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Tax avoidance and fiscal limits:
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Abstract:

The paper extends the QUEST III model by home production to discuss fiscal limits in an economy with tax avoidance. It finds that revenue-maximising labour and corporate tax rates in the benchmark model are relatively high (54% and 72%) compared to current EU-average implicit tax rates. No such limit is found for the consumption tax. Higher substitutability between market and home production flattens the Laffer curves for labour and corporate taxation and introduces one for the consumption tax. Although higher tax rates raise additional tax revenue, the economic costs of higher distortionary taxation in terms of output contraction are substantial.

JEL classification: E62, H20, H30

Keywords: Fiscal limits, distortionary taxes, Laffer curve, informal sector

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1. Introduction

Government debt to GDP has risen in EU member states as a consequence of the financial and economic crisis, long-term demographic trends, fiscal profligacy, or a mix of these components. Where current fiscal positions make public debt unsustainable, consolidation is needed. In this context, it is important to analyse the feasibility of alternative consolidation schemes, which depends on the likely effects of fiscal measures on the economy. Such feasibility constraints can be labelled as *fiscal limits* and the distance between the limits and current fiscal positions as *fiscal space* in a given situation.

The fiscal limits may depend on economic and political factors alike, as reflected in the two main strands of the literature on the determinants of fiscal limits (e.g. Leeper and Walker, 2011): The *economic* approach focuses on the economic limits to tax collection, which depend on the response of tax bases to tax policies. The *political* approach relates fiscal limits to the political economy of taxation and government spending and is based on the observation that electorates tend to show limited support for tax increases or expenditure cuts. The political limits can be inferred from estimated fiscal reaction functions (e.g., Ghosh et al., 2011).

The concept of fiscal limits is, in principle, applicable to the revenue side and the expenditure side of public finances, i.e. it may refer to the ability to either generate additional revenue or reduce non-interest expenditure. This paper focuses on the limits of taxation, i.e. the revenue side of the government budget, which appears inherently more exposed to economic as opposed to political limits. Depending on its impact on productivity and production, economic limits to expenditure reduction might exist for public investment.

The paper offers a general-equilibrium analysis of economic limits to taxation. The general-equilibrium approach captures direct and indirect effects of policy measures, i.e. the first-round mechanical impact of a tax rate increase on tax revenue at a given tax base and the second-round effect of tax rates on their own or other tax bases, which is the other crucial determinant of the amount of tax revenue collected.

The analysis in this paper builds on the concept of Laffer curves that relate tax revenues to tax rates. Laffer curves have an inverted U-shape, because distortionary taxation reduces the tax base on which tax revenue is collected. Increasing labour taxation, e.g., widens the wedge between net wages and labour costs and reduces taxable official employment. Capital income taxation introduces a wedge between investment costs and the net returns to capital, which tends to reduce the equilibrium stock of productive capital. Taxing consumption reduces the purchasing power of income and affects the choice between consumption and leisure, or the choice between official and informal activity.

The peak of the Laffer curve shows the revenue-maximising tax rate. It is the point at which direct and indirect tax base contraction offsets the positive impact of further tax

increases on the total tax revenue. Raising taxes beyond the peak reduces the total tax revenue.

The paper analyses the revenue functions for labour income, corporate income and consumption taxes in the QUEST III model for an average EU member state. The paper adds an informal sector in the form of home production to the open-economy framework. Home production is modelled as informal alternative to activity in the official sector. Neither informal activity nor informal output is taxed.

Home production gives rise to tax avoidance by relocating activity from the official to the informal sector, which tends to increase the sensitivity of tax bases to distortionary taxes. It can therefore be expected to affect the shape and location of Laffer curves. The open-economy framework furthermore addresses some aspects of cross-border tax competition.

The exercise relates to existing work on fiscal limits in general-equilibrium models. Trabandt and Uhlig (2010) present Laffer curves for labour and corporate income taxation in a neoclassical growth model with perfect competition and derive Laffer curves for the US, the EU aggregate and individual EU member states. Busato and Chiarini (2009) derive Laffer curves for income and corporate taxation in an economy with shadow sector and find a strong impact of the shadow economy on the limits to taxation. Contrary to the present paper, Busato and Chiarini (2009) treat informal production as an illegal activity, making the choice between official and informal activity a function of detection probabilities and penalties. Neither does the present paper address other concepts of tax avoidance or evasion, such as not declaring income and tax base erosion from shifting between forms of compensation, which are discussed by Piketty et al. (2011), Saez et al. (2009), and Slemrod and Yitzhaki (2000).

The paper focuses on economic limits to distortionary taxation and attempts to quantify the limits in the QUEST model, which can subsequently be compared against actual tax rates at EU-average and country levels. The paper also discusses the associated economic costs in terms of output contraction. The political limits to taxation are certainly important, but difficult to model in a general way. Any assessment of the fiscal limits should, however, acknowledge that political constraints might be tighter than the economic ones.

2. Model

The QUEST III model is an open-economy New-Keynesian dynamic general equilibrium model with optimising households and firms, international goods and capital market integration and monetary and fiscal policy. Ratto *et al.* (2009) provide a detailed description of the model and estimate it on euro area data. The present section augments a one-country version of QUEST with home production.

Including home production provides a framework for modelling tax avoidance by work in

the informal sector. Models of home production have been developed by Benhabib et al. (1991), Campbell and Ludvigson (2001), Gomme et al. (2001), Greenwood and Hercowitz (1991), McGrattan et al. (1997), and Zhang et al. (2008). This paper uses a simplified model version, which abstracts from capital accumulation in home production. Instead, home production uses labour as the only input.

Home production is a way of modelling a shadow sector of the economy. Contrary to Busato and Chiarini (2009) informal production is not conceived as a strategy of firms to evade taxation in the production of a homogeneous good, but as household activity that produces home consumption goods, which are imperfect substitutes for output of the official sector. The work and output of the informal sector are untaxed.

Home production captures the responsiveness of official and informal activity to changes in labour and consumption taxes. In the model, households decide about the allocation of work effort to official and shadow activities based on the real net consumption wage from official employment and the alternative return from home production. Income and sales taxes affect this trade-off and the households' decisions. Growing substitutability between the two sectors amplifies the negative impact of tax increases on tax bases and tightens the fiscal limit.

In addition, the open-economy structure captures aspects of international tax competition. Within the framework, rising corporate tax rates in one country affect the relative return on domestic and internationally traded assets and trigger capital outflows from the respective economy.

The model bases taxation on the residence principle, but allows for cross-border arbitraging of asset returns. Optimal portfolio allocation requires the net returns to capital to be equal across assets and countries. For example, taxing the return on corporate investment, while exempting returns on domestic or foreign government bonds, will distort the portfolio allocation towards sovereign debt. These elements are in line with the discussion in Mendoza and Tesar (1998, 2005). Incorporating this form of after-tax return arbitrage in the model does, however, not address issues like the viability of residence-based taxation when households and integrated firms can shift tax bases across jurisdictions. The model also excludes other elements of tax competition such as cross-border sales tax arbitrage in the internal market.

QUEST III includes a large set of nominal and real adjustment costs to generate persistence in macroeconomic variables and distinguishes between intertemporal optimising and liquidity-constrained households to reproduce standard business cycle dynamics. This paper focuses on a comparative static analysis of fiscal limits in steady state, where short-term adjustment frictions play no role. It therefore simplifies the presentation of the QUEST model by omitting adjustment frictions for prices and volumes in goods and factor markets and by modelling the entire household sector as continuum of intertemporal optimising households that receive labour, capital, profit and transfer income. The households can borrow in financial markets and invest in financial and productive assets to transfer income over time. Limiting the household sector to one type of household helps focusing the analysis of fiscal space, but precludes an analysis of the distributional

effects of alternative tax policies.

