VAT compliant and monopoly firms cannot under-shift their output VAT. These and the symmetry of firms assumptions do not allow us to consider VAT evasion at the extensive margin that is associated with production chains or with tax notches. However, they are not too restrictive for those developed countries like Italy, where the share of firms operating underground is limited (5% of total firms in the industry and 13% in the service sectors according to the Italian Statistical Bureau, see Mantegazza et al., 2012: 224) and where the VAT exemption threshold is rather low.[5] The assumptions that input suppliers are fully VAT compliant and do not bear any burden of the output VAT charged by monopoly firms are made for simplicity. However, the former assumption is incentive-compatible here, given that input suppliers have no reason to under-report their sales in order to hide tax base.[6] The latter assumption is consistent with evidence for the Eurozone according to which the long-run pass through to consumer prices of changes in the standard VAT rate is no less than 100% (Benedek et al. 2015: 18-19). This evidence weakens the possibility of under-shifting of the output VAT.

One key assumption of the current paper is that firms are monopolistically competitive. As far as we know, the only papers that consider indirect tax evasion with monopolistic competition and endogenous number of firms are Davies and Paz (2011) and Paz (2015).[7] Their papers, in contrast to the current model where all firms are identical, allow for differences in firm productivity. Thus, tax evasion depends on firm efficiency, with less efficient firms operating underground and more efficient firms choosing full compliance. However, Davies and Paz (2011) assume that the VAT is formally equivalent to a retail sales tax. Thus, they are unable to capture the input tax feature associated with the credit-invoice method for VAT collection. Conversely, Paz (2015) introduces intermediate goods and a true VAT in his model. Similarly to the current paper, Paz (2015) shows that a change in the substitution elasticity affects VAT compliance when firms are imperfectly competitive. But the mechanism pointed out by Paz (2015) is of different kind, as it

[5] In Italy, the VAT threshold is set at €10,000, but varies within the range €15,000-€40,000 for small enterprises. The majority of EU countries has lower thresholds, see European Commission (2015a).

[6] This would be the case if they were subject to an income tax, see Fedeli and Forte (1999).

[7] Best et al. (2015: 1329-1330) show how market power affects a firm's evasion incentives with minimum tax schemes. Marrelli (1984), Das-Gupta and Gang (2003) consider monopoly firms. These papers take the number of firms as given.

operates at the extensive margin of the firm VAT evasion decision. Namely, it operates through the effects that a change in the substitution elasticity has on the size of the informal sector. More specifically, his paper derives a cut-off productivity level below which firms operate informally, outside the VAT system. However, firms in the formal sector face a positive detection probability that is increasing in their size (thus, in their productivity). As long as suppliers of intermediates are fully VAT compliant by assumption, Paz (2015: 473-74) shows that the VAT credit on intermediate goods allows formal firms to charge lower consumer prices than informal firms with the same productivity level, given that formal firms pay a lower effective price for their intermediate goods. In such a situation, an increase in the substitution elasticity, by making varieties more similar, raises the market share of firms selling at lower prices and makes it more profitable for a firm, other things being equal, to become formal.

Conversely, as we shall see below, in the current paper changes in the substitution elasticity affect a monopoly firm's VAT evasion decision at the intensive margin, by increasing the expected marginal cost of VAT evasion. In fact, in the current model when the firm under-reports one unit of its sales it has also to waive the corresponding input VAT credit. This is proportional to the real producer price (the price of inputs divided by the price of outputs). As long as the real producer price is increasing in the substitution elasticity (i.e. the higher the elasticity is, the lower the output price mark-up over marginal costs will be), an increase in the substitution elasticity will raise the opportunity cost of VAT evasion, improving VAT compliance.

3. The model

Consider a closed economy composed of a competitive agricultural sector, producing a homogeneous consumption good under constant returns to labour, and a monopolistically competitive industrial sector, producing differentiated consumption goods under increasing returns. Industrial firms use an intermediate input, produced with homogeneous labour, which they buy at arm's length price from households. Industrial firms pay the VAT on intermediate inputs and are legally obliged to charge the VAT on their sales. There is a common VAT rate. However, the agricultural sector faces a zero VAT rate.[8] Households offer their labour services inelastically. The total labour supply is equal to H. The labour market is competitive, with labour mobility between sectors at a common wage. The wage is the numéraire. Thus, in contrast to the existing

[8] This assumption is broadly consistent with the observation that, at least in the EU, reduced and super-reduced VAT rates and exemptions apply to a limited range of goods and sectors, see European Commission (2015b).

literature, we do not focus on the employment effects of changes in the substitution elasticity, which are potentially associated with product market reforms (see Fiori et al., 2012, for a discussion).

3.1 Consumers

The representative household has the following preferences over the two final goods:

$$U_i \equiv Y_i + \mu \ln C_i$$

$$C_i = n_i^{\upsilon} \left[n_i^{-1} \sum_{j=1}^{n} c_{ji}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \quad \text{j} = 1,2...\text{n}, \ \text{i} = \text{FC, RST, VAT}, \sigma > 1, \ \text{H}>\mu>\upsilon \geq 1 \qquad (1).$$

$$P_i = n_i^{-\upsilon} \left[n_i^{-\sigma} \sum_{j=1}^{n} p_{ji}^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

In Eq. (1), the *i* subscript denotes the alternative regimes of Full Compliance (FC), Retail Sales Tax (RST), and Value Added Tax (VAT), see below. Y_i is consumption of the competitive agricultural good, C_i is a CES consumption index of j=1, 2…n different industrial brands and P_i is its corresponding price index. Following Davies and Paz (2011) and Bauer et al. (2014), Eq. (1) posits a quasi-linear utility function. From utility maximisation, this implies a constant total expenditure for the industrial goods, provided the marginal utility of income $\Lambda=1/P^A$ (P^A denoting the agricultural good price) is also constant. That is, $P_iC_i=\mu/\Lambda$. This simplification has the useful property of eliminating income effects from changes in VAT rates and VAT compliance. Following Bénassy (1996),[9] the CES index introduces a distinction between the love of variety or preference for diversity effect, which is captured by the parameter $\upsilon\geq1$, and the measure of the intra-brand elasticity of substitution, which is captured by the parameter $\sigma>1$. When $\upsilon=1$, there is no love of variety as in the Blanchard and Giavazzi (2003) model. This implies that P_i will be independent of the number of brands in a symmetric equilibrium with free entry and exit of firms. When $\upsilon>1$, there is love for variety and P_i will be a decreasing function of the number of brands. The special case when the two parameters are related such that $\upsilon\equiv\sigma/(\sigma-1)>1$ corresponds to the Dixit and Stiglitz (1977) specification of the CES index. This case is the standard assumption in models of monopolistic competition. Notice that the distinction between the love for variety and the intra-brand substitution elasticity parameters will have no implications for the key mechanism of an individual firm's evasion decision considered in this paper. However, alternative market

[9] The specific parameterization of love of variety used in Eq. (1) is due to Heijdra and Van der Ploeg (1996: 1286).

equilibria and welfare effects will emerge depending on this assumption. Utility maximization yields the following demand function for the typical industrial brand j (where we made use of P_i from Eq. 1):

$$c_{ji} = \left(p_{ji}\right)^{-\sigma} \left(P_i\right)^{\sigma-1} \left(n_i\right)^{[\upsilon(\sigma-1)-\sigma]} \left(\mu / \Lambda\right); \; j = 1,2,...n \qquad (2)$$

$\sigma>1$ is the constant own-price elasticity of demand. The representative household receives the aggregate income of the economy, denoted by Ω_i. This is composed of labour income, profits (zero in equilibrium) and lump-sum transfers from redistributed tax receipts.[10] The demand for the agricultural good is $Y_i= (\Omega_i/P^A)- \mu$.

3.2 Producers

In the competitive agricultural sector, a representative firm produces Y_i under constant returns to labour. Together with the assumption that the wage is the numéraire, this implies that the agricultural output price is equal to unity, $P^A =1$. Thus, the marginal utility of income is $\Lambda=1$. The industrial sector produces differentiated brands under increasing returns to scale and monopolistic competition. Technology uses both a fixed requirement of overhead labour F (for example managerial labour),[11] and a variable input requirement L_{ji}. A monopoly firm produces one unit of output x_{ji} by using one unit of input L_{ji}, provided it has F units of overhead labour. The input L_{ji} is a homogeneous intermediate good purchased from households in a competitive market at the arm's length price $P_L=w+\tau \Phi P_L$ (see for example Keen, 2008: 1897), where $w\equiv1$ is the VAT-free price of one input unit, $\tau\in (0,1)$ is the single VAT rate and $\Phi=\{0,1\}$ is a dummy variable. When $\Phi=1$, each (not managerial) household produces with her labour one unit of the intermediate input, which she sells to industrial firms at the VAT-inclusive price P_L. The paper hypothesises that each worker-firm collects the VAT paid by industrial firms and fully remits it to the tax authority. If industrial firms were fully compliant, they would remit to the tax authority their output VAT debt, while receiving back full input VAT credit. In this case, firms would face an effective input price of w. However, for each unit of undeclared output, they would instead face an effective input price of $w+ \tau P_L$. In fact, by assumption in this case industrial firms would not claim the input VAT credit in order to avoid signalling their output VAT evasion to the tax authority. When $\Phi=0$, it is as if each monopoly firm produces in house, without additional costs, the required inputs by using hired labour paid at the market wage w. This makes the VAT formally

[10] Section 4 extends the model by introducing a utility-enhancing public good that is financed with VAT revenues.

[11] Alternatively, F can be interpreted as overhead capital (e.g. plants, buildings) or as fixed red-tape costs, both measured in terms of labour, which are needed to setting up firms.

equivalent to a retail sales tax (RST) for Φ=0. This alternative interpretation of the input price allows us to consider both RST and VAT tax evasion in a parsimonious model. In either case, the total number of workers (directly or indirectly) employed by a monopoly firm is equal to F+ x_{ji}. Monopoly firms maximise profits, subject to the market demand, Eq. (2), by choosing simultaneously the price/output level for the brand they produce and the fraction of revenue they want to evade. This problem will be analysed in the next section.

4. VAT evasion

The model of indirect tax evasion is built on Cremer and Gahavari (1993). Assume that monopolistically competitive firms must report their revenue to the government. If they are honest, they report revenue $p_{ji}x_{ji}=p_{ji}c_{ji}$ and pay the tax at the rate τ. However, they may choose to under-declaring their revenue. $0\leq\delta_{ji}\leq1$ is the fraction of revenues that a firm j does not report: $\delta_{ji}=0$ means honest tax reporting and $\delta_{ji}=1$ means full evasion. Firms are assumed to engage in some explicit and costly concealment activity if they wish to evade the tax. Following the literature, concealment costs are assumed increasing and convex in the size of the tax being evaded (see for example Virmani, 1989, and Eq. 3 below).[12] The tax authority can obtain information on true revenue levels by auditing firms. For simplicity, assume this is costless. In order to enforce tax compliance, the tax authority audits firms with an exogenous probability of detection that is given by $0<\lambda<1$. This corresponds to random auditing at the industry level. When discovered, tax evaders must pay the evaded tax plus a penalty. The penalty is proportional to the size of the *output VAT tax* being evaded, with $\psi>1$ representing the penalty rate (see Eq. 3 below).[13] Because of the former assumptions, a monopoly firm j=1, 2,…n chooses the output level x_{ji} and the fraction of unreported revenue, δ_{ji}, to solve the problem:[14]

[12] Several firm's needs can justify this assumption: hiring extra and better- paid personnel (e.g. better accountants and lawyers, guards) that keep account of, store in warehouses and move around increasingly larger volumes of physical goods to be concealed; paying higher bribes to corrupt audit customs officials; offering larger side payments to bank employees when firms use multiple bank accounts for hiding their unofficial transactions. Concealment costs may also include non-pecuniary costs of evasion (e.g. jail terms) provided by law when firms alter account books or evasion exceeds a threshold. Hashimzade et. al. (2010) present a model with endogenous convex concealment costs.

[13] Alternatively, the tax authority could apply the penalty on the *net VAT liability*, by computing the input VAT credit a fully compliant firm would receive. In this case, the evader's expected penalty would be smaller than being specified below (the last term in Eq. 3 being multiplied by $0<(1-\lambda\psi)<1$). However, no key qualitative result of the paper would be affected by this.

