TAX REFORM IN TWO-SECTOR GENERAL EQUILIBRIUM

Olivier CARDI\(^2\) and Romain RESTOUT\(^3\)

Abstract

We use a two-sector open economy model with an imperfectly competitive non traded sector to investigate the effects of three tax reforms: [i] two revenue-neutral shifting the tax burden from labor to consumption taxes and [ii] one labor keeping the marginal tax wedge constant. Regardless of its form, a tax restructuring crowds-in consumption and investment and raises employment. While tax multipliers for overall output are always positive, their size depends on the type of the tax reform and the financing scheme. The trade balance plays a key role in determining the relative size of sectoral multipliers: whereas the long-term multiplier is always slightly higher in the traded sector than in the non traded sector, this result is reversed in the short-term. Finally, time horizon matters in determining the relationships between both overall and sectoral tax multipliers and labor responsiveness.

Keywords: Non Traded Goods; Investment; Employment; Tax Multiplier.

JEL Classification: F41; E62; E22; F32.

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1 Introduction

Can a tax restructuring have beneficial effects on overall economic performance? Surprisingly, the dynamic general equilibrium literature offers little guidance on what kind of tax reform strategy makers should employ to stimulate employment without depressing consumption and raising the public debt burden. However, the two last decade have been witness of numerous episodes of fundamental tax reforms in European countries urged to reduce public deficits and unemployment rates. Hence, we address this issue by developing a novel and analytically tractable model which can be viewed as a two-sector extension of the open economy version of the Baxter and King [1993] dynamic general equilibrium model. Since tax reforms take various forms, we consider three simple and practicable tax restructuring: two revenue-neutral tax reforms that shift the tax burden from labor to consumption taxes and [ii] one labor tax reform keeping the marginal tax wedge constant.\(^1\) We show formally that regardless of the type of the tax reform, a tax restructuring crowds-in consumption and investment in the long-term, raises permanently employment and leads to overall welfare gains.

In particular, the stability and growth pact is aimed at achieving budget balance in EMU member countries over the medium run. To compensate for the reduction in tax revenue, governments must find other source of tax financing. Since raising lump-sum taxes is a difficult political task, a tax restructuring that is revenue-neutral would be easier to implement. Several countries experienced fundamental tax reforms. From 1986, Denmark gradually moves the tax burden from labor income taxes to consumption taxes; over 1994-1999, Hungary reduces payroll taxes while increasing the effective labor income tax rates; in 2005 Germany cut its payroll taxes while increasing the standard consumption tax rate from 16\% to 19\% in 2007. This question has triggered an intense debate in the European countries until recently, in particular in France regarding the eventual adoption of the social VAT implemented in Germany.

Building on that, a key policy question for European countries is wether a shift of the labor tax burden to consumption tax could be a useful tool for stimulating employment without increasing public debt. Additionally, the type of a tax restructuring should rely upon current countries’ tax structure. Table 1 reports the rate of consumption tax \(\tau^c\), the employers’ part of labor taxes \(\tau^F\) and the employees’ part of labor taxes \(\tau^H\) across thirteen OECD countries over the recent period (2000-2006).\(^2\) The most striking feature is that both consumption and labor taxes vary considerably across countries and thus there exists a room for a tax reform in several OECD economies. For instance, a strategy which involves simultaneously cutting payroll taxes and raising the consumption tax rate in France and Italy which reached upper
Table 1: Consumption and Labor Tax rates in 13 OECD countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>$\tau^c$</th>
<th>$\tau^F$</th>
<th>$\tau^H$</th>
<th>Countries</th>
<th>$\tau^c$</th>
<th>$\tau^F$</th>
<th>$\tau^H$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>0.18</td>
<td>0.16</td>
<td>0.32</td>
<td>Italy</td>
<td>0.14</td>
<td>0.27</td>
<td>0.28</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.13</td>
<td>0.20</td>
<td>0.42</td>
<td>Japan</td>
<td>0.07</td>
<td>0.08</td>
<td>0.19</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.26</td>
<td>0.00</td>
<td>0.42</td>
<td>Netherlands</td>
<td>0.18</td>
<td>0.09</td>
<td>0.33</td>
</tr>
<tr>
<td>Spain</td>
<td>0.14</td>
<td>0.22</td>
<td>0.20</td>
<td>Sweden</td>
<td>0.20</td>
<td>0.23</td>
<td>0.31</td>
</tr>
<tr>
<td>Finland</td>
<td>0.23</td>
<td>0.23</td>
<td>0.32</td>
<td>UK</td>
<td>0.15</td>
<td>0.07</td>
<td>0.26</td>
</tr>
<tr>
<td>France</td>
<td>0.16</td>
<td>0.27</td>
<td>0.29</td>
<td>US</td>
<td>0.05</td>
<td>0.06</td>
<td>0.25</td>
</tr>
<tr>
<td>Germany</td>
<td>0.15</td>
<td>0.15</td>
<td>0.44</td>
<td><strong>Average</strong></td>
<td>0.16</td>
<td>0.16</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Notes: $\tau^c$: consumption tax rate, $\tau^F$: employers’ part of labor taxes, and $\tau^H$: employees’ part of labor taxes. Source: OECD. Data coverage: 2000-2007

bounds of $\tau^F$, reducing labor income taxes and increasing $\tau^c$ in Belgium, or decreasing $\tau^F$ while raising $\tau^H$ in Spain.

There has been recently a growing interest for tax policy, as exemplified by Leeper and Yang [2008], Mankiw and Weinzierl [2006], Trabandt and Uhlig [2006], who consider a closed-economy model. Instead, Ganelli and Tervala [2008], Lin [1999], Mendoza and Tesar [1998] investigate the implications of a tax reform in an open-economy framework. One major contribution of our paper is to cover both the closed- and open-economy dimensions of contemporaneous industrialized countries by considering both non tradables and tradables. The relevance of the distinction between a non traded sector and a traded sector is supported by the data as shown in Table 2. More specifically, empirical evidence reveal that in OECD countries, the non tradable share in overall GDP and total employment averages to 65% and about 60% in total investment expenditure. A second interesting feature is that the response of a two-sector economy to a shock depends heavily on relative sectoral capital intensities. However the two-sector theoretical literature (see e.g. Coto-Martinez and Dixon [2003], Obstfeld [1989]) commonly assumes that the traded sector is more capital intensive for analytical convenience. Our estimation of sectoral output shares of capital income shows that the non traded sector is relatively more capital intensive in 6 of 13 industrialized countries. Hence, we consider the two cases both analytically and numerically. A third key feature is that our estimation of the markup at a sectoral level shows that the non traded sector displays a large market power. This has been introduced by assuming that the non traded sector is imperfectly competitive.

What are the main economic lessons drawn from our two-sector general equilibrium model? One virtue of the model we developed is that it allows to express the steady-state changes of a tax restructuring as a scaled-down version of long-term effects of a labor tax cut financed
Table 2: Sectoral Capital Intensities, Markups and Non-Tradable Share

<table>
<thead>
<tr>
<th></th>
<th>$\theta^T$</th>
<th>$\theta^N$</th>
<th>$\mu^N$</th>
<th>$\mu^T$</th>
<th>$Y^N/Y$</th>
<th>$L^N/L$</th>
<th>$I^N/I$</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>0.27</td>
<td>0.30</td>
<td>1.42</td>
<td>1.22</td>
<td>0.69</td>
<td>0.64</td>
<td>0.63</td>
</tr>
<tr>
<td>Germany</td>
<td>0.22</td>
<td>0.35</td>
<td>1.55</td>
<td>1.17</td>
<td>0.64</td>
<td>0.61</td>
<td>0.61</td>
</tr>
<tr>
<td>Italy</td>
<td>0.22</td>
<td>0.33</td>
<td>1.73</td>
<td>1.24</td>
<td>0.63</td>
<td>0.56</td>
<td>0.54</td>
</tr>
<tr>
<td>Japan</td>
<td>0.42</td>
<td>0.39</td>
<td>1.63</td>
<td>1.28</td>
<td>0.64</td>
<td>0.61</td>
<td>0.59</td>
</tr>
<tr>
<td>US</td>
<td>0.36</td>
<td>0.32</td>
<td>1.42</td>
<td>1.24</td>
<td>0.68</td>
<td>0.72</td>
<td>0.59</td>
</tr>
<tr>
<td>Average (13)</td>
<td>0.32</td>
<td>0.32</td>
<td>1.48</td>
<td>1.23</td>
<td>0.65</td>
<td>0.64</td>
<td>0.59</td>
</tr>
<tr>
<td>$k^T &gt; k^N$ (6)</td>
<td>0.37</td>
<td>0.31</td>
<td>1.44</td>
<td>1.26</td>
<td>0.64</td>
<td>0.64</td>
<td>0.60</td>
</tr>
<tr>
<td>$k^N &gt; k^T$ (5)</td>
<td>0.28</td>
<td>0.33</td>
<td>1.51</td>
<td>1.21</td>
<td>0.66</td>
<td>0.63</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Notes: $\theta^T$ ($\theta^N$ respectively): output share of capital income in the traded (non traded respectively) sector. $\mu^T$ and $\mu^N$ are the markups charged in the traded and non traded sector. $Y^N/Y$, $L^N/L$ and $I^N/I$ are the non tradable share in overall GDP, total employment and investment expenditure respectively. Source: OECD, EU KLEMS. Data coverage: 1970-2004.