2.1 Production

2.1.1 Market production

The market sector consists of monopolistically competing firms, which sell goods to domestic and foreign households and governments for consumption and investment. Each firm *i* produces output Y^i of a differentiated good under the production function:

$$(1) \qquad Y_t^i = A_t KG_{t-1}^{\alpha_g} \left(K_{t-1}^i\right)^{1-\alpha} \left(L_{M,t}^i\right)^{\alpha}$$

where A is a technology parameter, KG is the stock of public capital, K^i is the firm's capital stock and $L_M{}^i$ is firm level of employment. The parameters α and α_g respectively designate the marginal return to labour and public capital. Firms are owned by the households that receive the return to capital and the profit. Firms are price takers in factor markets and choose the cost-minimising factor mix of physical capital and market employment.

The firms face a CES demand aggregator for their specific output:

$$(2) \qquad Y_t = \left[\int \left(Y_t^i\right)^{\frac{\eta-1}{\eta}} dj\right]^{\frac{\eta}{\eta-1}}$$

where η is the elasticity of substitution between varieties *i*. The demand for variety *i* is given by the function:

$$(3) \qquad Y_t^i = \left(P_t^i / P_t\right)^{-\eta} Y_t$$

The firm sets the price of variety *i* to maximise profits:

$$(4) \qquad \underset{P_t^i}{Max}\, \Pi_t = \frac{P_t^i}{P_t} Y_t^i - \frac{MC_t^i}{P_t} Y_t^i$$

where MC^i is the marginal costs of producing Y^i.

The first-order conditions (FOC) for the firms' decisions are standard. The firms set prices with a mark-up $\eta/(\eta-1)$ over marginal production cost. As firms are identical with respect to the production and demand functions, production and pricing decisions are symmetric, which gives $Y^i=Y$ and $P^i=P$.

2.1.2 Home production

Each household *j* allocates employment between official market and informal home production. Output from home production is not traded between households. Households

produce home goods with decreasing marginal returns to home work (L_H), augmented by technology (A_H).

All output from home production is consumed (C_H):

$$(5) \qquad C_t^j = A_{H,t}\left(L_{H,t}^i\right)^{\gamma}$$

where γ is the elasticity of home production with respect to home work. The assumption of decreasing returns to home work dampens the reallocation of work between market and home production in response to changes in the real net market wage. While Busato and Chiarini (2009) assume constant returns to scale (γ=1), Lemieux et al. (1994) provide micro-econometric evidence for non-market production as concave function of hours worked (γ<1).[1]

2.2 Households

The economy is home to a continuum of households *j* ϵ [0; 1] who work, consume, own the capital stock and invest into domestic and foreign financial assets. Households are subject to an intertemporal budget constraint and can borrow and lend in financial markets to transfer income and smooth consumption over time.

Households allocate the labour effort between the official sector, where they earn the market wage (W), and the home sector, where they produce a utility-generating home good (C_H). While the paper assumes perfect elasticity in the allocation of labour supply between market and non-market activities, the marginal utility of market and home goods is decreasing in respective consumption levels. Market wages are set by trade unions representing the households. The part of the labour force not officially employed in the market sector receives unemployment benefits indexed to market wages.

Households maximise welfare as the discounted sum of utility:

$$(6) \qquad \max U_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left[\ln C_t^j + \frac{\omega}{1+\kappa}\left(1 - L_t^j\right)^{1+\kappa} \right]$$

where C^j is household aggregate consumption and L^j total hours worked. The parameter κ is the inverse of the Frisch labour supply elasticity and ω the relative weight of leisure in utility.[2]

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[1] Most papers on home production, e.g. Benhabib et al. (1991), Campbell and Ludvigson (2001), Gomme et al. (2001), Greenwood and Hercowitz (1991), McGrattan et al. (1997) and Zhang et al. (2008), choose a more complex setup with capital accumulation also in the non-market sector, where the home capital stock consist of investment goods produced in the market sector. This structure generates a trade-off between the consumption of market and home goods via the resource constraint in the market sector. On the other hand, these papers do not include leisure in the utility function, excluding a trade-off through employment in market versus home production.

[2] The standard utility specification in QUEST includes habit persistence in consumption. Habit persistence

Total consumption is a CES aggregate of market goods (C_M^j) and home goods (C_H^j):

$$(7) \qquad C_t^j = \left[h^{\frac{1}{\sigma}} \left(C_{H,t}^j \right)^{\frac{\sigma-1}{\sigma}} + (1-h)^{\frac{1}{\sigma}} \left(C_{M,t}^j \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

where *h* is the steady-state consumption share of home goods and σ the elasticity of substitution between C_M^j and C_H^j, bound between perfect complementarity ($\sigma \to 0$) and perfect substitutability ($\sigma \to \infty$).

The literature on home production works with different specifications for consumption utility. Gomme and Rupert (2007) and Greenwood and Hercowitz (1991) use a Cobb-Douglas function for consumption utility, which corresponds to equation (2) with σ converging to 1. Benhabib et al. (1991), Campbell and Ludvigson (2001), Gomme et al. (2001) and McGrattan et al. (1997) use additive-separable preferences over market and non-market goods. The CES aggregator (8) is a more encompassing formulation, which allows for robustness checks across alternative σ values.

Households maximise life-time utility with respect to consumption, work, physical capital investment (I), domestic bonds (B) and foreign bonds (B^*) subject to the intertemporal budget constraint and capital accumulation:

$$\begin{aligned} & \left(1+\tau_t^c\right) P_t^C C_{M,t}^j + P_t^C I_t + B_t^j + e_t B_t^{*,j} = \left(1-\tau_t^w\right) W_t^j L_{M,t}^j \\ (8) \qquad & + benr W_t \left(1 - L_{M,t}^j\right) + \left(1-\tau_t^k\right)\left(P_t Y_t^j - W_t^j L_{M,t}^j - \delta P_t^C K_t^j\right) + \Pi_t^j \\ & + \left(1+i_{t-1}\right) B_{t-1}^j + \left(1+i_{t-1}^*\right) e_t B_{t-1}^{*,j} + TR_t^j - TAX_t^j \end{aligned}$$

$$(9) \qquad K_t = \left(1-\delta\right) K_{t-1} + I_t$$

On the left side of the budget constraint, P^C is the consumer price index for market goods, here also applying to investment goods, and δ on the right side is the capital depreciation rate. Households receive unemployment benefits for the labour force not in official employment ($1-L_M^j$) at a constant benefit replacement rate (*benr*) times the gross wage in the economy. Households pay taxes on consumption (τ^c), labour income (τ^w) and corporate income (τ^k) and receive lump-sum transfers (TR^j). The household also receive interest income on domestic and foreign bonds, where e is the nominal exchange rate.

Maximising welfare (7) and (8) under the constraints (5), (6), (9) and (10) gives the FOC:

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improves the model's ability to replicate persistence in consumption and aggregate demand, but it does not affect steady-state values, which are the focus of this paper. The logarithmic transformation for consumption, i.e. unit intertemporal elasticity of substitution, is also used by Benhabib et al. (1991) and Greenwood and Hercowitz (1991). Campbell and Ludvigson (2001), Gomme and Ruppert (2007) and Gomme et al. (2001) use unit elasticity as baseline and alternative values for robustness checks. McGrattan et al. (1997) use a parameter estimate indicating lower intertemporal substitutability.