[14] Under monopolistic competition, each individual firm treats both sectoral variables and economy-wide variables as given. In particular, it does not see any effect of its own decisions on both the price index and sectoral expenditure.

x_{ji}, δ_{ji} arg max π_{ji}^{e} *s.t.* $x_{ji} = c_{ji}$ and Eq. (2) , where:

$$\pi_{ji}^{e} = \underbrace{[1-\lambda]}_{\substack{\text{probability of}\\ \text{not being detected}}} \left\{ \underbrace{[p_{ji}x_{ji} - P_L x_{ji} - wF]}_{\text{gross profits}} - \underbrace{\tau p_{ji}x_{ji}(1-\delta_{ji})}_{\substack{\text{tax paid on}\\ \text{reported revenue}}} + \underbrace{\tau P_L x_{jVAT}(1-\delta_{jVAT})}_{\substack{\text{VAT credit claimed}\\ \text{on reported purchases}\\ \text{of intermediate inputs}}}\Phi - \underbrace{p_{ji}x_{ji}\delta_{ji}^{2}/2}_{\text{concealment costs}} \right\}$$

$$+ \underbrace{\lambda}_{\substack{\text{probability of}\\ \text{being detected}}} \left\{ \begin{array}{l} \underbrace{[p_{ji}x_{ji} - P_L x_{ji} - wF]}_{\text{gross profits}} - \underbrace{\tau p_{ji}x_{ji}(1-\delta_{ji})}_{\substack{\text{tax paid on}\\ \text{reported revenue}}} + \underbrace{\tau P_L x_{jVAT}(1-\delta_{jVAT})}_{\substack{\text{VAT credit claimed}\\ \text{on reported purchases}\\ \text{of intermediate inputs}}}\Phi - \underbrace{p_{ji}x_{ji}\delta_{ji}^{2}/2}_{\text{concealment costs}} + \\ -\underbrace{\tau p_{ji}x_{ji}\delta_{ji}}_{\text{evaded tax}} - \underbrace{(\psi-1)\tau p_{ji}x_{ji}\delta_{ji}}_{\text{penalty on evaded tax}} \end{array} \right\}$$

with i=FC, RST, VAT. Simplifying, expected profits π_j^e can be written as

$$\pi_{ji}^{e} = [(p_{ji} - w)x_{ji} - wF] - p_{ji}x_{ji}[\tau(1-\delta_{ji} + \lambda\psi\delta_{ji}) + \delta_{ji}^{2}/2] - \tau P_L x_{ji}\delta_{jVAT}\Phi,$$
$$\textbf{with } \Phi = \{0, \mathbf{1}\}, \mathbf{w} \equiv \mathbf{1}, \mathbf{P_L} = w + \tau\Phi P_L, \textbf{ and } \tau \in (\mathbf{0}, \mathbf{1}) \tag{3}$$

Eq. (3) allows us to consider in a parsimonious way both Full Compliance (FC) for $\delta_{jFC}=0$, and Retail Sales Tax (RST) evasion for $\Phi=0$ and $0<\delta_{jRST}<1$, and VAT evasion for $\Phi=1$ and $0<\delta_{jVAT}<1$. The credit-invoice method for the VAT implies that the tax is charged at each stage of the production process. An important assumption implied by Eq. (3) is that a firm under-reporting its sales, thus evading part of its own output VAT debt, has to simultaneously give up the reimbursement of the VAT credit on the corresponding intermediate goods. To be sure, in the presence of a simple linear technology, the fact that a firm claims full input VAT credits while simultaneously under-reporting revenues can be seen as a signal of potential VAT evasion. This is the case as long as tax authorities can use information on a firm's VAT registered input purchases in order to deduce the firm's actual output sales. Thus, the decisions on how much output VAT debt to evade is correlated with the decision on how much input VAT credit to claim. As previously argued, this assumption is consistent with the stylized facts of VAT evasion in Italy and seems reasonable for those countries that use the sales/input ratio as a proxy for suspicion of evasion.

The former assumption has important implications for the current model. As Keen (2008: 1893) points out, if a firm does not claim full credit or refund, the VAT paid on the intermediate inputs purchased from VAT-compliant firms is equivalent to an input tax levied at the VAT rate. Here, it follows that, when choosing how much output VAT to evade, the firm must trade off the gains from under-reporting its final sales (i.e. higher net-of-tax revenue) with the losses from evasion, which includes the loss from not fully recovering the VAT paid on the inputs it has bought in the market. Note that this dimension of the evasion trade-off operates as long as the level of undeclared inputs is a fixed share of the level of undeclared outputs. Namely, this analysis is valid provided that $\delta_{inputVAT}$= k δ_{VAT}, where $\delta_{inputVAT}$ is the fraction of undeclared input VAT and 1≥k>0 (k=1 being the current assumption). As we shall see below, when the mode of VAT evasion has these features, a change in the substitution elasticity will affect the firm's evasion trade-off. However, if the decisions on output VAT evasion and input VAT declaration were completely independent of each other, this dimension of the evasion trade-off would disappear. More specifically, in this latter case the firm would fully claim its input VAT credit despite evading part of its output VAT debt. Thus, the credit-invoice method is a necessary but not a sufficient condition for the elasticity of substitution transmission channel to operate in our model.

To make these points explicitly, let us now consider tax evasion under RST firstly. This case is formally equivalent to VAT evasion when the firm claims full input VAT credit. From Eq. (3), it is clear that in the RST regime with Φ=0 a firm's evasion decision δ_j is independent of its decision on the profit-maximising level of sales. This "separability" result stems here from the combined assumptions that firms are symmetric, the probability of auditing is constant and the expected effective tax payments are proportional to the firm's true revenue level (Sandmo, 2005: 654-55). [15] However, it will break down below when considering VAT evasion with Φ=1. More specifically, the solution to the firm's problem is:

$$\begin{aligned} \delta_{jRST}{}^* = \delta_{RST}{}^* &= \tau[1-\lambda\psi] \quad \text{if } 0 \le \lambda < 1/\psi \\ &= 0 \qquad\qquad \text{otherwise} \end{aligned} \tag{4.1}$$

$$\begin{aligned} p_{jRST} &= \left(\frac{\sigma}{\sigma-1}\right)(1+\mathrm{s}^{\mathrm{RST}}), \quad \mathrm{j}=1,2,...\mathrm{n} \\ 1+\mathrm{s}^{\mathrm{RST}} &\equiv \frac{1}{1-t_{RST}{}^{e*}} \le \frac{1}{1-\tau} \equiv 1+s^{FC} \\ 0 < t_{RST}{}^{e*} &\equiv \tau\left[1-\delta_{RST}{}^* + \lambda\psi\delta_{RST}{}^*\right] + (\delta_{RST}{}^*)^2/2 = \tau - (\delta_{RST}{}^*)^2/2 \le \tau \end{aligned} \tag{4.2}$$

As long as the exogenous detection probability is the same for all the firms, they choose the same level of evasion δ_{jRST}*= δ_{RST}*. Eq. (4.1) shows that, other things being equal, the optimal fraction of undeclared revenue δ_{RST}* is an increasing function of the statutory tax rate τ, and a decreasing function of both the detection probability 0< λ<1 and the harshness of the penalty ψ>1, as one would expect. As Cremer and

[15] Göerke and Runkel (2006) discuss some of the conditions under which separability will not hold.

Gahavari (1993: 264) point out, $\lambda\psi<1$ is a necessary condition for an interior solution to the tax evasion problem. If this condition does not hold, the firm reports honestly its revenue by choosing $\delta_{RST}*=0$. Eq. (4.1) also shows that $0<\delta_{RST}*<1$, implying partial VAT evasion. Three further things are worthy noting. First, finding an internal solution to the tax evasion problem implies that the effective tax rate is lower than the statutory rate: $t_{RST}^{e}*< \tau$. If this were not the case, the firm would find it optimal to report truthfully its revenue by choosing $\delta* =0$ and paying the required tax bill. Second, an increase in the elasticity of substitution σ has no effect on the firm's decision to evade when $\Phi=0$. Lastly, from Eq. (4.2), the optimal producer's price is a constant mark-up over the tax-inclusive marginal costs $1+s^{RST}$. Thus, the optimal RST price is lower than the FC one, as long as $1+s^{RST}<(1+s^{FC})\equiv 1/(1-\tau)$. This result depends on the fact that the effective RST tax rate with evasion is lower than the statutory rate.

Turning to the VAT by setting $\Phi=1$ in Eq. (3), the optimal fraction of revenue evaded depends now on the producer's price, thus on the optimal level of firm's sales. More specifically, the FOC for tax evasion is quadratic in δ_{jVAT}. However, sufficient conditions can be found leading to an internal solution to the firm's problem. Appendix 1 shows this solution is:

$$\delta_{jVAT}* = \delta_{VAT}{}^{*} = \frac{-B+\sqrt{B^{2}-4AD}}{2A} \equiv \delta_{VAT}*\left(\underbrace{\sigma}_{-},\underbrace{\lambda}_{-},\underbrace{\psi}_{-},\underbrace{\tau}_{+}\right) < \tau$$

$$A \equiv \tau[\sigma+1]/2 > 0$$

$$B \equiv \sigma(1-\tau) - \tau^{2}(1-\lambda\psi) > 0 \qquad (5.1)$$

$$\mathbf{D} \equiv \tau(\mathbf{1-}\tau)[\sigma\lambda\psi - 1] < 0, \qquad \textbf{if } 0 \le \lambda < \frac{1}{\sigma\psi} \textbf{ and } 0 < \tau \le \mathbf{0.5};$$

$$\delta_{jVAT}* = \delta_{VAT}{}^{*} = 0 \qquad \textbf{otherwise}$$

$$p_{jVAT} = \left(\frac{\sigma}{\sigma-1}\right)(1+s^{VAT})$$

$$(1+s^{VAT}) \equiv \frac{1}{(1-\tau)}\left[\frac{1-\tau+\tau\delta_{VAT}*}{\left(1-t_{VAT}{}^{e}*\right)+\delta_{VAT}*\left(\delta_{RST}{}^{*}-\delta_{VAT}*\right)}\right] > \frac{\mathbf{1}}{\mathbf{1-}\tau} \equiv (\mathbf{1}+\mathbf{s}^{\mathbf{FC}}),\ \mathbf{j}=\mathbf{1,2,...n} \qquad (5.2),$$

$$t_{RST}{}^{e*} \le t_{VAT}{}^{e*} \equiv \tau - (\delta_{VAT}*)^{2}/2 \le \tau$$

where it is used $P_L=w/(1-\tau)$, with w=1, representing the effective unitary input price the firm pays when it does not claim the VAT credit; $t_{VAT}{}^{e}*$ is the expected effective VAT rate. From Eq. (5.1), by inspection of the optimal degree of tax evasion $\delta_{VAT}*$ it follows that $0\le\lambda<1/\sigma\psi$ and $0<\tau\le 0.5$ are sufficient conditions for the firm under-reporting a fraction of its revenue without it going underground.[16] These conditions are more restrictive than the corresponding condition for RST under-reporting, or $0 \leq \lambda < 1/\psi$, see Eq. (4.1). The optimal solution to the firm's problem highlights the role of the substitution elasticity: the higher is σ, the more likely is that, other things being equal, the firm will choose honest reporting or $\delta^*=0$. Moreover, it can be shown that, for $0<\delta_{VAT}^*<1$ and other things being equal, an increase in the substitution elasticity will lower the optimal degree of tax evasion: $\partial\delta_{VAT}^*/\partial\sigma<0$ (see Eq. A.6 in Appendix 1 for a proof). The idea for the effect of the substitution elasticity on VAT compliance is as follows. The expected marginal cost of evasion is higher with the VAT than RST, namely it is higher than the marginal concealment cost. This is because, when under-declaring its final sales, the firm cannot recover fully the VAT paid on its purchases of intermediate inputs. As a result, tax evasion will be lower with the VAT than the RST. From the FOC (see Appendix 1), it turns out that: $\delta_{VAT}^*= \delta_{RST}^*-\tau\, P_L/p_{jVAT}$, where $\delta_{RST}^*=\tau(1-\lambda\psi)$ Thus, in the current model, the additional cost of VAT evasion is proportional to the real producer price of intermediate inputs, P_L/p_{jVAT}. From the optimal pricing condition (see Eq. 5.2), and other things being equal, the real producer price is an increasing function of the substitution elasticity σ. Thus, an increase in the substitution elasticity, by raising the real produce price and the cost of the unrecovered input VAT, lowers an industrial firm's incentive to evade the VAT on its final sales.