by a fall in lump-sum transfers. This enables us to find analytically that regardless of the type of the tax reform and financing scheme, a tax restructuring crowds-in consumption and investment in the long-term, raises permanently employment and thereby boosts overall GDP. To estimate the effectiveness of a tax reform, we calculated both analytically and numerically the long-term and short-term tax multipliers and evaluated the size of overall welfare gains. We find that the tax multipliers for overall output are always positive and agents’ overall welfare rises for the benchmark parametrization. Interestingly, adjustments of both investment and trade balance play a key role in determining the effectiveness of a tax restructuring. As the trade balance enters on deficit on impact, the short-term tax multiplier which falls in the range 0.03-0.14 is always smaller than the long-term tax multiplier which comprises between 0.05 and 0.25. More interestingly, time horizon matters in determining the size of sectoral expansionary effects. Whereas its share in overall output is about 1/3 in industrialized countries, the boom in the traded sector in the long-term amounts for half of GDP increase. By contrast, in the short-term, output in the traded sector drops dramatically while the non traded sector expands sizeably.

One important contribution of our formal study is to highlight the roles of two critical parameters in determining the size of the tax multiplier: the elasticity of labor supply and the degree of tax progressiveness. Hence, we conducted a sensitivity analysis with respect to these to parameters. First, like Baxter and King [1993], we find that the long-term tax multiplier for overall output rises monotonically with labor responsiveness. Unlike, the short-term tax multiplier decreases as long as the elasticity labor supply exceeds unity since the
depressing effect on the domestic demand induced by the higher consumption price index predominates over the stimulating effect originating from the standard wealth effect. We get a more complete picture by conducting the sensitivity analysis at a sectoral level. We find that the short-term sectoral tax multiplier in the non traded sector rises and in the traded sector falls as labor supply gets more responsive since investment is crowded-in further by the tax reform. Finally, the long-term tax multiplier falls or rises with the degree of tax progressiveness depending on whether the tax restructuring keeps the tax revenue or the tax wedge constant since in the latter case, the depressing effect induced by the rise in the labor income tax gets smaller as the tax scheme gets more progressive.

The paper is organized as follows. Section 2 outlines the specification of a two-sector model. In sections 3 and 4, we discuss both analytically and numerically the steady-state and the dynamic effects of three tax restructuring. In section 5, we conduct a sensitivity analysis at an overall and a sectoral level with respect to key parameters. Section 6 concludes.

2 The Framework

Consider a small open economy that is populated by a constant number of identical households and firms that have perfect foresight and live forever. The country is small in world goods and capital markets and faces given world interest rate, $r^\star$. A perfectly competitive sector produces a traded good denoted by the superscript $T$ that can be exported and consumed domestically. An imperfectly competitive sector produces a non traded good denoted by the superscript $N$ which is devoted to physical capital accumulation and domestic consumption. Finally, the traded good is chosen as numeraire.

2.1 Households

At each instant the representative agent consumes traded goods and non traded goods denoted respectively by $c^T$ and $c^N$. We assume that there is a continuum of commodities indexed by the subscript $j \in [0,n]$ and denoted by $c^N(j)$, each produced by a different firm. Consumption of non traded commodity $j$ is aggregated by the means of the following formulation:

$$c^N = n^{1-\sigma} \left[ \int_0^n c^N(j)^{\frac{\sigma-1}{\sigma}} \right]^\frac{\sigma}{\sigma-1}, \quad \sigma > 1,$$

where the size of the parameter $\sigma$ reflects the ease with which any varieties can be substituted for each other. Denoting by $p$ the unit cost of the non traded composite good and using cost-minimizing, the demand for variety $j$ of the non traded consumption good can be written as
follows:
\[ c^N(j) = \frac{1}{n} \left( \frac{\varrho(j)}{p} \right)^{-\sigma} c^N, \quad p = n^{-\frac{1}{1-\sigma}} \left[ \int_0^n \varrho(j)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \]  
where \( c^N \) represents the composite non traded consumption good and \( \varrho(j) \) the price of commodity \( j \).

The agent is endowed with a unit of time and supplies a fraction \( L(t) \) as labor. At any instant of time, households gain utility from their consumption and experience disutility from supplying labor. The traded and the non traded good are aggregated by a constant elasticity of substitution function:
\[ c(e^T, c^N) = \left[ \phi \left( e^T \right)^{\frac{\phi-1}{\phi}} + (1 - \phi) \left( c^N \right)^{\frac{\phi-1}{\phi}} \right]^{\frac{1}{\phi-1}}, \]  
with \( \phi \) the weight attached to the traded good in the overall consumption bundle \((0 < \phi < 1)\) and \( \phi \) the intratemporal elasticity of substitution \((\phi > 0)\).

The representative household maximizes a lifetime utility function:
\[ U = \int_0^\infty \left[ u(c(t)) + v(L(t)) \right] e^{-\beta t} dt, \]  
where \( \beta \) is the consumer’s discount rate. For analytical simplicity, instantaneous utility function \( \xi = u(c) + v(L) \) is assumed to be separable in consumption and labor and to take an iso-elastic form:
\[ \xi = \frac{1}{1 - \frac{1}{\sigma_c}} c^{1 - \frac{1}{\sigma_c}} - \gamma \frac{1}{1 + \frac{1}{\sigma_L}} L^{1 + \frac{1}{\sigma_L}}, \]  
where \( \sigma_c \) is the intertemporal elasticity of substitution for consumption and \( \sigma_L > 0 \) the Frisch elasticity of labor supply (or intertemporal elasticity of substitution for labor supply); \( \gamma > 0 \) is a simple scaling factor which parametrizes the magnitude of disutility from working.\(^5\)

Households supply \( L(t) \) units of labor services for which they receive the after-tax labor income \( w^A L \). More specifically, households earn the gross real wage \( w \) and pay a labor income tax \( \tau^H \) above a certain threshold denoted by \( \kappa \). Hence, the after-tax wage writes as \( w^A = w - (w - \kappa) \tau^H \). They hold the physical capital stock for which they receive the capital rental rate \( r^K \). They accumulate internationally traded bonds holding, \( b(t) \), that yields net interest rate earnings \( r^* b(t) \), expressed in terms of the traded good. Additionally, households receive lump-sum transfers \( Z \) from the State. Hence, the flow budget constraint writes as follows:
\[ \dot{b}(t) = r^* b(t) + r^K K(t) + w^A L(t) - p_c (1 + \tau^c) c(t) - p(t) I(t) + Z. \]  
Total expenditure in consumption goods is equal to \( p_c (1 + \tau^c) c \) with \( \tau^c \) the consumption tax rate and \( p_c \) the consumption price index; \( pI \) represents capital investment measured in terms of the traded good.
We assume that \( I \) is defined analogously (all investment consists in non traded goods) to \( c^N \) with the same elasticity of substitution \( \sigma \):

\[
I = n^{\frac{1}{\sigma}} \left[ \int_0^n \varsigma j^\frac{\sigma-1}{\sigma} \right]^\frac{\sigma}{\sigma-1}, \quad \sigma > 1. \tag{7}
\]

Adopting a similar cost-minimizing procedure than we used for consumption, households’ demand for variety \( j \) of the investment good is thus given by:

\[
i(j) = \frac{1}{n} \left( \frac{\phi(j)}{p} \right)^{-\sigma} I. \tag{8}
\]

Since the specifications for \( c^N \) and \( I \) are identical, the price index for investment good is given by \( p \) (see (2)). Aggregate investment gives rise to overall capital accumulation according to the following dynamic equation:

\[
\dot{K}(t) = I(t) - \delta_K K(t). \tag{9}
\]

where we assume that physical capital depreciates at rate \( \delta_K \).

Since \( c(.) \) is homothetic, the household’s maximization problem can be decomposed into two stages. In the first stage, consumers choose their real consumption, \( c \), labor supply \( L \), and the rates of accumulation of both traded bonds and domestic capital to maximize (4) subject to the flow budget constraint (6) and initial conditions \( b(0) = b_0 \) and \( K(0) = K_0 \). At the second stage, the cost-minimizing intratemporal allocation between non traded and traded goods follows immediately from the Shephard’s Lemma: \( pc^N = \alpha c \) and \( c^T = (1 - \alpha c) p c \), with \( \alpha c \) the share of non traded goods in consumption expenditure.