(10a) $$\frac{1}{1+\left(\frac{h}{1-h}\right)^{1/\sigma}\left(C^j_{H,t}/C^j_{M,t}\right)^{(\sigma-1)/\sigma}}\frac{1}{C^j_{M,t}}-\lambda_t\left(1+\tau^c_t\right)P^c_t=0$$

(10b) $$\frac{1}{1+\left(\frac{1-h}{h}\right)^{1/\sigma}\left(C^j_{M,t}/C^j_{H,t}\right)^{(\sigma-1)/\sigma}}\frac{1}{C^j_{H,t}}-\chi_t=0$$

(10c) $$-\omega\left(1-L^j_{M,t}-L^j_{H,t}\right)+\lambda_t\left(1-\tau^w_t\right)W_t=0$$

(10d) $$-\omega\left(1-L^j_{M,t}-L^j_{H,t}\right)+\chi_t\gamma A_{H,t}L^{\gamma-1}_{H,t}=0$$

(10f) $$\lambda_t P^c_{t-1}-E_t\left[\beta\lambda_{t+1}P^c_t\left(1+(1-\tau^k_t)(i^k_t-\delta)_t\right)\right]=0$$

(10g) $$\lambda_t-E_t\left[\beta\lambda_{t+1}\left(1+i_t\right)\right]=0$$

(10h) $$\lambda_t-E_t\left[\beta\lambda_{t+1}\left(1+i^*_t\right)\left(1-\psi\frac{e_tB^*_{t-1}}{P_tY_t}\right)\frac{e_{t+1}}{e_t}\right]=0$$

The FOC determine the optimal allocation of consumption between market and home goods and the optimal intertemporal path of market consumption:

(11) $$\frac{C^j_{M,t}}{C^j_{H,t}}=\frac{1-h}{h}\left(\frac{1-\tau^w_t}{1+\tau^c_t}\frac{W_t}{P^c_t}\frac{1}{\gamma A_{H,t}L^{\gamma-1}_{H,t}}\right)^{\sigma}$$

The higher the net real market wage relative to marginal productivity in the home sector, the more households work in the official sector and consume market rather than home goods. As all households have identical constraints and preferences, the superscript *j* can be dropped to characterise aggregate variables. The higher the substitutability between official and home production in household consumption, i.e. the larger σ, the stronger is the response of official relative to home production volumes to changes in the consumption income from work in the official relative to labour productivity in the home sector.

QUEST III assumes monopolistic competition in the labour market. Households *j* supply differentiated types of labour L_M^j to employers *i*. The effective labour input hired by firms is a CES aggregate:

(12) $$L_t=\left[\int\left(L^j_t\right)^{\frac{\varepsilon-1}{\varepsilon}}dj\right]^{\frac{\varepsilon}{\varepsilon-1}}$$

where ε measures the elasticity of substitution between differentiated labour services, giving the demand function for variety *j*:

$$(13) \qquad L_t^j = \left(\frac{W_t^j}{W_t} \right)^{-\varepsilon} L_t$$

Nominal wages are set by trade unions, each representing a type of worker *j*. The trade unions set the wage to maximise the utility of their members, taking into account the demand for labour services (13). The optimal market wage is:

$$(14) \qquad \left(1-\tau_t^w\right) W_t = \frac{\varepsilon}{\varepsilon - 1} \left[\omega L_{M,t}^{\kappa} \frac{\left(1+\frac{L_{H,t}}{L_{M,t}}\right)^{\kappa}}{\lambda_t} + benrW_t \right]$$

Home production increases the total work effort of households for given hours in market employment, which increases the marginal utility of leisure and the wage claims. Unemployment benefits enter equation (14) as a reservation wage.

The total labour effort of household *j* (L^j) is the sum of official employment (L_M^j) and home work (L_H^j):

$$(15) \qquad L_t^j = L_{M,t}^j + L_{H,t}^j$$

The additivity of market and home work in equation (15) implies that from the perspective of labour supply, households are indifferent with respect to the distribution of work between the two sectors.

2.3 Fiscal policy

The model includes a rich set of fiscal variables. Primary government expenditure is the sum of government purchases (G), government investment (IG), benefit payments and lump-sum transfers. To focus on distortionary taxation and private sector adjustment, the real quantities G and IG are kept constant. Government revenue is the sum of consumption, labour and corporate income tax revenues. The primary budget deficit (D) is:

$$(16) \qquad \begin{aligned} D_t \equiv{}& P_t^C \left(G_t + IG_t\right) + benrW_t \left(1 - L_{M,t}\right) + TR_t - \tau_t^c P_t^C C_t \\ & - \tau_t^w W_t L_{M,t} - \tau_t^k \left(P_t Y_t^j - W_t^j L_{M,t}^j - \delta P_t^C K_t^j\right) - TAX_t \end{aligned}$$

Government debt evolves according to:

$$(17) \qquad B_t = \left(1 + i_{t-1}\right) B_{t-1} + D_t$$

The nominal government transfers are a fixed share (*trshare*) of nominal GDP:

$$(18) \qquad TR_t = trshare P_t Y_t$$

which accounts for the indexation of, e.g., pension to income growth.

Public capital evolves analogously to private one (9) as:

$$(19) \qquad KG_t = (1-\delta) KG_{t-1} + IG_t$$

and enters the market-sector production function (1) as productivity shifter.

The government sets the level of government purchases and investment, the benefit replacement rate and consumption, corporate and labour tax rates exogenously. The lump-sum tax adjusts endogenously to stabilise government debt at its target level. Letting the lump-sum tax adjust endogenously to compensate for the impact of labour, corporate and consumption tax changes on the government budget provides a convenient measure of the budgetary impact of tax policies.[3]

2.4 Trade

QUEST III is an open economy model. Trade equations are derived from the demand for domestically produced and imported market goods given domestic product and import prices. The preferences for market goods are a CES function of domestically produced and imported tradable goods:

$$Z = \left((1-s)^{\frac{1}{\sigma_x}} Y^{i\,\frac{\sigma_x - 1}{\sigma_x}} + s^{\frac{1}{\sigma_x}} IM^{i\,\frac{\sigma_x - 1}{\sigma_x}} \right)^{\frac{\sigma_x}{\sigma_x - 1}}$$

where Z ϵ (C, I, G, IG) and σ_x is the elasticity of substitution between domestically produced and imported goods. In order to facilitate aggregation, private households and the government are assumed to have identical preferences concerning import demand. The CES aggregation and its RoW counterpart give the import and export demand functions:

$$(20) \qquad IM_t = (1-s)\left(e_t P_t^* / P_t^C\right)^{-\sigma_x} (C_t + I_t + G_t + IG_t)$$

$$(21) \qquad X_t = (1-s^*)\left(P_t / (e_t P_t^*)\right)^{-\sigma_x} Y_t^*$$

Adding up the private and government budget constraints gives the economy's aggregate resource constraint and the current account as the sum of the trade balance and the interest income on the net foreign asset (NFA) position:

[3] An alternative would be to keep lump-sum taxes constant to determine the new steady-state level of sustainable government debt, i.e. the level that could be maintained given the changes in the available debt service. The steady-state level of debt depends crucially on assumptions about the sovereign risk premium associated with alternative debt levels, however, making each figure highly conditional.

$$(22) \qquad CA_t = i^*_{t-1} e_t B^*_{t-1} + \frac{P_t}{e_t P^*_t} EX_t - IM_t$$

The evolution of the NFA position follows from:

$$(23) \qquad B^*_t = \left(1 + i^*_{t-1}\right) e_t B^*_{t-1} + \frac{P_t}{e_t P^*_t} EX_t - IM_t$$

Domestic (i) and foreign interest rates (i^*) are linked by an augmented interest parity condition:

$$(24) \qquad i_t = i^*_{t-1} + E_t \frac{\Delta e_{t+1}}{e_t} - \psi \frac{e_t B^*_t}{P_t Y_t}$$

where the parameter ψ is a risk premium on the domestic interest rate that depends on the economy's NFA position and rules out explosive NFA dynamics (e.g., Schmitt-Grohé and Uribe, 2003).