Table 1 below reports numerical examples showing δ^* as a function of the relevant parameters. These examples satisfy the conditions $0 \leq \lambda < 1/\sigma\psi$ and $0<\tau \leq 0.5$. The elasticity of substitution is set at $\sigma=\{2.4, 3.5\}$. These values represent, respectively, Broda et al.'s (2006: Table 4) estimates of the lowest median (for the UK) and the median median (for Denmark) elasticity of substitution in import-competing industries in the EU-17 countries. (The value for Italy being estimated at 3.7 by Broda et al.). As long as these elasticities are likely to be larger than those occurring in non-traded sectors, the numerical examples of Table 1 put a lower bound on the value of δ^* one would expect to observe in a closed economy. The statutory tax rate is set at $\tau=\{0.2, 0.25\}$. The first number is both the Italian and the median standard VAT tax rate for the EU-25 countries in 2006. The second number is the standard VAT rate in Denmark and Sweden in 2006. The penalty rate is set at $\psi=\{1.2, 2\}$. The first number implies a 20% fine on VAT evasion, which corresponds to

[16] Note that $\tau \leq 0.5$ is a sufficient condition for the SOCS to be satisfied, see Appendix 1. We rule out the corner solution with a firm fully submerging (that is, 100% output VAT evasion). This is because in this model all the industrial sector would consequently submerge in symmetric general equilibrium.

a "cooperative" agreement between tax evaders and the tax administration.[17] The second number is a 100% fine. The probability of detection is set equal to $\lambda=\{0.05, 0.1\}$. Table 1 shows that the share of un-reported revenue δ_{VAT}* is a decreasing function of the elasticity of substitution σ. This result is qualitatively illustrated in Figure 1. Table 1 provides an estimate of the share of VAT evasion that is associated to the mode of VAT evasion considered in this paper. Table 1 also shows that, other things being equal, the share of un-reported VAT revenue is a decreasing function of the penalty rate $\psi>1$ and of the probability of detection $0<\lambda<1$, and an increasing function of the statutory tax rate $0<\tau\leq0.5$; moreover, it is lower than RST evasion, as expected.

Turning to the firm's optimal pricing rule, Eq. (5.2) shows that, other things being equal, the producer price p_{jVAT} is *higher* with VAT evasion than FC than RST evasion, given that $(1+s^{VAT})>(1+s^{FC})\equiv1/(1-\tau)> 1+s^{RST}$. This result will be discussed in section 4.1 below. Eq. (5.2) also shows that an increase in the substitution elasticity σ induces firms to set a lower optimal price, $\partial p_{jVAT}/\partial\sigma<0$. The channel through which the elasticity of substitution operates is two-fold. First, there is a standard mark-up effect: a bigger elasticity lowers the price mark-up. This effect is present with both FC and RST evasion. Second, there is a tax compliance effect, which is specific to the mode of VAT evasion considered in this paper: a bigger elasticity lowers the fraction of optimal un-reported revenue. This lowers the tax component of effective marginal costs $(1+s^{VAT})$, thus prices (see Eq. A.8 in Appendix 1).

Provided product market liberalisation or deregulation policies can be modelled as an increase in the substitution elasticity (a preference parameter), as being suggested by Blanchard and Giavazzi (2003) and Fiori et al. (2012), the analysis made in this section can be interpreted and summarised in Proposition 1:

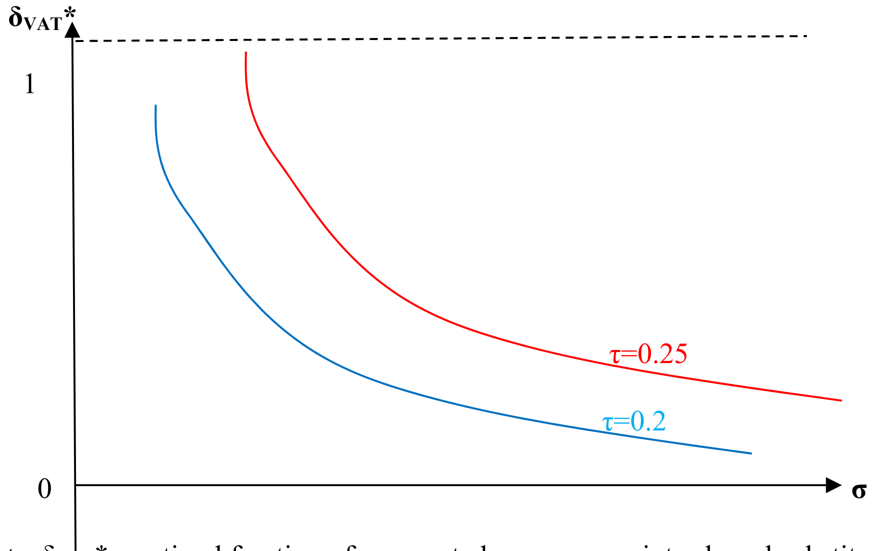
Table 1. VAT evasion: optimal fraction of un-reported revenue δ_{VAT}* (per cent values in italics)

	τ=0.20				**τ=0.25**			
	λ=0.05 ψ=1.2	**λ=0.05 ψ=2**	**λ=0.1 ψ=1.2**	**λ=0.1 ψ=2**	**λ=0.05 ψ=1.2**	**λ=0.05 ψ=2**	**λ=0.1 ψ=1.2**	**λ=0.1 ψ=2**
σ=2.4	*7.18*	*6.38*	*5.98*	*4.37*	*9.01*	*8.01*	*7.51*	*5.49*
σ=3.5	*4.45*	*3.74*	*3.34*	*1.73*	*5.69*	*4.69*	*4.19*	*2.17*
RST evasion	*18.8*	*18*	*17.6*	*16*	*23.5*	*22.5*	*22*	*20*

Note: σ = intra-brand elasticity of substitution, λ= detection probability, ψ= penalty rate; τ=statutory VAT rate; RST evasion= $\tau(1- \lambda \psi)$. Each cell satisfies the condition for under-reporting $0\leq\lambda<1/ \sigma \psi$ and $0<\tau\leq0.5$.

[17] This applies to Italy as well as other EU countries. For example, since 2002 the UK enacted "new civil procedures" for evaders who fully cooperate with customs in case of detected under-reporting. These procedures imply that "any penalty imposed will not normally exceed 20 per cent of the tax evaded", National Audit Office (2004: 17).

Figure 1. Increasing the substitution elasticity lowers the optimal degree of VAT evasion.



Note: δ_{VAT}*= optimal fraction of unreported revenue, σ= intra-brand substitution elasticity. λ and ψ given.

Proposition 1. Tax evasion and product market liberalisation. Assuming an exogenous detection probability λ, an increase in the intra-brand substitution elasticity σ, capturing, say, product market liberalisation: i) has no effect on firms' evasion with the RST (see Davies and Paz, 2011); ii) it makes it more likely that an industrial firm reports honestly its revenue with the VAT. iii) If a firm chooses under-reporting, increasing the substitution elasticity lowers its VAT evasion and improves compliance.
Proof: See Appendix 1.

The key result of Proposition 1 is that, under some conditions, an increase in the substitution elasticity improves VAT compliance. This transmission channel of product market liberalisation on VAT compliance operates as long as the VAT evasion mode consists in simultaneous under-reporting of output VAT debts and input VAT credits. Although the decisions to report output VAT debts and input VAT credits are taken independently of each other in many practical situations, this paper contends that they will be interrelated when firms anticipate knowledge of the input-output coefficients by part of the tax authority. It is in these situations that the transmission channel of product market liberalisation considered in this paper will matter mostly. Notice that, although the paper assumes that one unit of output VAT evasion induces the firm to give up one unit of input VAT credit, this channel operates as long as there is a fixed relationship between declared inputs and outputs. Moreover, in practice we would expect that the size of the elasticity of substitution effect on VAT evasion will depend on other factors as well. As Proposition 1i) has shown, when there are no intermediate goods product market liberalisation does not affect tax evasion incentives. Thus, one would expect that the size of the elasticity of substitution effect will be reduced as the share of intermediate input expenditure in total costs falls. Similarly, one would expect a smaller size of the VAT evasion effect if, following the increase in the substitution elasticity, monopolistically competitive firms can pass-through part of the reduction in consumer prices onto their intermediate input suppliers. By assuming that monopolistically competitive firms are price takers in the input market, this model rules out this possibility.

The analysis of this section has shown that an increase in the substitution elasticity affects a monopolistically competitive firm's behaviour through a two-fold transmission channel. First, following the reduction in the mark-up over marginal costs, the firm sets lower prices. This pro-competitive result is standard. Second, as the cost of unrecovered VAT on inputs increases, the firm reduces VAT evasion at the intensive margin. This lowers the effective tax-inclusive marginal costs and the optimal firm price. This latter result, as far as we know, has not been previously considered in the literature. The general equilibrium implications of this two-fold transmission channel will be examined next.

4.1 VAT evasion in general equilibrium

This section considers the general equilibrium solution of the model, by imposing both a symmetric equilibrium under free entry and exit of firms in the monopoly industry and market clearing. Turning to the industrial sector first, imposing the zero-profit condition in Eq. (3), using Eq. (1) and (2) equilibrium is summarised in Eq. (6) below. For expositional convenience, Eq. (6) shows compactly the alternative tax-compliance regimes i=FC, RST, VAT. For Φ=0, it holds with both FC and RST, for Φ=1 with the VAT:

$$
\begin{aligned}
(\mathbf{n_i})^{\nu} &= \frac{C_i}{F(\sigma-1)}\left[\frac{1-\tau(1-\delta_i^*)}{1-\tau}\right]^{\Phi} \\
n_i &= \frac{\mu}{F(\sigma-1)p_{ji}}\left[\frac{1-\tau(1-\delta_i^*)}{1-\tau}\right]^{\Phi} \\
x_{ij} &= F(\sigma-1)\left[\frac{1-\tau}{1-\tau(1-\delta_i^*)}\right]^{\Phi} \\
p_{ji} &= \left(\frac{\sigma}{\sigma-1}\right)(1+s^i) \\
P_i &= n^{1-\nu}p_{ji} \\
C_i &= \mu / P_i
\end{aligned}
\tag{6}
$$

$(1+s^i)$ is the effective tax-inclusive marginal costs, see Eq.s (4) and (5) above, with $1+s^{VAT}>1+s^{FC}>1+s^{RST}$. In Eq. (6), the first line is the zero profit condition, yielding the equilibrium number of firms as shown by the second line. The third line is the average firm size or a firm's equilibrium output. The fourth line is the individual firm's optimal price. The fifth line is the industrial price index. The last line is the industry consumption level or market size. With love for variety $\upsilon>1$, the industrial price index becomes a decreasing function of the number of brands. (For $\upsilon=1$, the price index is independent of the number of brands). Tables 2.1 and 2.2 below report the solution for each regime.