### 2.2 Firms

Both sectors use physical capital, \( K^T \) and \( K^N \), and labor, \( L^T \) and \( L^N \), according to a constant returns to scale production function, \( Y^T = F(K^T, L^T) \) and \( Y^N = H(K^N, L^N) \), which are assumed to have the usual neoclassical properties of positive and diminishing marginal products. The traded and non traded sectors face two cost components: a capital rental cost equal to \( r^K \), and a labor cost equal to \( w^F = w (1 + \tau^F) \) with \( \tau^F \) denotes the payroll tax rate (i.e. the employer’s part of labor taxes).

The first order conditions derived from profit-maximization in the traded sector state that capital marginal product is equal to capital rental rate, i.e. \( F_K = r^K \), and labor marginal product equalizes labor cost, i.e. \( F_L = w^F \). Firm \( j \) in the non traded sector produces a level of output \( Z^N(j) = Y^N(j) - FC(j) \) with \( Y^N(j) = H(K^N(j), L^N(j)) \) and \( FC(j) > 0 \) is a fixed cost. Each firm \( j \) chooses capital and labor to maximize profits subject to the demand for
each brand originating from the private \( c^N(j) + \iota(j) \) and the public sector \( g^N(j) \), taking the price index \( p \) for the composite consumption good and input prices as given:

\[
\varrho(j) H \left( K^N(j), L^N(j) \right) - r^K K^N(j) - w^F L^N(j) - \varrho(j) FC(j),
\]

subject to \( Y^N(j) = c^N(j) + \iota(j) + g^N(j) \),

which assumes that labor is perfectly mobile across firms so that all firms are constrained to pay the same wage \( w^F \). This choice problem for firm \( j \) yields the conditions that the marginal revenue of capital and labor equalizes the capital rental rate \( r^K \) and the producer wage \( w^F \). The marginal product of each input is lowered by the (constant) markup \( \mu (= \mu^N) \) which is defined as follows:

\[
\mu \equiv \frac{\sigma}{\sigma - 1},
\]

with \( \sigma > 1 \) the elasticity of demand facing firm \( j \). Since commodities are differentiated, each firm has market power and is able to set a price over the marginal cost. In this paper, we further assume that free entry drives profits down to zero.

We should focus on a symmetric equilibrium where all non competitive firms will produce the same output and will charge the same price \( \varrho(j) = \varrho = p \). Under symmetry, aggregate consumption and investment in the non traded good are \( c^N = n c^N \) and \( I = n u \). In addition, we have the resource constraints \( L^T + L^N = L \) with \( L^N = n L^N \) and \( K^T + K^N = K \) with \( K^N = n K^N \). With free-entry, the zero-profit condition determines the number of firms which is given by \( n FC = (\mu - 1) Z^N \), using the fact that \( Z^N = Y^N / \mu \).

### 2.3 Government

The final agent in the economy is the government who finances lump-sum transfers to households \( Z \) together with public spending falling on the traded \( g^T \) and the non traded good \( pg^N \) by raising taxes on consumption, \( \tau^c p_c \), and labor, \( [\tau^H (w - \kappa) + \tau^F w] \), according to the following balanced condition:

\[
\tau^c p_c + [\tau^H (w - \kappa) + \tau^F w] L = Z + g^T + pg^N.
\]

Similar to consumption, government spending in the composite non traded good \( g^N \) is defined analogously to \( c^N \) and \( I \).

### 2.4 Macroeconomic Equilibrium and Equilibrium Dynamics

Denoting by \( k^i \equiv K^i / L^i \) the capital-labor ratio for sector \( i = T, N \), we express the production functions in intensive form \( f \left( k^T \right) \equiv F \left( K^T, L^T \right) / L^T \) and \( h \left( k^N \right) \equiv H \left( K^N, L^N \right) / L^N \), where small letters mean that the variable is expressed in terms of the sector specific labor.
To obtain the macroeconomic equilibrium, we first derive the optimality conditions for households and firms and then combine these with the inputs allocation constraints and accumulation equations. The macroeconomic equilibrium is summarized by the following set of equations:

\[ u_c(c) = p_c(p) (1 + \tau_c) \lambda, \]  
\[ v_L(L) = -\lambda w^A, \]  
\[ f_k(k^T) = \frac{p}{\eta} h_k(k^N) \equiv r^K, \]  
\[ f(k^T) - k^T f_k(k^T) = \frac{p}{\eta} [h(k^N) - k^N h_k(k^N)] \equiv w (1 + \tau^F), \]  
\[ L^T k^T + L^N k^N = K, \]  
\[ L^T + L^N = L, \]  
\[ \dot{\lambda} = \lambda (\beta - r^*), \]  
\[ \frac{r^K}{p} - \delta_K + \frac{\dot{p}}{p} = r^*, \]  
\[ \dot{K} = \frac{Y^N}{\mu} - c^N - g^N - \delta_K K, \]  
\[ \dot{b} = r^* b + Y^T - c^T - g^T, \]  

and the appropriate transversality conditions; \( \lambda \) is the co-state variable associated with dynamic equation (6). We require the time preference rate to be equal to the world interest rate:

\[ \beta = r^*, \]  

in order to generate an interior solution. This standard assumption made in the literature implies that the marginal utility of wealth, \( \lambda \), must remain constant over time, i.e. \( \lambda = \bar{\lambda} \) (see e.g. Cardi [2007] on that subject).

Static efficiency conditions (13a) and (13b) can be solved for real consumption and labor which of course must hold at any point of time:

\[ c = c(\bar{\lambda}, p, \tau^c), \quad L = L(\bar{\lambda}, p, \tau^F, \tau^H), \]  

with \( c_{\bar{\lambda}} < 0, c_p < 0, c_{\tau^c} < 0, L_{\bar{\lambda}} > 0 \); additionally, \( L_{\tau^F} < 0, L_{\tau^H} < 0 \), and \( L_p \leq 0 \) according to wether \( k^N \geq k^T \). To save some space, we restrict the discussion to the implications of tax rate changes. While a rise in the consumption tax rate \( \tau^c \) depresses consumption by raising its marginal cost, a fall in the labor income tax rate levied on employers \( \tau^F \) or employees \( \tau^H \) stimulates labor supply by raising the after-tax labor income.

Static efficiency conditions (13c)-(13d) state that sectoral marginal revenue products must equalize to the labor producer cost \( w^F \) and capital rental rate \( r^K \). They can be solved for sector
capital intensities ratios which together with resource constraints and production functions lead to short-term static solutions for sectoral output:

\[ k^T = k^T(p), \quad k^N = k^N(p), \quad Y^T = Y^T(K, p, L), \quad Y^N = Y^N(K, p, L), \]  

(16a)

where the signs of partial derivatives are dependent upon relative sectoral capital intensities, with the exception for \( Y_p^T < 0 \) and \( Y_p^N > 0 \). An increase in overall capital stock (resp. total employment) causes a labor inflow in the more capital (resp. labor) intensive sector. A labor tax cut boosts labor supply which thereby shifts employment in favor of the less capital intensive sector.

The transitional adjustment of the two-sector economy is driven by three equations (13h), (13i) and (13j). The two dynamic equations (13h)-(13i) form a separate subsystem in \( p \) and \( K \). The capital accumulation equation (13i) which states that investment must eliminate an eventual excess demand or excess supply in the non traded good market. The dynamic equation for the real exchange rate (13h) adjusts to equalize the returns on domestic capital and foreign assets. Since the number of predetermined variables \( (K) \) equals the number of negative eigenvalues denoted by \( \nu_1 \), and the number of jump variables \( (p) \) equals the number of positive eigenvalues denoted by \( \nu_2 \), the equilibrium yields a unique one-dimensional stable saddle-path, irrespective of the relative sizes of capital-labor ratios.

2.5 Steady-State

Substituting first the short-run static solutions (15) and (16), the steady-state of the economy is obtained by setting \( \dot{K}, \dot{p}, \dot{b} = 0 \) and is defined by the following set of equations:

\[ \frac{h_k [k^N(\bar{p})]}{\mu} - \delta K = r^*, \]  

(17a)

\[ \frac{1}{\mu} Y^N(\bar{K}, \bar{b}, \bar{\lambda}, \tau_F, \tau_H) - c^N(\bar{\lambda}, \bar{\rho}, \tau^c) - \delta \bar{K} - g^N = 0, \]  

(17b)

\[ r^* \bar{b} + Y^T(\bar{K}, \bar{b}, \bar{\lambda}, \tau_F, \tau_H) - c^T(\bar{\lambda}, \bar{\rho}, \tau^c) - g^T = 0, \]  

(17c)

and the intertemporal solvency condition

\[ \left( b_0 - \bar{b} \right) = \Omega \left( K_0 - \bar{K} \right), \]  

(17d)

where \( \Omega < 0 \). The steady-state equilibrium composed by these four equations jointly determines \( \bar{p}, \bar{K}, \bar{b} \) and \( \bar{\lambda} \).