2.5 Parameterisation

Parameter values for the model are summarised in Table 1. The steady-state values for trade openness, consumption, private investment, government purchases, government investment, benefits and transfers are taken from national accounts data. The EU averages for implicit labour, corporate and consumption tax rates come from European Commission (2011). The baseline tax rates are 37% on labour income (including social security contributions), 32% on corporate income and 20% on consumption.[4] To locate the position of individual member countries relative to the average, country-specific implicit tax rates are given in Table 2. Government consumption is 17%, government investment 3%, transfers 18% and benefits 2% of GDP. The steady-state import share is 41% of GDP.

With respect to home production, the following parameter values are set: Home goods account for 20% of total consumption and home work for 20% of official employment at baseline tax rates. These values imply a steady-state ratio of non-market goods to official GDP of 15%, which reflects shadow-economy estimates for EU countries by Tafenau et al. (2010).

Based on empirical estimates in Lemieux et al. (1994), the elasticity of informal output

[4] The value of 32% corresponds to the average implicit tax on capital, not to the average corporate tax rate (25%). Using the average tax on capital captures not only the taxation of profits at the corporate level, but also the taxation of returns to capital and profit income at the level of equity owners. Using values for the capital income instead of the corporate tax in the simulations affects the characterisation of the status quo, i.e. the position of the vertical lines in Figures 1-4, but has no impact on the shape of the Laffer curves. Using tax data for 2008 instead data for 2009 for the baseline parameterisation avoids the implicit tax burden being influenced by the 2009 recession. Implicit tax rates on corporate income tend to be more sensitive to economic activity than effective labour, capital and consumption taxation.

with respect to home work is set to 0.70. The elasticity of substitution between market and home goods in consumption is set to one, i.e. Cobb-Douglas preferences. With these values, a 1 percentage-point increase in the labour tax wedge increases the share of the shadow economy by 0.25 percentage points of total output, i.e. official GDP plus informal production, and reduces official employment by around 0.5 percent. These numbers correspond to the estimated impact of the labour tax wedge in Tafenau et al. (2010) and Causa (2009). Section 3 also presents robustness checks for alternative parameters. Intuitively, the higher the substitutability between market and home production, the tighter are fiscal limits. Table 3 summarises alternative calibration exercises of models with home production to provide an idea about typical parameter values.

Table 1: Parameterisation of the model

Parameter	Value
Preferences:	
Inverse of elasticity of labour supply (κ)	-5.00
Utility weight of leisure (ω)	0.003
Consumption share of home goods (*h*)	0.14
Substitution between market good varieties (η)	5.00
Substitution between market and home goods (σ)	1.00
Price elasticity of trade (σ_x)	1.50
Market production:	
Technology level (A)	0.73
Cobb-Douglas labour parameter (α)	0.70
Cobb-Douglas public capital stock parameter (α_g)	0.09
Elasticity of substitution between labour services (ε)	6.00
Depreciation rate private capital stock (δ)	0.03
Depreciation rate public capital stock (δ_g)	0.01
Risk-free interest rate (i) in %	0.50
Interest rate on capital (i^k) in %	1.25
Home production:	
Technology level (A_H)	0.53
Return to labour in home production (γ) hsub	0.70
Labour share in home production (L_H/L)	0.17
Fiscal policy:	
Corporate profit tax (t^k)	0.32
Consumption tax (t^c)	0.20
Labour income tax (t^w)	0.37
Benefit replacement rate (*benr*)	0.30
Transfer share (*trshare*)	0.18
Government debt (% of GDP)	60.0
Risk premium (ψ) in %	0.01
National accounts (% of GDP):	
Private consumption	61.8
Investment	18.3
Government purchases	17.0
Government investment	3.00
Imports	41.0

Note: Interest rates, depreciation rates and risk premia are at a quarterly basis.

Table 2: Implicit tax rates in EU member countries in percent (2008)

	Labour	Corporate income	Capital	Consumption
Austria	41.3	25.2	26.5	21.6
Belgium	42.5	21.6	32.6	21.2
Bulgaria	27.4	:	:	24.9
Cyprus	24.7	:	:	20.8
Czech Republic	39.2	23.8	19.8	21.1
Denmark	36.2	24.0	43.4	32.6
Estonia	33.7	8.0	10.5	21.1
Finland	41.4	19.6	28.0	26.0
France	41.5	27.0	38.1	19.1
Germany	39.2	:	23.0	19.7
Greece	32.2	:	:	14.8
Hungary	42.1	18.9	18.6	26.6
Ireland	25.3	8.0	16.3	23.3
Italy	43.0	32.3	35.6	16.5
Latvia	28.5	17.9	17.0	17.4
Lithuania	32.7	11.1	12.7	17.6
Luxemburg	31.7	:	:	27.3
Malta	19.6	:	:	19.3
Netherlands	36.2	11.1	16.6	26.9
Poland	32.6	20.3	22.8	21.1
Portugal	23.3	:	37.5	18.0
Romania	27.3	:	:	17.7
Slovakia	33.1	22.0	16.9	18.7
Slovenia	35.9	28.3	21.7	23.9
Spain	33.1	35.1	31.7	14.1
Sweden	41.2	17.4	26.2	27.8
United Kingdom	26.4	22.8	44.7	17.5

Source: European Commission (2011).

Table 3: Examples of calibrations of home production models in the literature

	L_H/L	C_H/C	γ	σ
Benhabib et al. (1991)	0.46		0.64	5;2
Campbell and Ludvigson (2001)	0.66	0.66	0.66	1.0
Gomme and Ruppert (2007)	0.48	0.52	0.72	1.0
Gomme et al. (2001)		0.44	0.67	1.0
Greenwood and Hercowitz (1991)	0.24	0.26	0.70	1.0
Lemieux et al. (1994)			0.66	
McGrattan et al. (1997)			0.78	1.8

3. Results

The QUEST model with home production can be used to assess tax revenues and the distortionary impact of labour, corporate and consumption taxes in steady state. Figure 1 shows the Laffer curves for these taxes in the benchmark model, which adopts the parameterisation of Table 2. Solid lines in the charts indicate the revenue from the respective tax. Dashed lines show the total tax revenue associated with the specific labour, corporate or consumption tax rate, holding all other tax rates constant. The vertical lines indicate EU average implicit tax rates as provided by European Commission (2011): 37% for the labour tax, 32% for the corporate tax, and 20% for the consumption tax. Tax revenue in Figures 1-3 is measured in percent of official GDP at the current actual effective tax rates, i.e. relative to a constant denominator.