In order to close the model, the labour market equilibrium condition is now derived. Recall that market clearing in the agricultural sector implies $Y_i= \Omega_i-\mu$ (as long as $P^A=w\equiv1$), where Y_i is sector output-employment and Ω_i is total income received by the representative household. With zero profits in both sectors, total income is equal to the sum of wage income H plus tax revenue R_i. Tax revenue is redistributed to households by means of a lump-sum transfer. The labour market equilibrium condition reads:

$$\underbrace{H}_{\substack{\text{aggregate}\\ \text{labour}\\ \text{supply}}} = \underbrace{H + R_i - \mu}_{\substack{\textit{agriculture}\\ \textit{employment}}} + \underbrace{n_i[F + x_{ji}]}_{\substack{\textit{industry}\\ \textit{employment}}} \qquad (7)$$

Using Eq. (7), the equilibrium tax revenue is derived (see Table 2 below). Note that in equilibrium the level of agricultural employment is a linearly increasing function of the tax revenue. Thus, with full employment, the tax revenue and the equilibrium level of industry employment N_i are inversely related: $N_i=\mu-R_i$. Finally, the government is benevolent. Thus, the social welfare function corresponds to the indirect utility function of the representative household. Using Eq. (1), social welfare is: $SW_i = H + R_i - \mu + \mu[\ln \mu - \ln P_i]$. Table 2.2 below reports semi-reduced forms for SW_i. By direct inspection of Tables 2.1 and 2.2, yields

Lemma 1. Tax-compliance regimes. Consider a symmetric equilibrium with free entry and exit of firms in the industrial sector for given parameter values $\{\sigma, \tau, \lambda, \psi, \upsilon, \mu, F, H\}$ and market clearing. Comparing the general equilibrium solution with Full Compliance (FC), the Retail Sales Tax (RST) and the Value Added Tax (VAT), yields: i) number of firms: $n_{FC}< n_{VAT}< n_{RST}$; ii) average firm's size: $x_{jVAT}<x_{jFC}=x_{jRST}$; iii) firm level prices: $p_{jVAT}> p_{jFC}> p_{jRST}$; iv) industrial prices: $P_{VAT}\geq P_{FC}> P_{RST}$ for $1<\upsilon\leq\upsilon^*$; or $P_{FC}> P_{VAT}> P_{RST}$ for $\upsilon>\upsilon^*>1$; v) industrial market size: $C_{VAT} \leq C_{FC}< C_{RST}$ for $\upsilon\leq\upsilon^*$; $C_{FC} <C_{VAT} < C_{RST}$ for $\upsilon>\upsilon^*>1$; vi) tax evasion: $\delta^*_{VAT} <\delta^*_{RST}$; vii) tax revenue: $R_{FC} >R_{VAT} >R_{RST}$; viii) agricultural employment: $Y_{FC} >Y_{VAT} >Y_{RST}$; ix) industrial employment: $N_{FC} <N_{VAT} <N_{RST}$; x) social welfare: $SW_{RST} =SW_{FC}>SW_{VAT}$ for $\upsilon=1$; $SW_{RST}>SW_{FC}\geq SW_{VAT}$ for $\upsilon^{**}\geq\upsilon>1$; $SW_{RST} >SW_{VAT}>SW_{FC}$ for $\upsilon>\upsilon^{**}>1$.

Proof: Directly form Tables 2.1 and 2.2, see Appendix 2 for details.

Table 2.1. General equilibrium solution

	VAT	RST	Full Compliance
Evasion Share	$\delta_{VAT}* = \tau[1-\lambda\psi] - \tau P_L/p_{jVAT}$	$\delta_{RST}* = \tau[1-\lambda\psi]$	$\delta_{FC} = 0$
Effective tax rate	$t_{VAT}^{e*} = \tau - \frac{\delta_{VAT}^2}{2}$	$t_{RST}^{e*} = \tau - \frac{\delta_{RST}^2}{2}$	$t_{FC}^{e} = \tau$
Number of firms	$n_{VAT} = \left(\frac{\mu}{F\sigma}\right)\left(1 - t_{VAT}^{e*} + \delta_{VAT}*\left(\delta_{RST}* - \delta_{VAT}*\right)\right)$	$n_{RST} = \left(\frac{\mu}{F\sigma}\right)\left(1 - t_{RST}^{e*}\right)$	$n_{FC} = \left(\frac{\mu}{F\sigma}\right)(1-\tau)$
Firm size	$x_{jVAT} = F(\sigma-1)\left(\frac{\mathbf{1-\tau}}{\mathbf{1-\tau(1-\delta_{VAT})}}\right)$	$x_{jRST} = F(\sigma-1)$	$x_{jFC} = F(\sigma-1)$
Firm price	$p_{jVAT} = \left(\frac{\sigma}{\sigma-1}\right)\left(\frac{\mathbf{1}}{\mathbf{1-\tau}}\right)\left(\frac{1-\tau(1-\delta_{VAT})}{1-t_{VAT}^{e*} + \delta_{VAT}*\left(\delta_{RST}* - \delta_{VAT}*\right)}\right)$	$p_{jRST} = \left(\frac{\sigma}{\sigma-1}\right)\left(\frac{1}{1-t_{RST}^{e*}}\right)$	$p_{jFC} = \left(\frac{\sigma}{\sigma-1}\right)\left(\frac{1}{1-\tau}\right)$
Industry price	$P_{VAT} = n_{VAT}^{1-v} p_{jVAT}$	$P_{RST} = n_{RST}^{1-v} p_{jRST}$	$P_{FC} = n_{FC}^{1-v} p_{jFC}$
Industry size	$C_{VAT} = \frac{\mu}{n_{VAT}^{1-v} p_{jVAT}}$	$C_{RST} = \frac{\mu}{n_{RST}^{1-v} p_{jRST}}$	$C_{FC} = \frac{\mu}{n_{FC}^{1-v} p_{jFC}}$
Industry employment	$N_{VAT} = n_{VAT}\left[F + x_{j_{VAT}}\right]$ $=\mu(1-t_{VAT}^{e*})$	$N_{RST} = n_{RST}\left[F + x_{jRST}\right] =$ $= \mu(1-t_{RST}^{e*})$	$N_{FC} =$ $n_{FC}\left[F + x_{jFC}\right] =$ $= \mu(1-\tau)$
Agriculture employment	$Y_{VAT} = H + R_{VAT} - \mu$	$Y_{RST} = H + R_{RST} - \mu$	$Y_{FC} = H + R_{FC} - \mu$
Tax revenue	$R_{VAT} = \mu\, t_{VAT}^{e*}$	$R_{RST} = \mu\, t_{RST}^{e*}$	$R_{FC} = \mu\,\tau$

Note: $1/2 \geq \tau > t_{VAT}^{e*} > t_{RST}^{e} > 0$ is the effective tax rate; $\sigma > 1$ is the substitution elasticity; $\upsilon \geq 1$ is love of variety ($\upsilon = 1$ corresponding to no love of variety); $0 < \lambda < 1$ is the detection probability; $\psi > 1$ is the penalty rate, with $\lambda\psi < 1/\sigma$. $H > \mu > 1$, where H is the fixed labour supply and μ is constant spending on the industrial good; $\frac{\mathbf{P_L}}{\mathbf{p_{jVAT}}} = \left[\frac{\sigma-1}{\sigma}\right]\left[\frac{1-t_{VAT}e* + \delta_{VAT}*\left(\delta_{RST}* - \delta_{VAT}*\right)}{1-\tau+\tau\delta*_{jVAT}}\right] < 1$ is the producer's price of intermediates.

Table 2.2. General equilibrium solution

Social Welfare	$SW_{VAT} = K + + \mu \left[t_{VAT}{}^{e*} + \ln(1-\tau) + \ln \frac{\left(1 - t_{VAT}{}^{e*} + \delta_{VAT}(\delta_{RST} - \delta_{\mathbf{VAT}})\right)^{\nu}}{(1-\tau+\tau\delta_{VAT})} \right]$ $\approx K + \mu \left[\tau(1-\nu) + \delta_{VAT} \left(\nu\left(\delta_{RST} - \frac{\delta_{VAT}}{2}\right) - \left(\tau + \frac{\delta_{VAT}}{2}\right) \right) \right]$	$SW_{RST} = K + + \mu\left[t_{RST}{}^{e*} + \nu \ln(1 - t_{RST}{}^{e*})\right]$ $\approx K + \mu\left(\tau - \frac{\delta_{RST}{}^{2}}{2}\right)(1-\upsilon)$	$SW_{FC} = K + + \mu[\tau + \nu \ln(1-\tau)]$ $\approx K + \mu\tau(1-\upsilon)$

Note: $K \equiv H - \mu + \mu\ \upsilon \ln\mu + \mu(1-v)\ln F + \mu \ln\left[(\sigma-1)/(\sigma)^{\nu}\right] > 0$. See Table 2.1 for variables definition. Welfare functions are approximated using first-order Taylor expansions of the type ln (1-x)≈-x for x being small.

Lemma 1 shows that, other things being equal, both firm level and industrial prices and tax revenue are the lowest, while the number of industrial firms, industrial employment, industrial market size and social welfare are the highest in the RST equilibrium, other things being equal. These results depend on the fact that RST tax evasion is the largest. Thus, for given statutory tax rate the expected effective tax rate will be the lowest. This means both the lowest prices at the individual firm level and the largest market size for given number of firms. In turn, this generates higher expected profits for prospective entrants. Imposing the zero profit condition, this means the highest equilibrium number of firms, the average firm's size being pinned down at $x_{jRST}=F(\sigma-1)=x_{jFC}>x_{jVAT}$. From a welfare perspective, this leads to the highest utility from consumption of industrial goods (as the industrial price $P_{RST}= n_{RST}{}^{1-\upsilon}\ p_{jRST}$ is the lowest) and the lowest tax revenue. However, as long as the tax revenue is merely redistributed to households, with love of variety $\upsilon>1$ it is optimal for society to trade-off higher industrial entry with lower tax revenue. Actually, in this situation it would be optimal for society to subsidize monopolistically competitive firms rather than taxing consumption.[18] Tax evasion acts here as an implicit output subsidy for industrial firms, thus inducing more entry than FC in symmetric equilibrium. This explains why, under the current assumption of no utility-enhancing public spending (an assumption that will be relaxed below) the RST evasion regime is socially desirable in general equilibrium.

[18] For the RST and FC regimes, the social welfare maximising expected effective tax rate is equal to: $t^{e}= 1-\upsilon$, namely it becomes negative with love of variety $\upsilon>1$ and it is equal to zero without love $\upsilon=1$.

The comparison between the VAT evasion and FC is mixed. From an equilibrium perspective, firm level prices are the highest with VAT evasion, but the equilibrium number of firms is the lowest with FC. The reasons for these results is as follows. First, as previously pointed out, tax evasion acts as an implicit subsidy to firms, inducing firms to set lower prices than with FC. However, with the VAT there is an additional cost of evasion in terms of unrecovered input tax. Firms evading the output VAT have an incentive to shift into their own prices, thus to pass-through to their consumers, the implicit input tax resulting from their choices. With CES demand functions, it turns out that marginal cost increases are over-shifted into prices, implying that firm level prices will be higher than with FC.[19] However, this also means higher expected profits with the VAT than FC. Consequently, a larger number of firms will enter the industry in VAT symmetric equilibrium. As a result, the combined effect on industrial prices and consumption of higher level of entry and higher firm level prices depends on the strength of love of variety. For a sufficiently high value of the love of variety parameter, VAT industrial prices are lower than FC ones. In this case, it is again optimal for society to trade off more entry, which is encouraged by VAT evasion, for less revenue, which is the largest with FC. Thus, other things being equal, social welfare is larger with VAT evasion than FC. Section 5 below will return on welfare analysis.

Turning to the general equilibrium implications of an increase in the intra-brand substitution elasticity, they are summarised in Proposition 2.

Proposition 2. General equilibrium effects of product market liberalisation. A marginal increase in the intra-brand substitution elasticity σ, capturing, say, product market liberalisation has the following effects in a symmetric general equilibrium with free entry and exit of firms: i) it provokes a reduction in the number of firms and in the firm price level; ii) it increases the average firm's size; iii) it lowers the industry price level and raises the industry market size if love of variety is not too strong or $1 \leq \upsilon < \sigma/(\sigma-1)$; iv) it lowers the effective VAT rate, raising VAT revenues; it has no effect on RST and FC tax revenues; v) it raises social welfare if love of variety is not too strong $1 \leq \upsilon < \sigma/(\sigma-1)$; with Dixit-Stiglitz love of variety $\upsilon \equiv \sigma/(\sigma-1)$, it improves social welfare with the VAT only.
Proof. From direct inspection of Tables 2.1 and 2.2, using Lemma 1. See also Appendix 2.