Equation (17a) asserts that the rate of return on domestic capital income is equal to \( r^* \). Since the world interest rate is fixed, this equality determines the steady-state values
of \( p \) which thereby is unaffected by a tax restructuring. Equation (17b) restates that the production of non traded goods net of fixed cost must be exactly outweighed by a demand counterpart. Equation (17c) implies that in the steady-state equilibrium, the current account must be zero which means that interest receipts from foreign assets holding, i.e. \( r^* \tilde{b} \), must be equal to net exports denoted by \( \tilde{n}x \) with \( nx = Y^T - c^T - g^T \).

### 3 Lump-Sum Transfer Financing and Tax Rate Changes

For the reader’s convenience we discuss briefly the steady-state effects of a labor tax cut and a rise in the consumption tax rate separately. Note that the change of tax rate are financed by a change in lump-sum transfers. Qualitative and quantitative responses of main macroeconomic variables are reported in Table 3.

#### Table 3: Steady-State Effects of a Rise in Consumption Tax and a Fall in Payroll Tax

<table>
<thead>
<tr>
<th>Model</th>
<th>Numerical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( k^T &gt; k^N )</td>
</tr>
<tr>
<td>( d\tau^c ) &gt; 0</td>
<td>( d\tau^f ) &lt; 0</td>
</tr>
<tr>
<td>( c )</td>
<td>-</td>
</tr>
<tr>
<td>( L )</td>
<td>-</td>
</tr>
<tr>
<td>( K )</td>
<td>-</td>
</tr>
<tr>
<td>( Y )</td>
<td>-</td>
</tr>
</tbody>
</table>

**Notes:** All steady-state effects are reported as percentage changes relative to the initial steady-state after the consumption tax rise \((d\tau^c = +0.03)\) and income tax cuts \((d\tau^f \text{ and } d\tau^H = -0.03)\).

#### Benchmark Parametrization

The model is calibrated for a plausible set of utility and production parameters in order to be consistent with data of OECD countries (see Table 4 for a summary). The production functions are supposed to take a Cobb-Douglas form:

\[
f (k^T) = (k^T)^{\theta^T}, \quad h (k^N) = (k^N)^{\theta^N},
\]

where \( 0 < \theta^T < 1 \) and \( 0 < \theta^N < 1 \) represent the output share of capital income in the traded and non traded sector respectively.

We first briefly discuss the calibration. Based on empirical estimates provided by Cashin and McDermott [2003], we set the intertemporal elasticity of substitution \( \sigma_c \) to 0.7 and the intratemporal elasticity of substitution \( \phi \) to 2. Following Stockman and Tesar [1995], the parameter \( \varphi \) is assigned so as the the non tradable content in total consumption expenditure denoted by \( \alpha_e \) falls in the range 40-60%. Hence, \( \varphi \) is set to 0.5. A critical parameter is the
elasticity of labor supply. While empirical studies based on micro data find low values, say broadly lower than 0.5, the real business cycle literature often set higher values for $\sigma_L$, say broadly equal or higher than unity. While we choose an average value and set $\sigma_L$ to 0.75, we conduct a sensitivity analysis with respect to this parameter in section 5. The world interest rate, which is constrained to equalize the subjective time discount rate $\beta$, is chosen to be 4%. The rate of depreciation of capital is set to 6%.

Table 4: Benchmark parameter values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_c$</td>
<td>0.70 0.70</td>
<td>Intertemporal elasticity of substitution</td>
</tr>
<tr>
<td>$\sigma_L$</td>
<td>0.75 0.75</td>
<td>Frisch elasticity of labor supply</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.90 0.90</td>
<td>Scaling parameter in labor disutility function</td>
</tr>
<tr>
<td>$\varphi$</td>
<td>0.50 0.50</td>
<td>Share of traded goods in consumer’s bundle</td>
</tr>
<tr>
<td>$\phi$</td>
<td>2.00 2.00</td>
<td>Intratemporal elasticity of substitution</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.04 0.04</td>
<td>Subjective time discount rate</td>
</tr>
<tr>
<td>$\delta_K$</td>
<td>0.06 0.06</td>
<td>Rate of physical capital depreciation</td>
</tr>
<tr>
<td>$\theta^T$</td>
<td>0.37 0.28</td>
<td>Capital share in the Traded sector</td>
</tr>
<tr>
<td>$\theta^N$</td>
<td>0.31 0.33</td>
<td>Capital share in the Non Traded sector</td>
</tr>
<tr>
<td>$\mu$</td>
<td>1.45 1.51</td>
<td>Markup charged by the non traded sector</td>
</tr>
<tr>
<td>$\tau^c$</td>
<td>0.135 0.175</td>
<td>Consumption tax rate</td>
</tr>
<tr>
<td>$\tau^F$</td>
<td>0.125 0.184</td>
<td>Employer’s payroll tax rate</td>
</tr>
<tr>
<td>$\tau^H$</td>
<td>0.257 0.354</td>
<td>Employee’s wage tax rate</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.20 0.15</td>
<td>Tax allowance</td>
</tr>
</tbody>
</table>

We calculate the output shares of capital income, the markup, the tax rates, and tax allowances, which are summarized in Table 4. The markup has been estimated by using the Roeger’s [1995] consistent methodology; $\mu$ is set to 1.45 if $k^T > k^N$ and 1.51 if $k^N > k^T$, in line with empirical evidence; we calculated the effective tax rates on consumption and labor by using OECD database. Since the adjustment of a two-sector country depends on the relative sectoral capital intensities, we consider two different scenarios; in the first scenario, the traded sector is more capital intensive than the non traded sector ($\theta^T > \theta^N$); in the second scenario, the non traded sector is more capital intensive than the traded sector ($\theta^N > \theta^T$).

A Labor Tax Cut

While numerical results confirm the tax invariance incidence principle, the magnitude of the long-term effects displays a modest discrepancy depending on whether the tax cut benefits to employers or employees. The economic intuition of steady-state changes is as follows. A
reduction of the labor tax $\tau^j \ (j = F, H)$ induces agents to supply more labor. As after-tax labor income increases, individuals are induced to raise their real expenditure. An excess demand arises in the non traded good market which leads to an investment boom and a current account deficit.

**A Rise in Consumption Tax**

A rise in $\tau^c$ raises the marginal cost of consumption which in turn induces agents to reduce their real expenditure. The drop in consumption in the non traded good market requires a fall in the capital stock. As the open economy decumulates physical capital, the stock of foreign bonds grows. In the same time, the government returns the net receipts to agents in a lump-sum transfer, households get richer and lower their labor supply.

It is worthwhile noticing that numerical values of steady-state changes summarized in Table 3 do not display a considerable variability across scenarios. Households lower or raise real consumption, employment and physical capital by about 1% depending on whether the government raises the consumption tax rate by 3% or cuts the labor tax by the same amount.

**4 Three Tax Reform strategies**

Since countries differ markedly in their tax structure, we consider three types of tax restructuring. More specifically, we explore two revenue-neutral tax reforms which involve simultaneously either cutting payroll taxes by $d\tau^F < 0$ or cutting labor income taxes by $d\tau^H < 0$ and raising the consumption tax rate by $d\tau^c > 0$. While the two previous tax reforms cause a fall in the marginal tax wedge, we study a third tax reform which involves simultaneously cutting payroll taxes by $d\tau^F < 0$ and raising labor income taxes by $d\tau^H > 0$ so as to leave the marginal tax wedge, denoted by $\tau^M$, constant.

As long as tax allowances are positive, the tax system is progressive which means that the average tax burden rises with the wage rate. Hence, the marginal tax wedge denoted by $\tau^M$ does no longer coincide with the average tax wage $\tau^A$. In line with Heijdra and Lightart [2008], $\tau^M \equiv 1 - \frac{(1 - \tau^H)}{(1 + \tau^F)}$ which enables us to define the average tax wedge as $\tau^A \equiv \tau^M - \frac{\tau^H \kappa}{w_F}$. Remembering that the coefficient of average tax progression denoted by $\Psi$ is defined as the difference between the marginal and the tax wedge, we provide a measure of the degree of tax progressiveness captured by $\Psi (\tau^F, \tau^H, \kappa) \equiv \frac{\tau^H \kappa}{w_F}$. Ceteris paribus, a rise in $\tau^H$ (resp. $\kappa$) raises the progressiveness of the tax scheme by increasing further $\tau^M$ (resp. lowering $\tau^A$).
4.1 Long-Term Effects of Revenue-Neutral Tax Reforms

To avoid confusion, we denote by $|j,c$ the effects of a fall in the labor tax by $d\tau^j < 0$ ($j = F, H$) coordinated with a rise in the consumption tax rate by $d\tau^c|j,c$ which is endogenously determined so as the government budget constraint is met.