3.1 Benchmark model

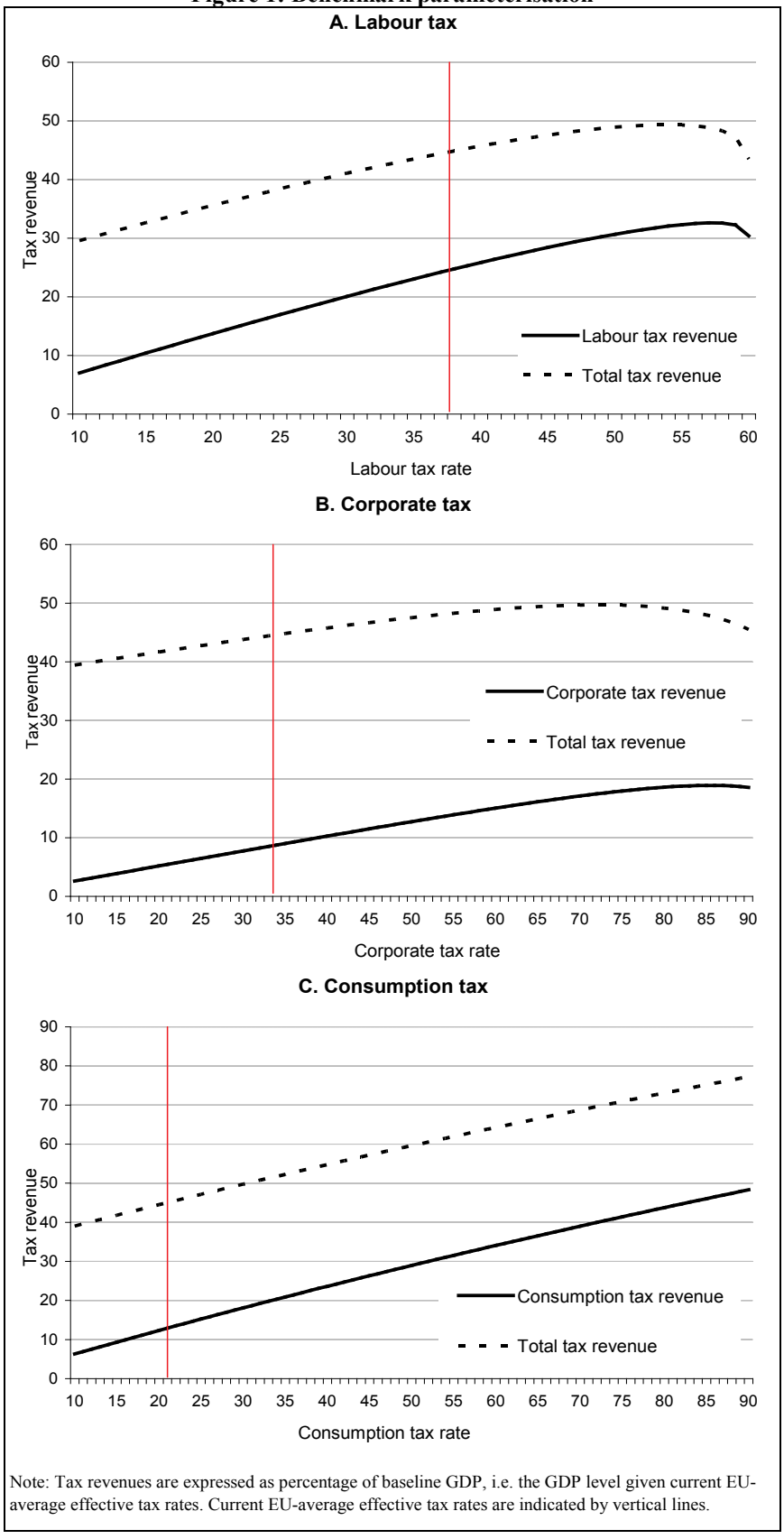
Figure 1 points to substantial differences in revenue-maximising rates and maximum tax revenue across the different taxes. Varying the labour tax rate, total revenue reaches its maximum at a tax rate of 54%. Varying the corporate tax rate, total revenue peaks at a tax rate of 72%. Raising the consumption tax, on the other hand, still generates additional revenue for tax rates of 90% and far beyond.[5]

The total tax revenue peaks at lower labour and corporate tax rates than the individual labour and corporate tax receipts themselves. The earlier peak of total receipts illustrates the negative indirect impact of labour and corporate taxes on other tax bases. Higher labour taxation, e.g., reduces corporate income by reducing employment and production in the official sector, and increasing corporate taxation reduces the labour tax base by lowering equilibrium wages and employment.

As a matter of principle, Laffer curves for labour and corporate taxation must peak in between tax rates of 0% and 100%. At the one extreme, no tax revenue is collected at tax rates of 0%. At the other extreme, the tax base vanishes at tax rates of 100%, because the incentive to work, invest and generate income in the official economy disappears. This logical limit does not apply to consumption taxes, however. Under the benchmark parameterisation of the model, a sales tax can generate additional revenue at tax rates far above 100%, illustrating the likely discrepancy between the economic limits and the political limits to taxing consumption.

[5] The results for the benchmark model are similar to an economy without home production. Laffer curves for labour and corporate taxes for the two models are almost identical. The only larger difference occurs for the consumption tax at high tax rates. Given the substitutability between market and home goods, the Laffer curve for the consumption tax is flatter in the economy with home production. At tax rates of around 20% the difference is practically zero. At tax rates of 40% and 90%, tax revenues relative to baseline GDP in the economy with home production are 1 and 4 percentage points lower than in an economy without.

Figure 1: Benchmark parameterisation



Note: Tax revenues are expressed as percentage of baseline GDP, i.e. the GDP level given current EU-average effective tax rates. Current EU-average effective tax rates are indicated by vertical lines.

The additional tax revenue that might be raised by moving from actual implicit to revenue-maximising labour and corporate tax rates is 5% of baseline GDP, i.e. 5% of the steady-state GDP at current effective tax rates (Table 4).

Table 4: Actual implicit and revenue-maximising tax rates for the average EU country

	Implicit tax rate[1] (%)	Revenue-maximising rate (%)	Additional tax revenue[2] (% of GDP)
Labour taxation	37	54	5
Corporate/caital taxation	32	72	5
Consumption taxation	20	-	…

[1] Actual implicit tax rates are based on European Commission (2011) data for 2008; social security contributions are included in labour taxation.
[2] The additional tax revenue from moving from current to revenue-maximising tax rates is given as percentage of baseline GDP, which is the steady-state GDP given actual implicit tax rates.

The revenue-maximising tax rate on labour income of 54% is similar to the 56% for the EU-14 with similar values for the intertemporal elasticity of substitution and the elasticity of labour supply in Trabandt and Uhlig (2010). The absence of a meaningful maximum rate for consumption taxes also corresponds to the absence of a Laffer curve for the consumption tax in Trabandt and Uhlig (2010). The revenue-maximising corporate tax rate of 72%, however, is substantially above the maximum rate of 46% for the EU-14 in Trabandt and Uhlig (2010).[6]

Part of this difference in the corporate tax peak relates to different assumption about market structure and capital depreciation. Trabandt and Uhlig (2010) use a neoclassical growth model with perfect competition, contrary to monopolistic competition in goods and labour markets in QUEST. With perfect competition, corporate taxes relate only to returns on capital, whereas with monopolistic competition the corporate tax applies to the sum of profit and capital income. In addition, the difference in the capital depreciation rates between 7% in Trabandt and Uhlig (2010) and annualised 11% in Table 2 implies higher depreciation allowances in the QUEST setup.

Another factor is differences in the parameterisation of the preference parameters, namely the weight of leisure in utility. The calibrated QUEST value of this parameter is relatively low, implying a moderate response of labour supply to changes in the real wage. Consequently, a reduction of the equilibrium capital stock, which affects marginal labour productivity and the real wage, has only moderate impact on labour supply, employment and labour tax receipts. The values in Trabandt and Uhlig (2010) imply a stronger crowding-out of labour tax revenue through the negative impact of lower investment and capital on wages and employment. Finally, the Laffer curve for corporate taxation in Figure 1 is fairly flat in the neighbourhood of the peak, so that the difference between the 72% revenue-maximising rate and the 46% in Trabandt and Uhlig (2010) should not be overemphasised. As illustrated by Figure 4 below, moving from 46% to 72% corporate

[6] In the results for individual EU countries, Trabandt and Uhlig (2010) find relatively little dispersion in the revenue-maximising labour tax rate, which ranges from 57% in Denmark to 69% in Ireland, but strong dispersion in the revenue-maximising corporate tax rate, which ranges from 29% in Sweden to 67% in Ireland.

tax rate gives little additional tax revenue, but a strong additional decline of activity in the official sector.