Proposition 2 (v) shows that an increase in the intra-brand substitution elasticity leads to welfare gains when the love of variety effect is not too strong. This includes the Dixit Stiglitz love of variety value for the VAT

[19] See Weyl and Fabinger (2013) for a general analysis of cost over-shifting with imperfect competition.

regime only. In the FC and RST regimes, an increase in the substitution elasticity improves social welfare if the industrial price falls accordingly, as long as tax revenues are independent of the substitution elasticity parameter. The effect on the industrial price results from the combination of the price mark-up effect (a higher elasticity lowering the price mark up and the industrial price) and the entry effect (a higher elasticity leading to lower expected profits, lower entry and a higher industrial price), namely:

$$\frac{\partial \ln P_i}{\partial \sigma} = \underbrace{\frac{(\upsilon - 1)}{\sigma}}_{entry\ \text{effect}} - \underbrace{\frac{1}{\sigma(\sigma - 1)}}_{markup\ \text{effect}} = \frac{[(\upsilon-1)(\sigma-1)-1]}{\sigma(\sigma-1)}, \text{ i= FC, RST} \qquad (8).$$

When love of variety is not too strong, the price mark-up effect dominates the entry effect: the industrial price falls and social welfare improves. The entry and the price mark-up effects cancel each other out when the love of variety parameter is set equal to the value implied by the Dixit-Stiglitz model: $\upsilon \equiv \sigma/(\sigma-1)$.This case, which corresponds to the one Blanchard and Giavazzi (2003) consider, yields no welfare improvements with both FC and RST. As regards the VAT, the presence of the additional transmission channel of product market liberalisation on tax compliance (see Proposition 1iii) strengthens the former effect: an increase in the substitution elasticity lowers the price mark-up and improves tax compliance at the same time. Therefore, the increase in tax compliance has an additional depressing effect on the equilibrium number of firms, as long as it further lowers expected profits and the individual firm price by reducing the tax inclusive marginal cost. The composite effect on the industrial price index depends on the strength of love of variety, given that:

$$\frac{\partial \ln P_{VAT}}{\partial \sigma} =$$

$$\underbrace{\frac{(\upsilon - 1)}{\sigma} + \underbrace{\left(\frac{(1-\upsilon)\left(\tau \dfrac{P_L}{p_{jVAT}}\right)\dfrac{\partial \delta_{VAT}}{\partial \sigma}}{1-\tau+\delta_{VAT}\delta_{RST}-\delta_{VAT}^2/2} \right)}_{\geq 0}}_{entry\ \textbf{effect}} + \left[\underbrace{\frac{\mathbf{-1}}{\sigma(\sigma - \mathbf{1})}}_{\textbf{markup effect}} + \underbrace{\underbrace{\left(\frac{\tau\left((1-\tau)\left(1-\dfrac{P_L}{PjVAT}\right)+\dfrac{\delta_{VAT}^2}{2}\right)}{\left(1-\tau+\delta_{VAT}\delta_{RST}-\delta_{VAT}^2/2\right)\left(1-\tau+\tau\delta_{VAT}\right)} \right)\frac{\partial \delta_{VAT}}{\partial \sigma}}_{<0}}_{\textbf{tax inclusive } marginal \textbf{ cost effect}} \right] \qquad \textbf{(9)}$$

where $\upsilon \geq 1, 0 < \delta_{RST} - \delta_{VAT} = \tau P_L / p_{jVAT} < 1, \dfrac{\partial \delta_{VAT}}{\partial \sigma} < 0$ (see Appendix 2 as well). The second and fourth RHS terms of Eq. (9) denote the compliance effect on the number of firms and marginal costs, respectively. Provided love of variety is not too strong, the industrial price index falls, which leads to a welfare improvement. Moreover, VAT revenues are an increasing function of the substitution elasticity. To be sure, increasing the substitution elasticity raises VAT compliance, the effective tax rate $\partial t_{VAT}^{e*} / \partial\sigma = -\delta_{VAT} \partial\delta_{VAT} / \partial\sigma > 0$, and tax revenues, leading to a further welfare improvement that is independent of the love of variety parameter. Note that the effect on the price index in Eq. (9) is zero when love of variety is equal to its Dixit-Stiglitz value. In this case, welfare improvements are only due to the tax revenue effect of increased substitution elasticity.

5. Optimal tax rates

The analysis made so far has treated tax rates as an exogenous policy variable. This section will derive optimal tax rates by introducing utility-enhancing public expenditure in the model. The model will compare optimal tax rates with VAT evasion, RST evasion and Full Compliance. More specifically, this section assumes that the government, rather than redistributing tax revenues R_i to households, transforms them without cost into a utility-enhancing public good G_i. This implies keeping a balanced budget with $G_i = R_i$. The public good is assumed to enter in a log-linear way the representative household utility function: $U_i \equiv Y_i + \mu \ln C_i + \chi \ln G_i$, where $\chi>0$ is a parameter capturing the utility benefit of public spending. Without loss of generality, it is assumed that $\chi=1$ from this moment on. In the absence of tax rebates to households, the labour market equilibrium condition (see Eq. 7) reads now: $H=H-\mu+n_i[F+x_{ij}]$. Thus, industry employment is fixed by industry expenditures: $N_i=\mu$. The social welfare function is $SW_i = K + \mu(\nu-1)\ln n - \mu \ln p_{ij} + \ln \mu t_i^e$. Using Tables 2.1 and 2.2, this reads

$$SW_i = K + \mu\left\{\nu \ln(1-t_i^e) + \Phi\left[\ln\left(\frac{1-\tau_{VAT}}{1-\tau_{VAT}+\tau_{VAT}\delta_{VAT}}\right) + \nu \ln\left(\frac{1-t_{VAT}^e + \delta_{VAT}(\delta_{RST} - \delta_{VAT})}{1-t_{VAT}^e}\right)\right]\right\} + \ln \mu t_i^e \qquad (10).$$

In Eq. (10), $K \equiv H-\mu+\mu\,\upsilon\ln\mu+\mu(1-v)\ln F+\mu\ln\left[\frac{\sigma-1}{(\sigma)^{\nu}}\right]>0$; $\Phi=1$ for i=VAT and $\Phi=0$ for i=FC, RST; $t_i^e=\tau$ for i=FC, $t_i^e=\tau_{RST}-(\delta^*_{RST})^2/2$, $\delta^*_{RST}=\tau_{RST}(1-\lambda\psi)$ for i=RST; $t_i^e=\tau_{VAT}-(\delta^*_{VAT})^2/2$, $\delta^*_{VAT}=\tau_{VAT}(1-\lambda\psi)-\tau P_L/p_{jVAT}$ for i=VAT. The FOC for the optimal tax rate yields the Samuelson rule for public good provision:

$$\frac{\partial SW_i}{\partial \tau_i}=0:$$

$$\mu\upsilon\left(\frac{1}{1-\tau_{FC}}\right)=\frac{1}{\tau_{FC}} \qquad \text{for FC}$$

$$\mu\upsilon\left(\frac{1-\delta_{RST}\dfrac{\partial\delta_{RST}}{\partial\tau_{RST}}}{1-\tau_{RST}+(\delta_{RST})^2/2}\right)=\left(\frac{1-\delta_{RST}\dfrac{\partial\delta_{RST}}{\partial\tau_{RST}}}{\tau_{RST}-(\delta_{RST})^2/2}\right) \qquad \text{for RST}$$

$$\mu\left\{\upsilon\left(\frac{1-(1-\lambda\psi)\delta_{VAT}-(\delta_{RST}-\delta_{VAT})\dfrac{\partial\delta_{VAT}}{\partial\tau_{VAT}}}{1-\tau_{VAT}+\delta_{VAT}(\delta_{RST}-\delta_{VAT}/2)}\right)+\frac{1}{1-\tau_{VAT}}-\left(\frac{1-\delta_{VAT}-\tau_{VAT}\dfrac{\partial\delta_{VAT}}{\partial\tau_{VAT}}}{1-\tau_{VAT}+\tau_{VAT}\delta_{VAT}}\right)\right\}=\left(\frac{1-\delta_{VAT}\dfrac{\partial\delta_{VAT}}{\partial\tau_{VAT}}}{\tau_{VAT}-\delta_{VAT}^2/2}\right) \qquad \text{for VAT}$$

(11).

In the FOC for the VAT, δ_{RST} is evaluated at τ_{VAT}. Eq. (11) shows the optimal tax rates in implicit form. In Eq. (11) the marginal utility of private consumption (i.e. the utility reduction following the increase in the industrial price index: the LHS terms of Eq. (11), denoting the marginal cost of public funds MC) is set equal to the marginal utility of public good consumption (i.e. the RHS terms of Eq. (11), denoting the corresponding marginal benefit MB). Using Eq. (11), it can be shown that the optimal FC tax rate is positive, though less than one half when assuming $\mu\upsilon>1$. Moreover, other things being equal, the optimal FC tax rate is *smaller* than the RST one. In fact, solving explicitly Eq. (11), it turns out that: $\frac{1}{2}>\tau_{RST}^*=\left(1-\sqrt{1-2(1-\lambda\psi)^2\tau^*_{FC}}\right)/(1-\lambda\psi)^2>\tau_{FC}^*=1/(1+\mu\upsilon)>0$ for $0<\tau_{FC}^*<\frac{1}{2}-(1-\lambda\psi)^2/8$ (see Appendix 3). As one would expect, the optimal tax rates are a *decreasing* function of the love of variety parameter υ and of the parameter representing the industrial sector size μ. The reason is as follows. The equilibrium number of firms is a decreasing function of the tax rate.[20] Moreover, the stronger love of variety is, the larger the increase in the industrial price index (which is associated with the tax-induced reduction in the number of firms) will be. Thus, a bigger value of υ leads to a larger MC of public good provision. Similarly, a bigger value of μ means that the tax-induced increase in the price index is associated with a larger welfare loss (see Eq. 1), thus with a smaller optimal tax rate. Finally, note that the higher is the probability of detection λ or

[20] Schröder (2004, Lemma 2), Reinhorn (2012: 219, 233) and Vetter (2013: 289-90) show that this is a general feature of ad valorem taxation, when assuming Dixit-Stiglitz monopolistic competition (i.e. constant mark-ups and symmetry) and when imposing the zero profit condition under free entry and exit of firms. These models do not consider tax evasion.

the penalty rate ψ, the smaller is RST evasion. As a consequence, and other things being equal, the values of the optimal RST and FC tax rates will be closer to each other. (Appendix 3 reports the analytical solution). Although the MB and MC of public good provision are both larger with FC than RST, the MC rises more steeply with the tax rate in the former case, given that a higher tax rate intensifies RST evasion. Thus, the price increase provoked by the tax hike is lower with RST than FC.

Because Eq.(11) is highly non-linear, comparisons between the optimal tax rates are only possible through numerical examples. Table 3 reports MB_{VAT} and MC_{VAT} when setting the optimal FC tax rate equal to $\tau^*_{FC}=1/(1+\mu\upsilon)=0.2$, or $\mu\upsilon=4$. Table 3 shows that $MB_{FC}>MB_{VAT}>MB_{RST}$. Recall that MB_{RST} and MB_{VAT} are a decreasing function of the share of unreported revenue, δ. However, $MB_{VAT}>MB_{RST}$, as long as, other things being equal, evasion is larger with RST than VAT. Moreover, note that δ is a decreasing function of the probability of detection λ and of the penalty rate ψ, while it is a decreasing function of the elasticity of substitution σ with the VAT only. To compute MC_{VAT} on the basis of Eq. (11), assuming $\mu\upsilon=4$ three cases are considered: no love of variety ($\upsilon=1$ and $\mu=4$); Dixit-Stiglitz love of variety ($\upsilon=\sigma/(\sigma-1)$ and $\mu\upsilon=4$); love of variety lower than the Dixit-Stiglitz value ($\upsilon< \sigma/(\sigma-1)$ and $\mu\upsilon=4$). Based on the numerical examples of Table 1, Table 3 sets $\sigma=\{2.4; 3.5\}$. The value of μ is set accordingly at $\mu=\{2.3345, 2.8571, 2.96296, 4\}$. Note that when υ gets bigger in size, μ has to get smaller in size to satisfy $\mu\upsilon=4$. Thus, other-things-being-equal comparisons concerning the effect of the love of variety parameter on the optimal VAT rate cannot be made. Table 3 shows MC_{VAT} using Eq. (11). For given values of λ, ψ and σ, MC_{VAT} gets smaller in size as υ rises and μ falls. The comparative static effects on MC_{VAT} of the other parameters are non-linear. Without love of variety ($\upsilon=1$), MC_{VAT} is increasing, while with love of variety ($\upsilon>1$) it is decreasing, in λ and ψ. For given λ, ψ, MC_{VAT} is decreasing in the elasticity of substitution when love of variety υ is high and industry size μ is small. (In the numerical examples of Table 3, MC_{VAT} falls with σ until υ is set equal to the Dixit-Stiglitz love of variety value of 1.7142 for $\sigma=2.4$). As a result, either $MC_{FC}>MC_{VAT}>MC_{RST}$ or $MC_{VAT}>MC_{FC}>MC_{RST}$ (see Appendix A.3 as well). In Table 3, $MB_{FC} = MC_{FC}$ by construction. When evaluated at $\tau^*_{FC} = \tau = 0.2$, the optimal VAT tax rate is larger than the statutory rate if $MB_{VAT} >MC_{VAT}$. The opposite is true if $MB_{VAT} >MC_{VAT}$. The greater is the size of the absolute gap between MB_{VAT} and MC_{VAT}, the further away is the optimal VAT tax rate from the statutory rate $\tau=0.2$. Table 3 shows that the optimal VAT tax rate can be above (corresponding to the shaded cells where $MC_{VAT} < MB_{VAT}$) or below the FC one. But this difference is very small in absolute value (see Table A.1, Appendix 3). This suggests that the values of τ^*_{VAT} and τ^*_{FC} are very close to each other in these numerical examples. Considering the numerical examples, the difference MB_{RST}-MC_{RST} evaluated at τ=0.2 is always positively signed and larger in size than the difference MB_{VAT}-MC_{VAT}. Thus, one can have either $\tau^*_{RST}> \tau^*_{VAT}.> \tau= \tau^*_{FC}$ for the parameter values corresponding to the shaded cells in Table 3; or $\tau^*_{RST}> \tau= \tau^*_{FC} >\tau^*_{VAT}$ otherwise. It is worthy noticing that the optimal VAT tax rate is an increasing function of σ. This is because the absolute value of the difference (MB_{VAT}-MC_{VAT}) gets larger in size, other things being equal, when σ becomes bigger (see Table A.1, Appendix 3). Hence, an increase in the substitution elasticity lowers VAT evasion, raises revenues and the optimal VAT tax rate in the long run.