**The Endogenous Rise in $\tau^c$**

Suppose that the policy maker wishes to replace the labor tax with a consumption tax, keeping the budget constraint balanced. For unchanged labor supply and consumption decisions, the labor tax cut (resp. increase in the consumption tax) leads to a fall (resp. a rise) in tax revenue commonly labelled the *tax rate effect*. In addition, a change of a distortionary tax modifies the behavior of households. This induces a *tax base effect* which works in opposite direction of the *tax rate effect* on public revenue. These two effects influence the size of the change of $\tau^c$ required to maintain the budget balance:

$$d\tau^c|j,c = -\frac{\chi^j}{\chi^c}d\tau^j = -\left\{\frac{\tau^j p_c \frac{d\tau^c}{d\tau^j} + (\tilde{w}^F - \tilde{w}^A) \frac{dL}{d\tau^j} + \Gamma^j}{\tau^j p_c \frac{d\tau^c}{d\tau^j} + (\tilde{w}^F - \tilde{w}^A) \frac{dL}{d\tau^j} + \Gamma^c}\right\}d\tau^j > 0,$$

(19)

where $\chi^c > 0$ and $\chi^j \geq 0$. We denoted by $\Gamma^j (j = F, H)$ and $\Gamma^c$ the labor and the consumption *tax rate effects*:

$$\Gamma^F = \frac{1 - \tau^H}{1 + \tau^F}\tilde{w}\tilde{L}, \quad \Gamma^H = (w - \kappa)\tilde{L}, \quad \Gamma^c = p_c\tilde{c}. \quad (20)$$

The terms $\chi^j$ and $\chi^c$ capture two conflictary effects induced by a reduction of the labor tax rate and an increase in the consumption tax rate respectively on public revenue. For given levels of real consumption and employment, a change of the tax rate modifies tax earnings as it is reflected by $\Gamma^j$ and $\Gamma^c$ (see the third terms on the RHS of (19)). However, as shown by the two first terms of the numerator and the denominator on the RHS of (19), the resulting long-term adjustment of employment and consumption moderate the labor and the consumption *tax rate effects*. For the benchmark parametrization, $\chi^c$ and $\chi^j$ are positive which reflects the fact that the influence of the *tax rate effect* on tax revenue more than that offsets the impact of the *tax base effect*. Consequently, $\tau^c$ must rise to compensate the tax revenue loss induced by the labor tax cut.

To have a sense of the magnitude of the labor and consumption *tax base effect* which counteract the *tax rate effects*, we estimated the following ratios:

$$\frac{\chi^j}{\Gamma^j} \approx 0.68 - 0.79 \quad \text{and} \quad \frac{\chi^c}{\Gamma^c} \approx 0.81 - 0.85 \quad \text{and} \quad \frac{\Gamma^H}{\Gamma^c} \approx 0.77, \quad \frac{\Gamma^F}{\Gamma^c} \approx 0.52 - 0.64,$$

depending on wether case $k^N \geq k^T$. These ratios show to what extent does a tax cut pay for itself. For example, the numerical values of $\frac{\chi^j}{\Gamma^j}$ and $\frac{\chi^c}{\Gamma^c}$ which are approximately 0.72 and 0.83 respectively show that a fall by 1% of public revenue induced by a labor tax rate shrinks to
0.72% due to the labor tax base effect (i.e. the resulting long-term increases in consumption and labor) and a rise in 1% in public revenue induced by the increase in the consumption tax rate shrinks to 0.83% due to the consumption tax base effect (i.e. the resulting long-term decreases in consumption and labor).

The magnitude of the rise in $\tau^c$ can be split into two components: the extent to which the tax base effects compensate the tax rate effects and the ratio labor tax base-consumption tax base, i.e. $\frac{x^j}{x^c}$. While the first component plays a minor role, the ratio $\frac{\Gamma^j}{\Gamma^c}$ is primarily responsible of $d\tau^c|^{j,c}$. The second component is approximately equal to 0.58 which means that the labor tax base is about two-times smaller than the consumption tax base. Hence, a labor tax cut by 1 percentage point requires a rise in $\tau^c$ which is in average approximately halfway of the labor tax cut.

**Steady-State Changes**

We now analyze the overall effects of a shift of the tax burden from labor taxes to consumption taxes. After some manipulations, the long-term change of $x$ following a shift in the tax burden is given by:

$$d\tilde{x}|^{j,c} = \frac{d\tilde{x}}{d\tau^j} d\tau^j + \frac{d\tilde{x}}{d\tau^c} d\tau^c|^{j,c} \equiv \Phi^{j,c} \frac{d\tilde{x}}{d\tau^j} d\tau^j > 0,$$

where $\Phi^{j,c} = \left[1 - \tilde{a} \frac{\tilde{A} \tilde{I}_j}{P(x(1+\tau^c))}\right]$ for $j = F, H$. A sufficient condition for $\Phi^{j,c}$ to be positive but smaller than unity is that households are net creditor, i.e. $\tilde{a} > 0$. The overall outcome a tax restructuring is equal to the sum of the long-term rise in $x$ after a labor tax cut by $d\tau^j < 0$ and the steady-state fall in $x$ following a rise in by $d\tau^c|^{j,c} > 0$. Interestingly, according to (21), the steady-state change of $x$ following a tax restructuring is a scaled-down version of the long-term changes of $x = c, L, K$ after a fall in the labor tax $\tau^j$ ($j = F, H$) financed by lump-sum taxes. The larger the share of financial wealth in real disposable income, the larger the consumption tax base in comparison to the labor tax base, and thereby the less $\tau^c$ must increase for a given labor tax cut. Consequently, the tax restructuring gets more effective as the scaled-down term $\Phi^{j,c}$ gets closer to unity. This result stems from the fact that in the neoclassical model, a reduction of labor taxes financed by a rise in a distorsionary tax have smaller effects than a tax cut financed by lump-ump tax financing. For our benchmark parametrization, the scaled-down $\Phi^{j,c}$ falls in a range between 0.36 and 0.51 depending on wether $k^T \geq k^N$; additionally, $\Phi^{j,c}$ gets closer to unity as the consumption tax base gets larger compared to the labor tax base. Finally, since $x$ increases in the long-term after a labor tax cut financed by a fall in lump-sum transfers, i.e. $d\tilde{x}/d\tau^j > 0$, a tax restructuring unambiguously raises consumption, labor and physical capital.

To have a better grasp of consumption’s and labor’s increases, it is convenient to split the
Table 5: Quantitative Effects of Three Tax Reforms

<table>
<thead>
<tr>
<th>Tax Reform</th>
<th>$k^T &gt; k^N$</th>
<th>$k^N &gt; k^T$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\frac{\partial F}{\partial \tau^c}$</td>
<td>$\frac{\partial F}{\partial \tau^c}$</td>
</tr>
<tr>
<td></td>
<td>$\frac{\partial H}{\partial \tau^c}$</td>
<td>$\frac{\partial H}{\partial \tau^c}$</td>
</tr>
<tr>
<td><strong>A. Tax rates changes</strong></td>
<td>1.8</td>
<td>2.1</td>
</tr>
<tr>
<td>$d\tau^c$</td>
<td>-3.0</td>
<td>-3.0</td>
</tr>
<tr>
<td>$d\tau^F$</td>
<td>-3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>$d\tau^H$</td>
<td>-3.0</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>B. Long-Term</strong></td>
<td>0.32</td>
<td>0.37</td>
</tr>
<tr>
<td>Output, $d\tilde{Y}$</td>
<td>0.31</td>
<td>0.36</td>
</tr>
<tr>
<td>Labor, $d\tilde{L}$</td>
<td>0.34</td>
<td>0.40</td>
</tr>
<tr>
<td>Consumption, $d\tilde{c}$</td>
<td>0.33</td>
<td>0.38</td>
</tr>
<tr>
<td>Capital, $d\tilde{K}$</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>Overall Welfare, $dU$</td>
<td>0.31</td>
<td>0.36</td>
</tr>
<tr>
<td><strong>C. Short-Term</strong></td>
<td>0.34</td>
<td>0.40</td>
</tr>
<tr>
<td>Labor, $dL(0)/\bar{L}_0$</td>
<td>1.21</td>
<td>1.40</td>
</tr>
<tr>
<td>Consumption, $d\tilde{c}(0)/\tilde{c}_0$</td>
<td>1.40</td>
<td>-1.40</td>
</tr>
<tr>
<td>Investment, $dI(0)/\bar{Y}_0$</td>
<td>-1.21</td>
<td>-1.40</td>
</tr>
<tr>
<td>Net Exports, $dnx(0)/\bar{Y}_0$</td>
<td>-1.21</td>
<td>-1.40</td>
</tr>
</tbody>
</table>

**Notes:** All steady-state effects are reported as percentage changes relative to the initial steady-state. Regarding the short-term variations, the table reports impact reactions at time $t = 0$.

steady-state changes into a *wealth effect* and a *tax effect*:

$$d\tilde{c}_{j,c} = c_{j,c}d\bar{\lambda}_{j,c}^c + d\tau^c = L_d\bar{\lambda}_{j,c}^c + L_{\tau^c}d\tau^c > 0, \quad j = F, H.$$  \hspace{4cm} (22)

While the steady-state increase in real consumption stems from the *wealth effect*, the long-term rise in labor supply originates from the *tax effect*. The *tax effect* impinges negatively on the long-term value of real consumption. However, it displays a smaller size than its positive influence on labor since $\tau^c$ must increase but by less than the size of the labor tax cut. In line with theoretical results, as shown by row 2 in Table 5B, the steady-state rise in real consumption gets larger as the required rise in the consumption tax rate gets smaller. For example, a payroll tax cut by 3% leads to an increase in $\tau^c$ by 1.3% (resp. 1.8%) if $k^N > k^T$ (resp. $k^T > k^N$) and $\tilde{c}$ is raised by 0.46% (resp. 0.34%).