The fact that the QUEST model applies the residence principle to taxation, which excludes the possibility to invest abroad or shift profits to other jurisdictions in order to avoid taxation at growing domestic rates, reduces the impact of corporate taxation on the tax basis furthermore, with a tendency of overestimating the revenue-maximising corporate tax rate.

Similarly, while home production allows supply and demand to shift to the informal sector, the model does not include the possibility of cross-border shopping, which would avoid domestic taxation on market consumption goods.

The Laffer curves in the Busato and Chiarini (2009) model with shadow economy peak at 66% for corporate and 64% for income taxation. The values are not directly comparable to Figure 1, because the taxes apply to different tax bases. Introducing the shadow economy substantially flattens the Laffer curves in Busato and Chiarini (2009) and strongly reduces the maximum collectable revenue. High probabilities of detection or high penalties on underground activity are required in their model to increase collectable tax revenues by crowding out the informal sector.

The strong impact of the shadow economy on Laffer curves in Busato and Chiarini (2009) derives from the high elasticity of substitution between official and informal activity. Busato and Chiarini (2009) model official and shadow output as alternative ways to produce one identical good, and production is the sum of formal and informal sector output. These assumptions imply perfect elasticity of substitution between official and shadow production, contrary to the limited substitutability between market and home goods in the utility function (6) of section 2.

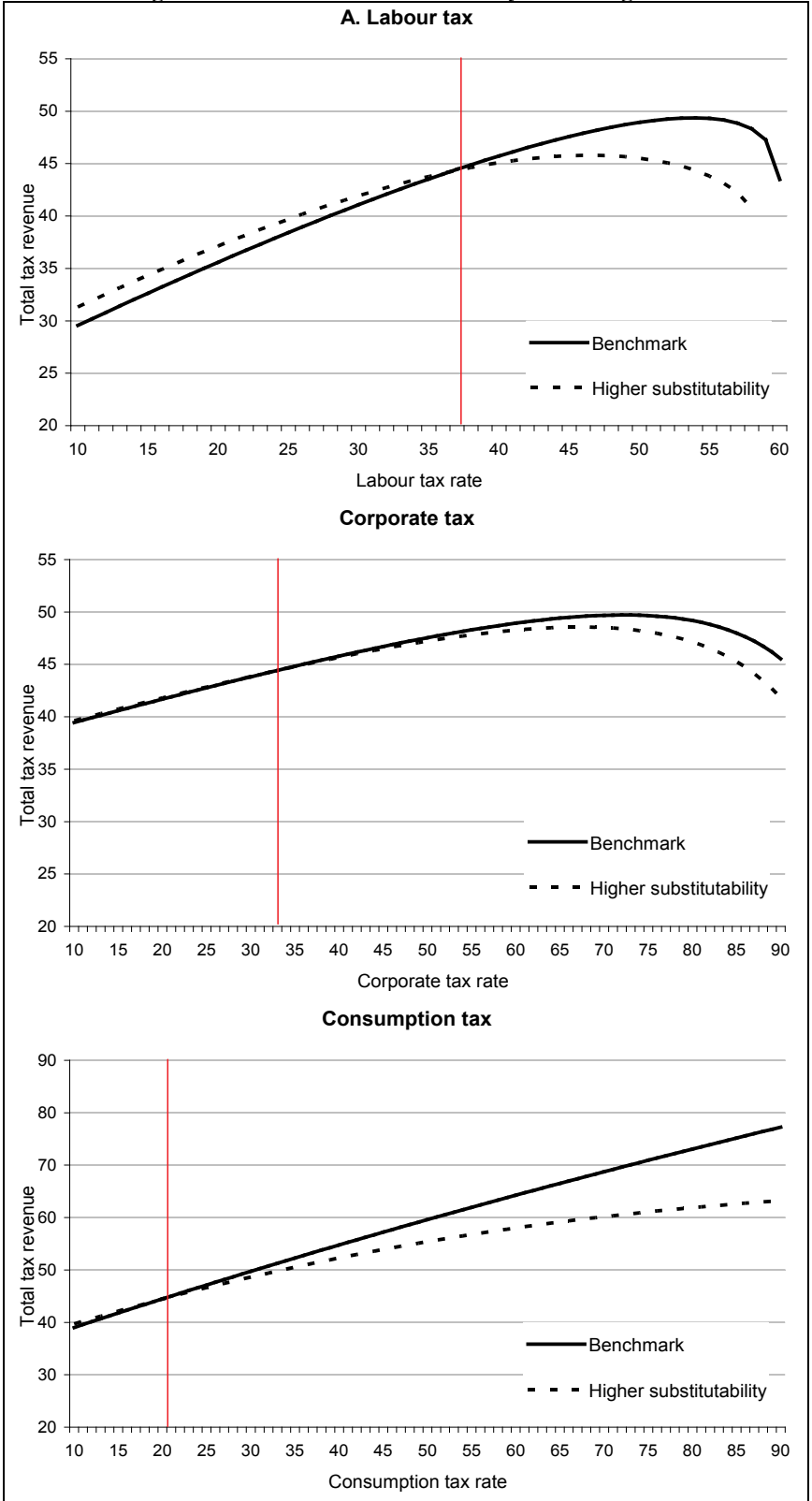
In addition, Busato and Chiarini (2009) use a production function, where output in the informal sector increases linearly with labour, so that the expansion of the shadow sector is not restricted by decreasing marginal returns. Lower elasticity values in both dimensions, i.e. production and use, would dampen the shadow economy's impact on the revenue-maximising tax rates and the maximum collectable tax revenue.

3.2 Increasing substitutability

Figure 1 is based on the benchmark parametrisation, which uses Cobb-Douglas preferences, i.e. $\sigma=1$, to aggregate market and home goods into household consumption. The effect of higher substitutability, namely $\sigma=5$, is illustrated in Figure 2. Increasing the substitutability between market and home goods flattens the Laffer curve and reduces revenue-maximising tax rates and the maximum collectable tax revenue.