The results of this section can be related to the findings of the optimal tax literature under imperfect tax enforcement. One well-known implication of the Diamond and Mirrlees (1971) production efficiency theorem is that, with competitive markets and no tax evasion, social welfare maximisation requires that inputs and turnover should not be taxed.

However, Newbery (1986) pointed out that, if final goods cannot be taxed for some reason, then it is desirable to tax inputs, even when the government would like to subsidise untaxed goods. More recently, Best et al. (2015) show explicitly that firm tax evasion introduces a trade-off between production efficiency and revenue efficiency, which gives support to second-best use of distortionary taxation. In the current paper, when the government provides a utility-enhancing public good, the optimal tax rate trades off production efficiency and revenue efficiency. The mechanism is as follows. An increase in the tax rate has the effect of lowering firm entry and increasing tax revenues with both RST and FC. A higher tax rate, however, induces more RST evasion, thus more entry and less revenue relatively to FC. As a result, the optimal tax rate is higher with RST than FC.

Turning to the VAT, the effects are qualitatively similar to the RST case. However, following the tax hike, more tax evasion is associated with smaller revenue losses and reduced firm entry. Thus, the optimal VAT tax rate is smaller than the RST one. The optimal VAT tax rate is bigger in size than the FC one when love of variety is strong enough (while it is smaller when love of variety is weak), as long as the consumption of a larger number of goods is more valuable for society in this case.

Table 3. Marginal Benefit (MB) and Marginal Cost (MC) of public good provision for $\tau = \tau^*_{FC}=0.2$

		$\lambda=0.05$ $\psi=1.2$		$\lambda=0.05$ $\psi=2$		$\lambda=0.1$ $\psi=1.2$		$\lambda=0.1$ $\psi=2$	
$MB_{FC}=MC_{FC}$			5		5		5		5
MB_{RST}			4.5154		4.5593		4.5802		4.6581
MC_{RST}			4.0274		4.10683		4.14534		4.2913
MB_{VAT}	**$\sigma=2.4$**	**$\delta_{VAT}=0.0728$**	4.9322	**$\delta_{VAT}=0.0638$**	4.9410	**$\delta_{VAT}^*=0.0598$**	4.9533	**$\delta_{VAT}^*=0.0437$**	4.9750
	$\sigma=3.5$	**$\delta_{VAT}=0.0442$**	4.9737	**$\delta_{VAT}=0.0374$**	4.9796	**$\delta_{VAT}^*=0.0334$**	4.9927	**$\delta_{VAT}^*=0.0172$**	4.9961
MC_{VAT}	**$\sigma=2.4$**	**$\upsilon=1$** **$\mu=4$**	5.1928		5.1909		5.1788		5.1511
		$\upsilon=1.35$ **$\mu=2.96296$**	4.9838		5.0017		5.0057		5.0239
		$\upsilon=1.4$ **$\mu=2.8571$**	4.9624		4.9824		4.988		5.0109
		$\upsilon=1.7142$ **$\mu=2.3345$**	4.8571		4.8870		4.9007		4.9468
	$\sigma=3.5$	**$\upsilon=1$** **$\mu=4$**	5.0852		5.0844		5.0641		5.0472
		$\upsilon=1.35$ **$\mu=2.96296$**	4.9557		4.9724		4.9777		4.9968
		$\upsilon=1.4$ **$\mu=2.8571$**	4.9425		4.9610		4.9689		4.9916
		$\upsilon=1.7142$ **$\mu=2.3345$**	4.8773		4.9045		4.9253		4.9662
Optimal tax rates: FC vs RST		**$\tau^*_{RST}=0.2217$ $\tau^*_{FC}=0.2$**		**$\tau^*_{RST}=0.2195$ $\tau^*_{FC}=0.2$**		**$\tau^*_{RST}=0.2184$ $\tau^*_{FC}=0.2$**		**$\tau^*_{RST}=0.2147$ $\tau^*_{FC}=0.2$**	

Note: Numerical simulations based on Eq. (11) and Table 1. Note that $\upsilon=1.71$ and $\upsilon=1.4$ are the Dixit-Stiglitz values of love of variety for $\sigma=2.4$ and $\sigma=3.5$, respectively. The shaded cells represent examples when $MC_{VAT}<MB_{VAT}$, implying $\tau^*_{RST}>\tau^*_{VAT}>\tau=\tau^*_{FC}$. For the remaining cells, $\tau^*_{RST}>\tau=\tau^*_{FC}>\tau^*_{VAT}$.

6. Conclusion

This paper has considered the positive and welfare implications of an increase in the substitution elasticity by presenting a model of a closed, monopolistically competitive economy with free entry and exit of firms and VAT evasion. The paper has shown that, when the mode of VAT evasion consists in simultaneous under-reporting of sales and input VAT credits, an increase in the substitution elasticity improves VAT compliance, as long as it increases the cost of unrecovered input VAT. Consequently, in a symmetric general equilibrium solution, tax revenues rise and social welfare improves. The latter result, however, requires that the value of the love of variety parameter is set equal to or less than the one corresponding to the Dixit-Stiglitz specification of CES preferences. When the model considers a utility-enhancing public good, the optimal VAT tax rate trades off production efficiency and revenue efficiency. Numerical examples show that an increase in the substitution elasticity leads to a higher optimal VAT tax rate.

This paper has interpreted an increase in the substitution elasticity as the potential outcome of un-modelled product market reforms and liberalisation. A possible policy implication is that these reforms can permanently reduce the VAT evasion component associated with simultaneous under-declaration of output VAT liabilities and input VAT credits. This mode of VAT evasion is of policy relevance in countries like Italy, where crosschecking of VAT records submitted by different firms to the tax authority is not automatically available in electronic form and where the sales-input ratio is taken as a proxy of suspicion of VAT evasion. In such situations, it is likely that firms will consider under-reporting of VAT registered input purchases as a necessary step for safer output VAT evasion. In other words, firms engaged in output VAT evasion will deliberately under-declare their input VAT credits because they do not want to exhibit a suspiciously low sales-input ratio (MEF, 2014: .87).

To tackle this mode of VAT evasion, in 2014 the Italian government under Matteo Renzi as PM enacted measures for improving firm voluntary compliance (art. 44 of Law 190/2014). These include sending letters to firms showing suspiciously low sales-input ratios according to an official benchmark (termed *spesometro* or “expenditure-meter”) and inviting them to resubmit their VAT returns. The Italian government estimates that, thanks to this measure, up to €2.58 billion of VAT revenue could be recovered over the years 2015-2017. The analysis of this paper suggests that enhancing product market competition could improve firm voluntary compliance and increase VAT revenues in the longer run.

Appendix

Appendix 1 Derivation of Eq.s (4) and (5) (see Section 4).

Maximising Eq. (3) with respect to x_{ji} and δ_{ji} yields the FOCS:

$$\partial\pi_{ji} / \partial x_{ji} = p_{ji}[1-1/\sigma]\left[1-T_{\mathbf{ji}}{}^{e*}\right] - w - \tau P_L \delta^*_{ji}\,\Phi = 0$$

$$\partial\pi_{ji} / \partial\delta_{ji} = -p_{ji}x_{ji}[-\tau(1-\lambda\psi)+\delta^*_{ji}] - \tau P_L x_{ji}\Phi = 0 \qquad \text{(A.1)},$$

with i= RST, VAT, $T_{ji}{}^{e*} \equiv [\tau(1-\delta^*_{ji}(1-\lambda\psi)) + (\delta^*_{ji})^2/2] \leq \tau$ and $w \equiv 1$. The FOCS refer to the RST (or to the VAT with full input credit refund) for $\Phi=0$, and to the VAT with input credit under-reporting for $\Phi=1$.

The SOCS are:

$$\partial^2\pi_{ji}/(\partial x_{ji})^2 = (\partial p_{ji}/\partial x_{ji})(1-1/\sigma)(1-T_{ji}{}^{e*}) < 0$$

$$\partial^2\pi_{ji}/(\partial\delta_{ji}{}^2) = -p_{ji}x_{ji}\left[1-(\partial \ln p_{ji}/\partial\delta_{ji})\tau(P_L/p_{ji})\Phi\right] = \qquad \text{(A.2)},$$

$$= -p_{ji}x_{ji}\left\{1-\left(\frac{\sigma-1}{\sigma^2}\right)(1-T_{ji}{}^{e*})\left(\frac{\tau\Phi}{1-\tau\Phi(1-\delta^*_{ji})}\right)^2\right\} < 0 \ \ \textbf{for } \mathbf{0} \leq \tau \leq \mathbf{0.5}$$

where we made use of Eq. (A.1) to derive $\partial \ln p_{ji}/\partial\delta_{ji} > 0$. In Eq. (A.2) $\sigma>1$, $\lambda<1$, $\psi>1$, $0 \leq \delta^*_{ji} < 1$; $0<\tau\leq 0.5$ is a sufficient condition for the SOC for the optimal degree of evasion to be negative when $\Phi=1$. The FOC for the optimal degree of tax evasion can be written as:

$$\delta^*_{ji} = \tau(1-\lambda\psi) - \tau(P_L/p_{ji})\Phi\,. \qquad \text{(A.3)},$$

where $0 \leq \delta^*_{ji} \leq \tau$. In Eq. (A.3), the last RHS term is the additional expected marginal cost of VAT evasion that is related to unrecovered input VAT credits. This term is absent when $\Phi=0$. In this latter case, Eq. (A.3) corresponds to Eq. (4.1) in section 4. Substituting this expression into the FOC for the optimal level of output, yields the equilibrium price reported in Eq. (4.2) section 4 as the solution to the RST case. Assume now that $\Phi=1$, corresponding to the VAT cum input credit under-reporting case. From Eq. (A.3) it turns out that the additional cost of VAT evasion is proportional to the real producer price of intermediate inputs. This price is derived from the FOC for the optimal output level, Eq. (A.1). Using $w \equiv 1 = P_L - \tau\,\Phi P_L$, Eq. (A.1) can be written as (with $\Phi=1$):

$$\partial\pi_{jVAT} / \partial x_{jVAT} = p_{jVAT}[1-1/\sigma](1-T_{jVAT}{}^{e*}) - P_L[1-\tau+\tau\delta^*_{jVAT}] = 0,$$

yielding: $$\frac{\mathbf{P_L}}{\mathbf{p_{jVAT}}} = \left[\frac{\sigma-1}{\sigma}\right]\left[\frac{1-t_{VAT}e^* + \delta_{VAT}{}^*(\delta_{RST}{}^* - \delta_{VAT}{}^*)}{1-\tau+\tau\delta^*_{jVAT}}\right] < 1 \qquad \text{(A.4)}$$

with $\delta^*_{jRST} = \delta^*_{RST} = \tau(1-\lambda\psi)$, $\delta^*_{jVAT} = \delta^*_{VAT}$ and $T_{jVAT}{}^{e^*} = T_{VAT}{}^{e^*}$ in symmetric equilibrium, where $T_{VAT}{}^{e^*} = t_{VAT}e^* - \delta_{VAT}{}^*\left(\delta_{RST}{}^* - \delta_{VAT}{}^*\right)$ and $t_{VAT}e^* = \tau - \delta^2_{VAT}/2$. Eq. (A.4) gives the real price in implicit form. (This is less than unity under our assumptions). Using Eq. (A.4) into (A.3) with $\Phi=1$ yields:

$$\begin{aligned} & A(\delta_j^*)^2 + B\delta_j^* + D = 0 \\ & A \equiv \tau[\sigma+1]/2 > 0; \\ & B \equiv \sigma(1-\tau) - \tau^2(1-\lambda\psi) > 0 \\ & \mathbf{D} \equiv \tau\mathbf{(1-}\tau\mathbf{)[}\sigma\lambda\psi - 1] \end{aligned} \qquad \text{(A.5)},$$