The steady-state change of the physical capital stock can be more easily discussed by differentiating totally the market-clearing condition for non tradables:

$$\frac{1}{\mu}(Y^N_K - \delta_K) d\tilde{K}^{j,c} + \frac{1}{\mu}Y^N_L d\tilde{L}^{j,c} = d\tilde{c}^N |^{j,c} > 0, \quad j = F, H.$$  \hspace{4cm} (23)
where \( Y_K^N - \delta_K \gtrless 0 \), \( Y_L^N \lesssim 0 \) depending on weather \( k^N \gtrsim k^T \). While it can be shown formally the capital stock rises in the long-term, the mechanism behind this result requires to consider two cases. If \( k^N > k^T \) (resp. \( k^T > k^N \)), the labor outflow (resp. inflow) from (resp. in) the more capital intensive sector reduces (resp. stimulates) \( Y^N \) while the demand for the non traded good rises. Consequently, an excess of demand (resp. excess of supply) arises which requires a long-term rise in the capital stock. In any cases, the tax reform leads to an investment boom which depresses the output of the relatively more labor intensive sector. As the open economy accumulates physical capital \( K \) over the transition towards the steady-state, agents reduce their foreign assets holding \( b \). For the current account to be null in the long-term, net exports \( \hat{n}x \) must rise to compensate the decrease in interest receipts from traded bonds holding.

As it can be seen from Table 5B, in line with theoretical results, a tax restructuring boosts capital accumulation in the long-term. Depending on whether employees or employers benefit from the labor tax cut, the steady-state rise in the overall capital stock falls in the range between 0.38%-0.56% if \( \tau^H \) is decreased and 0.33%-0.39% if \( \tau^F \) is cut. While for our benchmark parametrization, the former tax policy displays stronger effects on capital accumulation regardless of sectoral capital-labor ratios, we show in the next section that this result depends on the initial marginal tax wedge and the degree of tax progressiveness. The relevance of this discussion is supported by the cross-country comparison of the these two variables which display sizeable differences.

**A Cut in the Labor Income Tax or in the Payroll Tax?**

In this section, we provide an analytical comparison of the steady-state effects of a tax restructuring depending on whether the labor tax cut falls on the labor income tax or the payroll tax, i.e. depending on whether employees or employers benefit from the reduction in \( \tau^j \). A shift of the tax burden from labor taxes to consumption taxes implies that the long-term effect of a tax restructuring is a scaled-down version of the steady-state change after a cut in \( \tau^j \) financed by lump-sum taxes. Irrespective of the labor tax cut benefit to employers or employees, the scaled-down positive factor \( \Phi^{j,c} \) is identical, i.e. \( \Phi^{F,c} = \Phi^{H,c} \). The two tax reforms differ mainly in that the long-term change of \( x \) after a fall in \( \tau^H \) is a scaled-down or a scaled-up version of the steady-state change of \( x \) after a drop in \( \tau^F \) (financed by a fall in lump-sum transfers). To see it more formally, we express the steady-state change of \( x \) after a cut in \( \tau^H \) in terms of the long-term variation of \( x \) following a reduction of \( \tau^F \):

\[
\frac{d\hat{x}}{d\tau^H} = \frac{\hat{w} - \kappa}{\hat{w}} \frac{1 + \tau^F}{1 - \tau^H} \frac{d\hat{x}}{d\tau^F}.
\]

(24)

Technically, the size of the positive term \( \frac{\hat{w} - \kappa}{\hat{w}} \frac{1+\tau^F}{1-\tau^H} \), which might be higher or smaller than
unity, depends on the initial tax wedge $\tau^M$ and the degree of tax progressiveness. Intuitively, a cut in $\tau^F$ raises the wage rate and thereby the after-tax labor income by $\bar{w} \frac{1-\tau^H}{1+\tau^F} \equiv \bar{w} (1 - \tau^M)$. Rather, a drop in $\tau^H$ leaves unaffected $w$ and raises the after-tax labor income by $(\bar{w} - \kappa)$.

In brief, a tax restructuring displays stronger positive effects on labor market if households benefit from the labor tax cut than if payroll taxes are reduced as long as tax allowances $\kappa$ gets smaller and the initial marginal tax wedge $\tau^M$ gets closer to unity. Depending on whether the traded sector is more or less capital intensive than the non traded sector, steady-state changes after a cut in $\tau^H$ are about 1.15 or 1.43 the size of long-run changes following a reduction of $\tau^F$.

Finally, an interesting feature is that the effectiveness of a tax restructuring decreases with the degree of tax progressiveness, i.e. as tax allowances $\kappa$ rises, since the taxable labor income $w - \kappa$ and thereby the incentive to raise labor supply gets smaller. In brief, the tax progressiveness moderates the rise or the fall in the after-tax labor income and consequently the long-term effects of a tax restructuring which involves a cut in $\tau^H$.

4.2 Dynamics Effects of Consumption and Labor Tax Reforms

Having discussed the steady-state changes, which influence in turn agents’ expectations because of the perfect foresight property, we now investigate the dynamic effects of a shift of the tax burden from labor taxes to consumption taxes.

If $k^T > k^N$, the dynamics of the relative price of non tradables degenerate so that labor and real consumption increase immediately to their final long-term levels. Instead, if $k^N > k^T$, the temporal path of the real exchange rate is no longer flat which in turn restores the transitional dynamics for consumption and labor. The increase in the after-tax labor income causes a positive wealth effect that boosts consumption. As demand for non tradables rises and labor shifts towards the more labor intensive sector, an excess of demand arises in the non traded good market. This excess of demand appreciates the real exchange rate on impact by 0.05% (see Table 5C) which raises the consumption price index and lowers the wage rate.

Hence, consumption and labor rise initially but by a smaller amount than in the long-run.

Investment is the result of demand and supply reactions in the non traded good market which directions rely upon sectoral capital-labor ratios. If $k^N > k^T$ (resp. $k^T > k^N$), the increase in total employment induces a labor outflow (resp. inflow) in the non traded sector which depresses (resp. boosts) $Y^N$. As long as the non traded sector is more capital intensive, the real exchange appreciation attracts resources in that sector which more than offsets the former effect. While the initial demand boom for non tradables withdraws resources to capital
accumulation in either cases, the stimulus of non traded output is large enough to cause an investment boom on impact. Interestingly, as shown in Table 5C, a tax reform crowds-in investment by more if $k^N > k^T$ than with the reversal of capital intensities (i.e. 1.5% and 2.1% rather than 1.2% and 1.4%).

4.3 A Labor Tax Restructuring

In this section, we explore the effects of a labor tax reform strategy denoted by the superscript \{F, H\} which involves simultaneously cutting a payroll tax by $d\tau^F < 0$ and increasing the labor income tax $d\tau^H > 0$ so as to leave unaffected the marginal tax wedge denoted by $\tau^M$.

The labor tax reform strategy requires a rise in the wage income tax by an amount given by:

$$d\tau^H |^F,H = \frac{1 - \tau^H}{1 + \tau^F} d\tau^F,$$

(25)

where $\frac{1 - \tau^H}{1 + \tau^F} < 1$. From (25), the labor income tax must be increased by a smaller amount than the fall in $\tau^F$ for leaving unchanged the marginal tax wedge. In short, since the tax rate on a relatively large base is reduced and the tax rate on a relatively small base is increased, the latter must rise by a smaller proportion than the former decreases so as to leave unchanged $\tau^M$.