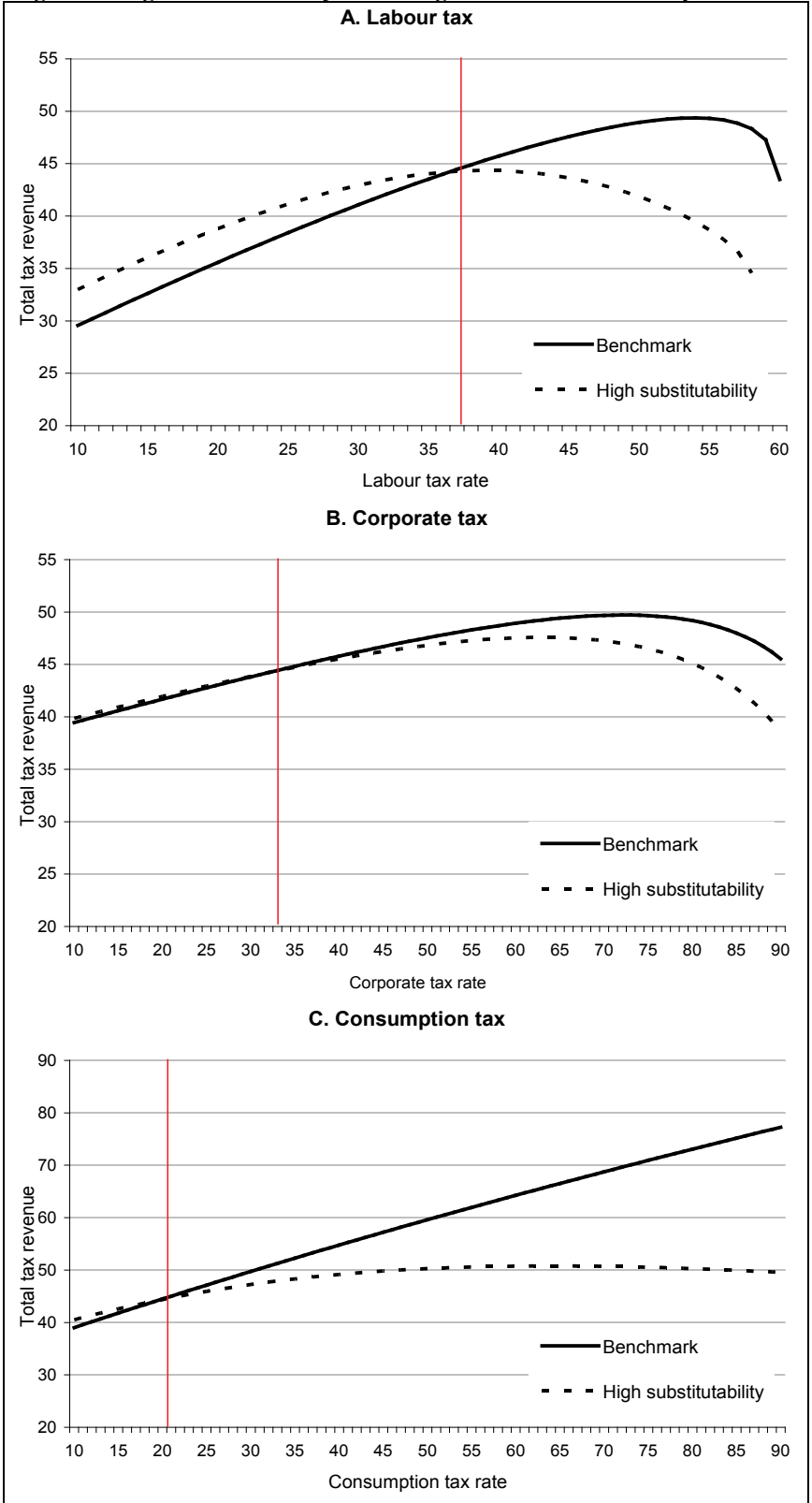
With $\sigma=5$, the labour tax curve peaks at 46%, instead of 54% for $\sigma=1$, and the maximum revenue declines by 4% of baseline GDP (or, 7% of the revenue volume). With this modified Laffer curve for labour taxation, raising labour tax rates above the actual average implicit rate generates very little additional tax revenue.

Figure 2: Alternative substitutability between goods



Note: Tax revenues are expressed as percentage of baseline GDP, i.e. the GDP level given current EU-average effective tax rates. Current EU-average effective tax rates are indicated by vertical lines.

Figure 3: High substitutability between goods and linear home production



Note: Tax revenues are expressed as percentage of baseline GDP, i.e. the GDP level given current EU-average effective tax rates. Current EU-average effective tax rates are indicated by vertical lines.

Given the higher elasticity of substitution between market and home goods, the Laffer curve for the corporate tax rate now peaks at 67%, instead of 72%, and the maximum revenue falls by 1% of baseline GDP (or, 2% of the revenue volume). The revenue function for the consumption tax remains upward sloping as in Figure 1, but flattens visibly for high tax rates.

Moving from decreasing returns in home production to a linear production technology flattens the Laffer curves further. Figure 3 compares the benchmark parametrisation (Figure 1) to a scenario with $\sigma=5$ and $\gamma=1$, i.e. an economy in which market and home consumption goods are close substitutes and labour productivity is similar in both sectors. Moving from decreasing to constant returns to labour in home production removes a supply-side constraint to the sectoral reallocation of activity and increases the willingness of households to substitute home work for official employment.

In the economy with higher substitutability between market and home production on the demand and the supply side (Figure 3), the Laffer curves for labour and corporate taxes peak at tax rates of 39% and 63%, respectively. Raising the labour tax from the current to the revenue-maximising rate would raise tax revenues by only 0.1% of baseline GDP (or, 0.5% of the revenue volume). Raising the corporate tax rate from the current to the revenue-maximising level would raise tax revenues by only 3% of baseline GDP (or, 8% of the revenue volume).

The labour tax curve in Figure 3 suggests that in a country with high substitutability between market and home production on the demand and the supply side, actual EU average implicit tax rates on labour may already be very close to the maximum. In this case, there is almost no additional revenue to be raised from further increasing the tax burden on labour in the official economy.

Contrary to the continuously increasing revenue functions for the consumption tax in Figures 1 and 2, Figure 3 shows a revenue maximum for the consumption tax at the tax rate of 64%. Total tax revenues at the revenue-maximising consumption tax exceed current revenues by 7% of baseline GDP (or, 15% of the revenue volume), but tax revenues are almost flat above a tax rate of 40%. The consumption tax revenue itself continues to increase with higher consumption tax rates, but the tax increase crowds out labour and corporate tax revenue through the shrinking of the official and the expansion of the informal sector.

Overall, the simulations suggest Laffer curves for labour and corporate taxes, where the revenue-maximising tax rates are fairly high compared to current EU-average levels. The fiscal limits are tighter in circumstances, where higher substitutability between official and informal production on the demand side (preferences) and/or the supply side (production technology) makes it easier to avoid taxes by moving to the informal sector. The higher the degree of substitutability between the two sectors, the tighter the fiscal limits become. High substitutability introduces even a meaningful revenue limit also for the consumption tax.

The fact that the limits to corporate taxation in the open-economy framework of this pa-

per are no tighter than the Laffer curve peaks in closed-economy models (e.g., Trabandt and Uhlig, 2010) suggests that the element of cross-border tax policy spillover that is captured in the QUEST model has very limited impact. This element of tax policy spillover is the equalisation of after-tax returns across domestic and foreign investment opportunities, which in general equilibrium affects savings rates and the relative demand for domestic and foreign assets.

The model misses key aspects of potential international tax competition, namely the possibility of cross-border profit shifting by households and integrated corporations, which would increase international tax base mobility in response to international tax differentials and restrict the ability of domestic capital and profit taxation to generate additional tax revenue.