$0<\tau\leq 0.5$, namely the sufficient condition for the SOC to hold (see Eq. A.2), is imposed in Eq. (A.5). Thus, if $D\geq 0$, the optimal degree of VAT evasion is $\delta^*_{jVAT}=0$. If $D<0$, it is $0<\delta^*_{jVAT}<1$. This latter case corresponds to the positive root of the quadratic equation. The necessary and sufficient condition for honest reporting is $D\geq 0$, namely $\lambda\geq 1/(\sigma\psi)$. If $D<0$, namely if $0\leq\lambda<1/(\sigma\psi)$, the solution is given by Eq. (5.1) in section 4.

Proof of Proposition 1. Provided $0<\delta^*_{jVAT}<1$, totally differentiating Eq. (A.5), yields (with $\psi>1$):

$$\partial\delta^*_{jVAT}/\partial\sigma = -\left[\frac{(\delta^*_{jVAT})^2[\tau/2] + \delta^*_{jVAT}(1-\tau) + \tau(1-\tau)\lambda\psi)}{2\delta^*_{jVAT}A + B}\right] < 0 \qquad \text{(A.6)}.$$

Comparative statics for the optimal degree of VAT tax evasion (see Eq. 5.1 in section 4)

Provided $0<\delta^*_{jVAT}<1$, totally differentiating the FOC for the optimal degree of VAT evasion, yields

$$\begin{aligned} & \partial\delta^*_{jVAT}/\partial\psi = -\tau\lambda\left[\frac{\delta^*_{jVAT}\tau + (1-\tau)\sigma}{2\delta^*_{jVAT}A + B}\right] < 0 \\ & \partial\delta^*_{jVAT}/\partial\lambda = -\tau\psi\left[\frac{\delta^*_{jVAT}\tau + (1-\tau)\sigma}{2\delta^*_{jVAT}A + B}\right] < 0 \\ & \partial\delta^*_{jVAT}/\partial\tau = -\left[\frac{(\delta^*_{jVAT})^2(\sigma+1)/2 - \delta^*_{jVAT}[\sigma + 2\tau(1-\lambda\psi)] + (1-2\tau)[\sigma\lambda\psi - 1]}{2\delta^*_{jVAT}A + B}\right] \end{aligned} \qquad \text{(A.7)}.$$

The sign of the last derivative depends on the size of δ^*_{jVAT}. The numerical examples of Table 1 show that: $\partial\delta^*_{jVAT}/\partial\tau>0$, other things being equal. Differentiating Eq. (5.1) with respect to p_{jVAT} and σ yields:

$$\partial p_{jVAT}/\partial\sigma = -\left[\frac{1+s^{VAT}}{(\sigma-1)^2}\right] + \left(\frac{\sigma}{\sigma-1}\right)\frac{\partial(1+s^{VAT})}{\partial\sigma} < 0,$$

$$\frac{\partial(1+s^{VAT})}{\partial\sigma} = \left[\frac{(1-\tau)[\tau - (\delta_{RST} - \delta_{VAT})] + \tau\delta^2_{VAT}/2}{(1-\tau)[1-\tau+\delta^2_{VAT}/2 + \delta_{VAT}(\delta_{RST} - \delta_{VAT})]}\right]\frac{\partial\delta_{VAT}{}^*}{\partial\sigma} < 0 \qquad \text{(A.8)},$$

using $(\delta_{RST} - \delta_{VAT}) = \tau P_L/p_{jVAT} < \tau$.

Appendix 2.

Proof of Lemma 1.

Consider Table 2. By direct computation, it follows that:

i) $n_{FC} < n_{VAT} < n_{RST}$, as long as: $\delta_{VAT}{}^* < \delta_{RST}{}^* < \tau \leq 1/2$ **and** $\mathbf{t}_{\mathbf{RST}}{}^{\mathbf{e*}} < \mathbf{t}_{VAT}{}^{e*} < \tau$.

ii) $x_{jVAT} \leq x_{jFC} = x_{jRST}$ as long as $\tau\delta_{VAT} \geq 0$.

iii) $p_{jVAT} = [1/(1-\tau)]\{(1-\tau+\tau\delta_{VAT})/[(1-\tau+\delta^2_{VAT}/2+\delta_{VAT}(\delta_{RST}-\delta_{VAT})]\} > p_{jFC} = [1/(1-\tau)] > p_{jRST} = 1/(1-\tau+\delta_{RST}{}^2/2)$. The first inequality is met as long as $\tau > \delta_{RST} > 0$, the second inequality holds as long as $\delta_{RST} > 0$.

iv) $P_{VAT} \geq P_{FC} > P_{RST}$ for $1 < \upsilon \leq \upsilon^*$ (with strict inequality for $\upsilon = 1$); or $P_{FC} > P_{VAT} > P_{RST}$ for $\upsilon > \upsilon^* > 1$. Note that $P_{RST} < P_{FC}$ and $P_{RST} < P_{VAT}$ by using i) and ii) and the definition of a price index. Define υ^* as the value of υ such that $P_{VAT} = P_{FC}$. Equating the price indices, simplifying and taking logs, it turns out that $\upsilon^* = \ln[(1-\tau+\tau\delta_{VAT})/(1-\tau)]/\ln[(1-\tau+\delta_{VAT}(\delta_{RST}-\delta_{VAT}{}^2/2)/(1-\tau)] > 1$. Thus, for $\upsilon \leq \upsilon^*$, we have $P_{VAT} \geq P_{FC} > P_{RST}$, whereas $P_{FC} > P_{VAT} > P_{RST}$ for $\upsilon > \upsilon^* > 1$.

v) $C_{VAT} \leq C_{FC} < C_{RST}$ for $\upsilon \leq \upsilon^*$; $C_{FC} < C_{VAT} < C_{RST}$ for $\upsilon > \upsilon^* > 1$, as long as $C_i = \mu/P_i$, i=FC, RST, VAT.

vi) $\delta^*_{VAT} < \delta^*_{RST.}$ Using (A.3) $\delta^*_{VAT} = \delta^*_{RST} - \tau P_L/p_{jVAT} < \delta^*_{RST.}$

vii) $R_{FC} = \mu\tau > R_{VAT} = \mu\, t_{VAT}{}^{e*} > R_{RST} = \mu\, t_{RST}{}^{e*}$, as long as $t_{RST}{}^{e*} < t_{VAT}{}^{e*} < \tau$.

viii) $Y_{FC} = (H-\mu) + R_{FC} > Y_{VAT} = (H-\mu) + R_{VAT} > Y_{RST} = (H-\mu) + R_{RST}$ using vii).

ix) $N_{FC} = H - Y_{FC} < N_{VAT} = H - Y_{VAT} < N_{RST} = H - Y_{RST}$ using Eq. (7) and viii).

x) SWs are derived by taking first-order Taylor expansions of the log terms around zero, as long as $\delta_i < \tau \leq 1/2$, such that $\ln(1-x) \approx -x$. It turns out that: $SW_{RST} \approx K + \mu(\tau - \delta_{RST}{}^2/2)(1-\upsilon)$; $SW_{FC} \approx K + \mu\tau(1-\upsilon)$; and $SW_{VAT} \approx K + \mu\tau(1-\upsilon) + \mu\ \delta_{VAT}[\upsilon(\delta_{RST}-\delta_{VAT}/2)-(\tau+\delta_{VAT}/2)]$. Thus: $SW_{RST} - SW_{FC} = \mu(\upsilon-1)\ \delta_{RST}{}^2/2 \geq 0$ for $\upsilon \geq 1$. $SW_{RST} - SW_{VAT} = (\mu/2)[(\upsilon(\delta_{RST}-\delta_{VAT})^2-(\delta_{RST}{}^2-\delta_{VAT}{}^2)+2\tau\ \delta_{VAT})]$. A sufficient condition for $SW_{RST} - SW_{VAT} > 0$ is $\upsilon > \underline{\upsilon} = (\delta_{RST}{}^2-\delta_{VAT}{}^2-2\tau\ \delta_{VAT})/[(\delta_{RST}-\delta_{VAT})^2]$. This is met for any $\upsilon \geq 1$, as long as $\underline{\upsilon} < 1$. Then,

$SW_{FC} - SW_{VAT} = \mu\ (\delta_{VAT}/2)[(1-\upsilon)\ \delta_{VAT} - 2\upsilon(\delta_{RST}-\delta_{VAT})+2\tau]$. Thus, $SW_{FC} \geq SW_{VAT}$ for $1 < \upsilon \leq \upsilon^{**}$ and $SW_{FC} < SW_{VAT}$ for $\upsilon > \upsilon^{**}$, where $\upsilon^{**} = (2\tau+\delta_{VAT})/(2\delta_{RST}-\delta_{VAT}) > 1$. It follows that $SW_{RST} = SW_{FC} > SW_{VAT}$ for $\upsilon = 1$; $SW_{RST} > SW_{FC} \geq SW_{VAT}$ for $\upsilon^{**} \geq \upsilon > 1$; $SW_{RST} > SW_{VAT} > SW_{FC}$ for $\upsilon > \upsilon^{**} > 1$.

Proof of Proposition 2

Using Table 1, it follows that

i) Number of firms:

$d\ln(n_{RST})/d\sigma = d\ln(n_{FC})/d\sigma = -1/\sigma < 0$;

$d\ln(n_{VAT})/d\sigma = -(1/\sigma) + \{(\delta_{RST} - \delta_{VAT})/[1 - t_{VAT}^{e} + \delta_{VAT}(\delta_{RST} - \delta_{VAT})]\}(\partial\delta_{VAT}/\partial\sigma) < 0$, given that $\delta_{RST} > \delta_{VAT}$ and $\partial\delta_{VAT}/\partial\sigma < 0$ from (A.3) and (A.6).