By using (24), the long-term change of $x = c, L, K$ following a cut in $\tau^F$ coordinated with a rise in $\tau^H$ by an amount given by (25) writes as follows:

$$d\bar{x} |^F,H = \Phi_{F,H} d\tau^F > 0,$$

(26)

where $\Phi_{F,H} \equiv \kappa / \bar{w} < 1$. As long as the labor income tax rate is progressive, i.e. $\kappa > 0$, then the labor tax reform leaving constant the marginal tax wedge affects the long-term equilibrium of the economy. More specifically, the steady-state increases in consumption, employment and capital stock are a scaled-down version of their long-term changes following a labor tax cut financed by lump-sum taxes.

Interestingly, tax progression benefits employment and overall economic activity because the after-tax wage unambiguously rises as it can be shown formally:

$$dw^A |^F,H = -\Psi w \frac{1 - \tau^H}{\tau^H} d\tau^F > 0,$$

(27)

where we assume that $d\tau^F < 0$. As the wage rate is permanently raised and labor supply is mostly determined by the tax effect, employment rises in the long-term. More specifically, as the degree of tax progression rises, as reflected by an increase in tax allowances $\kappa$, the rise in the after-tax labor income gets larger which in turn magnifies the beneficial effects on
employment and overall economic activity. Instead, if \( \kappa \) is set to zero, then a larger rise in \( \tau^H \) is required so that the long-term equilibrium of the open economy remains unchanged.

What is the effect of the reform on public revenue? The overall effect of a labor tax restructuring so as to leave unaffected \( \tau^M \) induces two conflictory effects on public revenue. Without tax base effects, a negative revenue effect would arise. Intuitively, the tax rate on a relatively large tax base is lowered while the tax rate on a relatively small base is raised. However, via the tax effect for employment and the wealth effect for consumption, the tax bases increase but not sufficiently so as to offset the negative tax rate effect. Accordingly, lump-sum transfers drop by -3.39% if \( k^T > k^N \) and -0.85% if \( k^N > k^T \).

### 4.4 Short-Term and Long-Term Tax Multipliers

Having discussed the steady-state and dynamics effects, we now investigate the effectiveness of the three tax reform strategies by calculating steady-state and impact tax multipliers for output at an overall and a sectoral level.

**The Overall Tax Multiplier**

Using the fact that overall output equalizes its demand counterpart, the steady-state tax multiplier for GDP is given by:

\[
d\tilde{Y}_{j,k} = p_c d\tilde{c}_{j,k} + d\tilde{n}x_{j,k} + \tilde{p}d\tilde{I}_{j,k} > 0, \quad j = F, H, \quad k = c, H,
\]

where we denoted net exports by \( nx \equiv Y^T - (c^T + g^T) \). According to (28), the domestic demand boom for consumption and investment goods is strengthened by a trade balance improvement. Since the tax reform raises overall demand, aggregate output unambiguously rises. Table 6 reports the numerical values of the steady-state tax multipliers for overall output. For the benchmark parametrization, the tax multipliers are positive and fall in the range between 0.06-0.25. As expected, a revenue-neutral tax reform displays larger beneficial effects than a strategy keeping the tax wedge constant since in the latter case the demand boom is strongly moderated by the fall in lump-sum transfers.

We now derive the short-term change of overall output by linearizing overall demand for the domestic good, i.e. \( Y = p_c c + (g^T + pg^N) + pI + nx, \) evaluating at time \( t = 0 \) and differentiating the resulting linearized version of this expression:

\[
dY(0)_{j,k} = p_c d\tilde{c}(0)_{j,k} + \tilde{p}d\tilde{I}(0)_{j,k} + \tilde{Y}^N dp(0)_{j,k} + dnx(0)_{j,k} > 0.
\]

The change of overall output on impact is driven by the initial demand boom for consumption goods and investment goods together with the strong real exchange rate appreciation which
raises the value of non traded output when expressed in terms of the traded good. While in the long-term, the trade balance improvement raises further GDP, the fall in net exports on impact, which reflects the current account deficit, lowers the effectiveness of the tax reform.

Let now investigate whether a tax reform displays more beneficial effects in the short- or in the long-term. While the short-run change of output benefits from the real exchange rate appreciation, the steady-state rise in net exports raises the steady-state value of GDP above that in the ST:

\[ 0 < dY(0)^{j,k} < d\bar{Y}^{j,k}. \] (30)

The numerical values reported in the Table 6 show that the short-term tax multiplier is about 1/3 or 1/2 the size of the long-term multiplier depending on whether \( k^T \gg k^N \). The smaller size of the short-term tax multiplier stems from the fact that part of the additional labor income is devoted to imports on impact which reduces as much as the demand for the domestic good. In addition, the short-run tax multiplier is reduced further since the strong real exchange rate appreciation on impact raises the consumption price index which thereby depresses private demand if \( k^N > k^T \).

<table>
<thead>
<tr>
<th>Tax Multipliers</th>
<th>( k^T &gt; k^N )</th>
<th>( k^N &gt; k^T )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-Term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y )</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>( Y^T )</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>( Y^N )</td>
<td>0.07</td>
<td>0.08</td>
</tr>
<tr>
<td>Short-Term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Y )</td>
<td>0.10</td>
<td>0.08</td>
</tr>
<tr>
<td>( Y^T )</td>
<td>-0.53</td>
<td>-0.63</td>
</tr>
<tr>
<td>( Y^N )</td>
<td>0.64</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Notes: The tax multipliers display the effects on the rate of change of GDP of a cut in labor taxes equal to -1 % point of initial GDP.

The Sectoral Tax Multiplier

So far, we investigated the effectiveness at the level of the overall economy. One central question in a two-sector model is: Which sector will benefit by more the tax reform strategy? We now show formally that regardless of sectoral capital intensities or the kind of tax reform, the tax multipliers in the traded and the non traded sector are both positive which implies
that a sector does not expand at the expense of the other sector.

Using the market-clearing condition together with the null current account equation to derive the long-term expenditure multipliers in the non traded and traded sector respectively:

\[
\frac{1}{\mu} d\tilde{Y}^N|_{j,k} = dc^N|_{j,k} + dI|_{j,k} > 0, \quad (31a)
\]
\[
d\tilde{Y}^T|_{j,k} = dc^T|_{j,k} + d\tilde{x}|_{j,k} > 0. \quad (31b)
\]

Since a tax restructuring induces a positive wealth effect by raising the after-tax labor income, the demand for both the traded and the non traded consumption goods unambiguously rises. Additionally, while the traded sector benefits from the trade balance improvement, the long-term stimulus of capital investment boosts the non traded output. Consequently tax multipliers are positive in both sectors. It is worthwhile noticing that in the long-run, the economic boom in the non traded sector enhances the traded output. The explanation is that the long-term capital accumulation drives the current account into deficit which requires a steady-state improvement in the trade balance. The numerical values reported in Table 6 show that the steady-state improvement in the trade balance raises the steady-state tax multiplier in the traded sector above the tax multiplier in the non traded sector. However, the sectoral discrepancy is modest. In conclusion, while the tradable share in overall output is about 1/3, its contribution to the growth of GDP amounts to about one half.

Interestingly, we get a different picture in the short-run:

\[
\frac{1}{\mu} dY^N(0)|_{j,k} = dc^N(0)|_{j,k} + dI(0)|_{j,k} > 0, \quad (32a)
\]
\[
dY^T(0)|_{j,k} = dc^T(0)|_{j,k} + d\tilde{x}(0)|_{j,k} \geq 0. \quad (32b)
\]

From (32a), output in the non traded sector is unambiguously stimulated by the domestic demand boom for consumption and investment goods $I$. By contrast, in the traded sector, the dramatic drop in net exports on impact now counteracts the positive influence of the domestic demand boom for the traded good. If $k^T > k^N$, it can be proven formally that the tax multiplier in the traded sector is negative on impact which reflects the fact that the trade balance deficit more than outweighs the domestic demand boom. With the reversal of capital intensities, we cannot exclude that the short-term tax multiplier is positive in the traded sector. Regardless of $k^N \geq k^T$, numerical values of the short-term sectoral tax multipliers summarized in Table 6 show that output in the traded sector drops on impact while the economic boom in the non traded sector is sizeable. Considerable discrepancy in the sectoral economic stance stemming from the $I$ boom and the trade balance deficit in the short-run.
4.5 Welfare Effects

Since the ultimate objective of individuals is their satisfaction, it is appropriate to study the welfare effects of a tax reform. In order to have an appealing measure of satisfaction, we estimate a measure of overall welfare which is defined by the discounted value of felicity flows over an infinite horizon:

\[ U = \int_0^\infty \xi(t)e^{-\beta t}dt, \]  
where \( \xi \equiv u(c(t)) + v(L(t)) \). Whereas households have welfare gains from higher consumption, they are subject to utility losses triggered by labor supply. If \( k_T > k_N \), the former predominates over the latter such that \( \xi \) unambiguously rises in the long-term. Instead, if \( k_N > k_T \), the households’ wealth is affected permanently by the transitional adjustment of the relative price of non tradables which raises further labor supply and moderates the long-term rise in real consumption.