3.3 Output costs of taxation

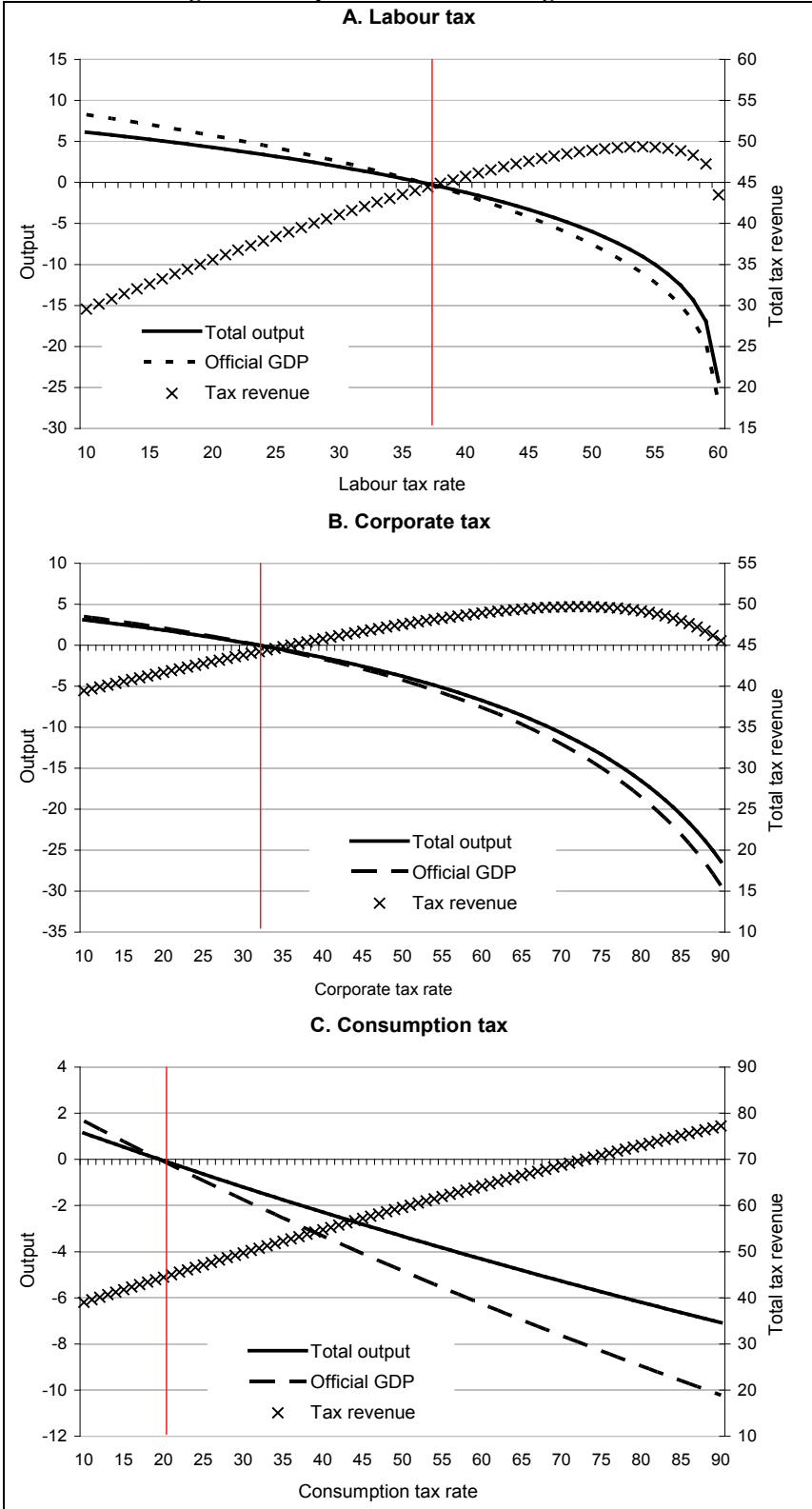
Increasing distortionary taxes has economic costs in terms of lower employment, investment and output, even if it succeeds in raising additional government revenue.[7] Figure 4 illustrates the output costs of taxation for the benchmark model, i.e. the tax revenue functions in Figure 1.

Increasing the effective labour tax rate from the EU average (37%) to the revenue-maximising level (54%) would lower real GDP in the official sector by 11%. Home production increases, but total output as the sum of official and informal production declines by 9%.

Increasing the corporate tax from the current EU-average rate (32%) to the revenue maximum (72%) reduces output in the official economy by 13% and total production by 12%. Increasing the consumption tax has a more moderate impact on official and total output, which coincides with the fact that shifting revenue collection from income to consumption taxes tends to increase employment and output levels. Increasing the substitutability between market and home production amplifies the output loss in the official sector and the growth of the shadow economy in response to rising tax rates. Consequently, it reduces additional collectable revenue for labour, corporate and consumption taxation.

[7] Of course, certain behaviourally non-neutral taxes are designed to correct *market* distortions, i.e. distort market outcomes, e.g. by making private agents pay for negative externalities and the reliance on public goods.

Figure 4: Output costs of increasing taxation



Note: Real total output (market sector plus home production) and official (market) GDP are expressed in percentage deviation from their baseline values. The tax revenue is expressed as percentage of baseline GDP, i.e. the GDP level given current EU-average effective tax rates. Current EU-average effective tax rates are indicated by vertical lines.

Table 5 summarises the economic costs of revenue collection by a simple measure of efficiency, namely the percent increase in revenue over the percent decline in economic activity. It compares the additional collectable tax revenue to the output loss from moving effective tax rates from current EU-average to revenue-maximising levels. The numbers in Table 5 suggest that in the benchmark setting (Figure 1), the consumption tax is the least distortive instrument for revenue collection, followed by the corporate tax.

Table 5: Revenue gains and output losses from rising distortionary tax rates

	Total tax revenue[1] (increase in %)	Official real GDP[1] (decline in %)	Total output[1] (decline in %)[2]	Efficiency[2]
Labour taxation	12	13	12	1.0
Corporate taxation	12	11	9.0	1.3
Consumption taxation	12	1.9	1.3	9.3

[1] Changes in tax revenue and output refer to a scenario in which effective tax rates are moved from current EU-average levels to the revenue maximising rates in Table 3. Given the lack of a revenue maximum for the consumption tax, a tax rate increase from 20 to 31% is chosen, which increases total tax revenue by 12% as well.
[2] The efficiency measure is the ratio of the tax revenue increase (in %) to total output losses (in %). Increasing values imply declining economic costs of revenue collection.

4. Conclusions

The paper derives fiscal limits, understood as peaks of the Laffer curve, in a model with tax avoidance. For this purpose, the QUEST III model is extended to include an informal sector in the form of home production.

The paper finds that fiscal limits for labour and corporate taxation in the benchmark model are relatively high (54% and 72%) compared to actual EU-average implicit labour and corporate tax rates (37% and 32%). No limit is found for the consumption tax, for which tax revenues are monotonically increasing with the tax rate.

Results change with higher substitutability between market and home production, i.e. in economies where the official and the informal sector are closer substitutes. Higher substitutability between the official and the informal sector flattens the Laffer curves for labour and corporate taxation.

In the most extreme case considered here, with high substitutability between market and home goods in consumption and constant return to scale in home production, the revenue-maximising labour tax corresponds practically to the actual EU-average implicit labour tax rate. This case introduces also a revenue limit for the consumption tax. Total tax receipts are practically flat for consumption tax rates of 40% and above, owing to the crowding out of official sector wage and corporate income and associated tax revenues.

Although higher tax rates increase tax revenues in the benchmark model, the economic costs of increasing distortionary taxation are substantial. Increasing total tax revenue by 12%, which is the maximum fiscal space for labour and corporate taxation, reduces total

output by 12% in the case of the labour tax increase, 9% in the case of the corporate tax increase, and 1% in the case of an equivalent increase in the consumption tax. The result also illustrates that among the three alternative taxes, the consumption tax is the least distortive one.

Taken at face value, the results suggest that the capacity to create additional tax revenue does not appear to be the first binding constraint on using tax increases for fiscal consolidation, because not many countries are likely to be located on the downward sloping part of the Laffer curve. This is particularly true with regard to the consumption tax.

On the other hand, the model misses important aspects of tax competition, such as portfolio and profit shifting across jurisdictions. Neither does the model incorporate sources of domestic tax avoidance or evasion other than migration to the shadow economy.

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