Firm level prices:

$d\ln p_{jRST}/d\sigma = d\ln p_{jFC}/d\sigma = -1/[\sigma(\sigma-1)] < 0$;

$d\ln p_{jVAT}/d\sigma = -1/[\sigma(\sigma-1)] + \{[(\tau - \delta_{RST} + \delta_{VAT})(1-\tau) + \tau\, \delta_{VAT}^{2}/2]/[(1-\tau+\tau\delta_{VAT})(1-\tau+\delta_{RST}\, \delta_{VAT} - \delta_{VAT}^{2}/2)]\}\ \partial\delta_{VAT}/\partial\sigma < 0$, where the first RHS term is the mark-up effect and the second RHS term the compliance effect, with $\partial\delta_{VAT}/\partial\sigma < 0$ from (A.6).

ii) $d\ln x_{jRST}/d\sigma = d\ln x_{jFC}/d\sigma = 1/(\sigma-1) > 0$; $d\ln x_{jVAT}/d\sigma = 1/(\sigma-1) - [\tau/(1-\tau+\tau\, \delta_{VAT})]\ \partial\delta_{VAT}/\partial\sigma > 0$, using (A.6).

iii) $d\ln P_i/d\sigma = (1-\upsilon)d\ln(n_i)/d\sigma + d\ln p_{ji}/d\sigma$. Using i), yields: $d\ln P_{RST}/d\sigma = d\ln P_{FC}/d\sigma = [(\upsilon-1)(\sigma-1)-1]/[\sigma(\sigma-1)]$. Thus, $d\ln P_{RST}/d\sigma = d\ln P_{FC}/d\sigma < 0$ for $1 \le \upsilon < \sigma/(\sigma-1)$, where $\sigma/(\sigma-1)$ is the Dixit-Stiglitz value of love of variety. Moreover, using i), yields:

$d\ln P_{VAT}/d\sigma = [(\upsilon-1)(\sigma-1)-1]/[\sigma(\sigma-1)] + \{\tau\Gamma/[(1-\tau+\tau\delta_{VAT})(1-\tau+\delta_{RST}\, \delta_{VAT} - \delta_{VAT}^{2}/2)]\}\partial\delta_{VAT}/\partial\sigma$, where the second RHS term is the compliance effect, $\partial\delta_{VAT}/\partial\sigma < 0$, and $\Gamma \equiv (1-\upsilon)(P_L/p_{jVAT})(1-\tau+\tau\delta_{VAT}) + (1-\tau)[1-(P_L/p_{jVAT})] + \delta_{VAT}^{2}/2$. Rearranging, using (A.4), yields $\Gamma \equiv (1-\tau) - \upsilon[(\sigma-1)/\sigma](1-\tau+\delta_{RST}\delta_{VAT} - \delta_{VAT}^{2}/2) + \delta_{VAT}^{2}/2 + \delta_{VAT}\, \tau(P_L/p_{jVAT})$. For $\upsilon = \sigma/(\sigma-1)$, using (A.3) such that $\tau(P_L/p_{jVAT}) = \delta_{RST} - \delta_{VAT}$, yields $\Gamma \equiv -\delta_{RST}\delta_{VAT} + \delta_{VAT}^{2}/2 + \delta_{VAT}^{2}/2 + \delta_{VAT}(\delta_{RST} - \delta_{VAT}) = 0$. Thus, $\Gamma \ge 0$ for $1 < \upsilon \le \sigma/(\sigma-1)$. It follows that $d\ln P_{VAT}/d\sigma < 0$ for $1 \le \upsilon < \sigma/(\sigma-1)$.

iv) $d\ln R_{RST}/d\sigma = d\ln R_{VAT}/d\sigma = 0$; $d\ln R_{VAT}/d\sigma = d\ln t_{VAT}^{e}/d\sigma = -\delta_{VAT}(\partial\delta_{VAT}/\partial\sigma)/t_{VAT}^{e} > 0$, using (A.6).

v) $dSW_{RST}/d\sigma = dSW_{FC}/d\sigma = \mu[\sigma - \upsilon(\sigma-1)]/[\sigma(\sigma-1)] \ge 0$ for $\upsilon \le (\sigma-1)/\sigma$; $dSW_{VAT}/d\sigma = \mu\, dt_{VAT}^{e}/d\sigma - \mu d\ln P_{VAT}/d\sigma$. Using iii) and iv), this is written as:

$dSW_{VAT}/d\sigma = -\mu\delta_{VAT}(\partial\delta_{VAT}/\partial\sigma) - \mu\{[(\upsilon-1)(\sigma-1)-1]/[\sigma(\sigma-1)] + \{\tau\Gamma/[(1-\tau+\tau\delta_{VAT})(1-\tau+\delta_{RST}\delta_{VAT} - \delta_{VAT}^{2}/2)]\}\partial\delta_{VAT}/\partial\sigma\}$.

The first RHS term is always positively signed, considering that $\partial\delta_{VAT}/\partial\sigma < 0$; the second RHS term in square brackets is lower than or equal to zero for $\upsilon \le (\sigma-1)/\sigma$. Thus, with the VAT, an increase in the substitution elasticity improves social welfare, provided $\upsilon \le (\sigma-1)/\sigma$.

Appendix 3 Optimal tax rates (see section 5).

Using Eq.t (11), with δ_{RST} = τ(1-λψ), yields $MC_{FC} \equiv \mu\upsilon\left(\frac{1}{1-\tau}\right)$ and $MC_{RST} \equiv \mu\upsilon\left(\frac{1-\tau(1-\lambda\psi)^2}{1-\tau+(\tau(1-\lambda\psi))^2/2}\right)$

for a given tax rate τ. By direct computation: $MC_{FC} - MC_{RST} \equiv \left[\frac{\mu\upsilon\delta_{RST}(1-\lambda\psi)(1-\tau/2)}{(1-\tau)(1-\tau+\delta_{RST}^2/2)}\right] > 0.$

Moreover: $MB_{FC} = \frac{1}{\tau}$ and $MB_{RST} = \left(\frac{1-\delta_{RST}\frac{\partial\delta_{RST}}{\partial\tau}}{\tau-(\delta_{RST})^2/2}\right)$. Thus: $MB_{FC} - MB_{RST} \equiv \left[\frac{\delta_{RST}^2/2}{\tau(\tau-\delta_{RST}^2/2)}\right] > 0.$

Using Eq. (11), the optimal FC tax rate is: $\tau^*_{FC} = \frac{1}{1+\mu\upsilon}$. Evaluating the FOC for RST at τ^*_{FC}, yields:

$MB_{RST} - MC_{RST} \equiv \left[\frac{\left(1-\tau^*_{FC}(1-\lambda\psi)^2\right)(1+\mu\upsilon)\delta^2_{RST}/2}{(1-\tau^*_{FC}+\delta^2_{RST}/2)(\tau^*_{RST}-\delta_{RST}^2/2)}\right] > 0.$ Thus, $\tau^*_{RST} > \tau^*_{FC}$. Using Eq. (11), the optimal RST tax rate solves: $\tau^2\frac{(1-\lambda\psi)^2}{2} - \tau + \frac{1}{1+\mu\upsilon} = 0.$ It follows that:

$\tau^*_{RST} = \frac{1-\sqrt{1-2(1-\lambda\psi)^2/(1+\mu\upsilon)}}{(1-\lambda\psi)^2} = \frac{1-\sqrt{1-2(1-\lambda\psi)^2\tau^*_{FC}}}{(1-\lambda\psi)^2}$. The condition ½> τ^*_{RST} implies that $1/2-(1-\lambda\psi)^2/8 > \tau^*_{FC}$, from which yields the condition reported in section 5. If the SOCS are negatively signed, $\tau^*_{RST}, \tau^*_{FC}$ maximise social welfare in the corresponding regimes. From Eq. (11), yields the SOC for FC: $-\left[\frac{1}{\tau^2}+\frac{\mu\upsilon}{(1-\tau)^2}\right] < 0$; the SOC for RST is

$-(1-\tau(1-\lambda\psi)^2)^2\left\{\frac{1}{(\tau-\delta^2_{RST}/2)^2}+\frac{\mu\nu}{(1-\tau+\delta^2_{RST}/2)^2}\right\} < 0$.

We now show that $MB_{FC}>MB_{VAT}$ for given τ. From Eq. (11) in section 5, recall that $MB_{VAT} = \left(\frac{1-\delta_{VAT}\frac{\partial\delta_{VAT}}{\partial\tau}}{\tau-(\delta_{VAT})^2/2}\right)$. Thus: $MB_{FC} - MB_{VAT} \equiv \left[\frac{\delta_{VAT}^2}{\tau(\tau-\delta_{VAT}^2/2)}\right]\left(\frac{\partial\ln\delta_{VAT}}{\partial\ln\tau}-\frac{1}{2}\right) > 0$, given that: $\frac{\partial \ln \delta_{\mathrm{VAT}}}{\partial \ln \tau}$ =1- $\frac{\tau P_L / p_{ji}}{\delta_{VAT}} \left(\frac{\partial \ln(P_L / \mathrm{p}_{\mathrm{jVAT}})}{\partial \ln \tau} \right) > \frac{\partial \ln \delta_{\mathrm{RST}}}{\partial \ln \tau}$ =1, using (A.3), as long as, from (A.4), and after rearrangement, yields:

$$\left(\frac{\partial \ln(P_L / \mathrm{p}_{\mathrm{jVAT}})}{\partial \ln \tau} \right) =$$

$$-\tau \left\{ \frac{(1-\tau)\left[\left(1-\frac{P_L}{p_{jVAT}}\right)\tau\left(\frac{\partial \delta_{VAT}}{\partial \tau}\right)+\lambda\psi\delta_{VAT}\right]+\frac{\tau\delta^2{}_{VAT}}{2}\left(\frac{\partial \delta_{VAT}}{\partial \tau}\right)+\delta_{VAT}\left[(\tau-\delta_{RST})+(1-\delta_{VAT})\frac{\delta_{VAT}}{2}\right]}{\left[1-\tau+\delta_{VAT}(\delta_{RST}-\delta_{VAT}/2)\right]\left[1-\tau+\tau\delta_{VAT}\right]} \right\} < 0$$

where $P_L/p_{jVAT}<1$, $0<\delta_{VAT}<1$, $\partial\delta_{VAT}/\partial\tau>0$. Thus, the real producer price of intermediates is a decreasing function of the tax rate τ. This implies that the elasticity of evasion with respect to the tax rate is larger with the VAT than RST: $\frac{\partial \ln \delta_{\mathrm{VAT}}}{\partial \ln \tau} > \frac{\partial \ln \delta_{\mathrm{RST}}}{\partial \ln \tau}$ =1. In other words, VAT evasion is more sensitive to the tax rate than RST evasion. The reason for this result is that an increase in the tax rate has two opposite effects on the cost of unrecovered input VAT. First, it raises the cost, for given real producer price of intermediate goods. Second, it lowers the cost, given that such a price falls with the tax rate.

Table 3 in section 5 reports numerical examples showing that $MB_{FC} > MB_{VAT} > MB_{RST}$; the same numerical examples show that, depending on parameter values, either $MC_{VAT} \geq MC_{FC} > MC_{RST}$ or $MC_{FC} > MC_{VAT} > MC_{RST}$, where the MCs are evaluated at a common τ=0.2. This is assumed to be equal to the optimal FC tax rate, namely $\tau^*_{FC} = \frac{1}{1+\mu\upsilon}$ =0.2, implying $\mu\upsilon$=4. Table (A.3) below reports the differences between MBs and MCs for the parameter values considered in Table 3. By construction, this difference is equal to zero with FC. Note that the difference between MBs and MCs is always positive and larger for the RST than the VAT. Thus, the optimal RST tax rate is larger. The optimal VAT tax rate is set above (below) the FC one when the computed difference between MBs and MCs takes on a positive (negative) value.

Table A.3 Differences between MBs and MCs evaluated at $\tau=\tau^*_{FC}=0.2$

			λ=0.05 ψ=1.2	λ=0.05 ψ=2	λ=0.1 ψ=1.2	λ=0.1 ψ=2
MB_{FC}-MC_{FC}			0	0	0	0
MB_{RST}- MC_{RST}			0.488	0.453	0.435	0.367
MB_V-MC_V	**σ=2.4**	**υ=1** **μ=4**	-0.261	-0.250	-0.226	-0.176
		υ=1.35 **μ=2.96296**	-0.052	-0.061	-0.052	-0.049
		υ=1.4 **μ=2.8571**	-0.030	-0.041	-0.035	-0.036
		υ=1.7142 **μ=2.3345**	0.075	0.054	0.053	0.028
	σ=3.5	**υ=1** **μ=4**	-0.111	-0.105	-0.071	-0.051
		υ=1.35 **μ=2.96296**	0.018	0.007	0.015	-0.001
		υ=1.4 **μ=2.8571**	0.031	0.019	0.024	0.005
		υ=1.7142 **μ=2.3345**	0.097	0.075	0.067	0.030

Note: Numerical simulations based on Eq. (11), Table 1 in section 4 and Table 3 in section 5. Note that υ=1.71 and υ=1.4 are the Dixit-Stiglitz values of love of variety for σ=2.4 and σ=3.5, respectively. Each cell represents the difference between MBs and MCs evaluated at $\tau^*_{FC}=0.2$. When the difference is positive, the corresponding optimal tax rate is higher than the optimal FC tax rate. When the difference is negative, the opposite is true.

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