Numerical results summarized in Table 5B show that both dynamic and steady-state adjustments of \( \xi \) raise \( U \). Hence, individuals unambiguously experience overall welfare gains discounted at time \( t = 0 \). More specifically, improvement in welfare falls in the range between 0.03% and 0.12%. Besides the effectiveness gains it induces, a tax reform increases welfare.

5 Sensitivity Analysis

One important contribution of our analysis is to shed light on the roles of two critical parameters in determining the size of the tax multiplier: [i] the elasticity of labor supply \( \sigma_L \) and [ii] the degree of tax progressiveness \( \Psi \).\(^{14}\)

**Tax Multipliers**

Figures 1(a)-1(b) portray the long-term (LT) and short-term (ST) overall tax multipliers against \( \sigma_L \). Like Baxter et King [1993], the long-term tax multiplier rises with \( \sigma_L \). As labor gets more responsive to the rise in the after-tax labor income, the excess of demand (resp. supply) in the non traded good market gets larger if \( k_N > k_T \) (resp. if \( k_T > k_N \)), the physical capital investment must be crowded-in further to clear the good market, and thereby the long-term multiplier gets larger. However, unlike Baxter and King [1993], the relationship between the short-term tax multiplier and the elasticity labor supply displays a hump-shaped pattern. As labor supply gets more responsive, the excess of demand in the non traded good market gets larger, the real exchange appreciates by more on impact which in turn softens further the short-term demand boom for consumption goods. Along the slippery slope side, the depressing effect on domestic demand triggered by the impact appreciation in \( p \) more than...
offsets the stimulating effect induced by the rise in the after-tax labor income.

Figure 1(c) traces out the long-term tax multiplier against the degree of tax progressive-
ness. According to our measure, the tax scheme gets more progressive as the indicator Ψ gets
larger. Ceteris paribus, an increase in tax allowances κ at a given wage rate yields an increase
in average tax progression. Figure 1(c) shows that the long-term tax multiplier falls or rises
with the degree of tax progressiveness depending on wether the tax reform is revenue neutral
or keeps the tax wedge constant. In the latter case, the depressing effect triggered by higher
labor income tax rate gets smaller as the tax scheme gets more progressive. Instead, in the
former case, labor rises by less since the after-tax labor income increases by a smaller amount.

Finally, we get a more complete and interesting picture of a tax reform by conducting a
sensitivity analysis at a sectoral level. The Figure 1(d) traces out the short-term sectoral tax
multiplier against the elasticity of labor supply in the case $k^N > k^T$ and for a tax reform strat-
egy which moves the tax burden from payroll taxes to consumption taxes. Interestingly, the
short-term tax multiplier in the non traded sector rises and in the traded sector falls as labor
supply gets more responsive. The explanation is as follows. As labor supply displays more
reactiveness to the rise in the after-tax labor income, the employment outflow from the non
traded sector (and thereby the excess of demand in that market) gets larger. Consequently,
the tax reform crowds-in investment by more which in turn drives the current account (and
hence the trade balance) into a larger deficit. In short, while the initial boom for capital goods boosts the non traded output, the dramatic drop in net exports on impact depresses traded output.

6 Conclusion

We employ a two-sector open economy version of the dynamic general equilibrium model by Baxter and King [1993] to examine the potential benefits of three tax restructuring. Based on empirical evidence, we distinguish between a traded and a non traded sector and assume the non tradables are produced by an imperfectly competitive sector. In line with general practice, we assume that wage taxes are progressive whereas payroll taxes are supposed to be proportional. We consider two budget-neutral strategies that shifts the payroll or personal labor income taxes to consumption taxes and one strategy keeping the marginal tax wedge constant that reduces the taxes paid by employers and raises the taxes paid by employees.

Irrespective of sectoral capital intensities, consumption and investment are unambiguously crowded-in and employment is permanently raised, as long as the consumption tax base is larger than the labor tax base. While the steady-state increase in consumption is driven by a positive wealth effect, the steady-state rise in employment is driven by the higher after-tax labor wage induced by the labor tax cut. The second finding is that the shift of the tax burden from labor taxes to consumption taxes so as to keep the tax revenue fixed is more effective than a strategy keeping the tax wedge constant. While estimating the effectiveness of the tax reform by calculating the tax multiplier, numerical results show that the long-term tax multiplier rises or falls with the degree of tax progressiveness depending on wether the tax reform keeps the tax wedge constant or keeps the government budget balanced.

Regardless of the type of tax reform, the sensitivity analysis shows that the long-term tax multiplier for overall output rises monotonically with elasticity of labor supply. Unlike, the relationship between the short-term tax and labor responsiveness displays a hump-shaped pattern stemming from the depressing effect on domestic demand triggered by the real exchange rate appreciation. One major question in a two-sector country is: Which sector will benefit by more from the tax reform? The answer to this question highlights the central role of the trade balance. Since net exports must rise in the long-term to exactly offset the fall in net interest earnings from foreign assets holding, the long-term tax multiplier is always higher in the traded sector than in the non-traded sector. However, the computed sectoral discrepancy is not considerable. Interestingly, the result is reversed in the short-term. In the traded sector, the dramatic drop in net exports on impact now counteracts the positive
influence of the domestic demand boom for the traded good. Numerical results show a
considerable discrepancy in the sectoral economic stance stemming from the investment boom
which boosts the non traded sector output and the trade balance deficit which depresses the
traded output.

Notes

1While the two-revenue neutral tax reforms lower the marginal tax wedge constant, we consider a third
strategy which involves simultaneously cutting payroll taxes and raising labor income taxes so as to keep the
tax wedge constant. Whereas this labor tax restructuring does no longer keep the tax revenue fixed, it allows
us to focus on the composition on the tax wedge rather than its level.

2The labor income tax rate encompasses the social security contributions paid by employees together with
personal income taxes.

3We restrict the countries panel table to the biggest OECD countries. A more complete picture is docu-
menced in Cardi and Restout [2008].

4We follow Startz [1989] in specifying the leading term in the subutility function, \( n^{-\frac{1}{\sigma}} \); this formulation is
adopted for reason of analytical simplicity since it eliminates the “taste of variety” inherent in the usual CES
form. Hence, individuals only care about the overall amount \( c^N \) which is consumed and thus adopt a neutral
attitude towards variety.

5See Greenwood et al. [1988] who specify a similar form for \( v(L) \).

6Overall fixed costs \( nFC \) are thus covered by setting the price above the marginal cost, i.e. by paying
inputs below their marginal products.

7These relations are fairly standard and the signs of partial derivatives are documented extensively in Cardi
and Restout [2008].

8Kimball and Shapiro [2003] provide an extensive discussion on empirical estimates of the compensated
elasticity of labor supply.

9The derivation of (21) requires to rewrite first the steady-state variation of \( x \) after a rise in \( \tau^c \) in terms
of that after a change of \( \tau^j \) financed by lump-sum taxes, \( \frac{dx}{d\tau^c} = \int_{\tau^c}^{\tau^j} \frac{dx}{d\tau^j} \), with \( \Xi^F = \frac{1+\tau^c}{\tau^c} > 0 \) and
\( \Xi^H = \frac{\tilde{w}}{\mu c} > 0 \). Formal details can be retrieved in Cardi and Restout [2008].

10More specifically, using the steady-state version of the budget constraint of households, we can express the
share in real disposable income of interest earnings from assets holding plus lump-sum transfers as follows:

\[
\frac{r^* \tilde{a} + Z}{p_c \tilde{c}} = 1 - \frac{\tilde{w}^d \tilde{L}}{p_c \tilde{c}}.
\]

A sufficient condition for the expression to be positive is that \( \tilde{a} > 0 \).

11Both the steady-state and the dynamic effects are similar to that derived in sections 4.1 and 4.2; hence we
do not discuss them further.

12Using the market-clearing condition, i.e. \( \frac{\Xi^N}{\mu} \tilde{c} = \tilde{c}^N + g^N + \tilde{I} \), and the null current account, i.e. \( \tilde{Y}^T = \tilde{c}^T + g^T \), aggregating and differentiating, we get (28).

13Using the fact that \( \tilde{Y} \equiv \tilde{Y}^T + \frac{L}{\mu} \tilde{Y}^N \), and keeping in mind that the capital stock is initially predetermined,
the impact tax multiplier can be written as follows:

$$dY(0)|_{j,k}^f = w^F dL(0)|_{j,k}^F > 0.$$  

Since labor rises on impact as the after-tax labor income increases, the short-run tax multiplier is unambiguously positive, irrespective of sectoral capital intensities and regardless of the kind of the tax reform strategy.

14Since computed relationships are similar for either sectoral capital intensities, we restrict the sensitivity analysis to the case $k^N > k^T$. Figures in the case $k^T > k^N$ are available from the authors upon request.

References


