Unemployment, Public Spending and International Trade: Challenges for an Optimal Tax Design

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Abstract

The paper characterises the optimal labour tax scheme in an open economy with labour market inefficiencies and public spending. We show the theoretical conditions underlying the optimal tax wedge in the long run. While labour market frictions call for reduced taxation, fiscal policy also offers a protectionist policy tool for the government to manipulate the terms of trade. Secondly, we provide a quantitative assessment of the optimal tax reform using France as the benchmark economy. We show in particular that the welfare gains from the optimal tax reform crucially depend on the size and the valuation of public spending.

Keywords: consumption tax, payroll tax, Ramsey allocation, labor market search, open economy, public spending.
JEL classification: E27, E62, H21, J38

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1 Introduction

The current euro-zone crisis has spurred a renewed interest in tax reforms as a tool to correct trade balances and boost employment, without reducing the size of the welfare state. This paper takes part in the debate, as we characterise the optimal labour tax scheme in an open economy featured with labour market inefficiencies and public spending. In doing so, our work is related to many strands of literature.

First, the paper is related to the literature devoted to the "European Unemployment Problem"[1]: The significant decrease in the total number of hours worked relative to the US over the recent decades calls for an improvement in labour market performances which is all the more necessary in European countries. While some authors (Blanchard & Wolfers (2000), among others) attribute this to an unemployment gap due to stringent labour market frictions (hereafter, LMF), Prescott (2004) suggests that a theory providing a robust link between hours per worker and taxes is sufficient to explain why Europeans, and in particular French workers, work less than Americans.[2] Prescott (2004) therefore obtains that the steady-state welfare gains to French households from adopting American taxes[3] "would be equivalent to a 20 percent increase in consumption, with no increase in work effort" (Lucas (2003)). Such large welfare gains would undoubtedly call for cutting French (and more broadly, European) taxes down to US levels.

In this paper, we put these results into perspective, by adopting a broader framework - which, in our view, is more in accordance with European specificities. In tackling the subject, the above literature indeed omits the open economy dimension, does not discuss the role of government spending in households' utility, and does not account for the imperfect substitutability between workers and hours linked to the heterogenous impact of LMF on both labour margins. In this paper, we show that these dimensions are key in shaping the optimal labour tax scheme. This stands in sharp contrast with Prescott's (2004) analysis, where the results are obtained using *i)* a closed economy model, *ii)* in which households do not value government spending, and *iii)* in a frictionless labour market. In this setting, the first-rank allocation calls for zero taxes and zero government spending, leading to large welfare gains from the tax reduction. We show that this result is quite sensitive to the

[1] Let us mention Bertola & Ichino (1995), Blanchard & Wolfers (2000), Daveri & Tabellini (2000), Ljunqvist & Sargent (1998), Ljunqvist & Sargent (2008), as well as Prescott (2004), Rogerson (2006) or Ohanian et al. (2008), among others.

[2] Hours worked in France, and in most European countries, are much lower than in the US, by a ratio equal to around 68% over the 1993-1996 period. See Rogerson (2006) or Ohanian et al. (2008).

[3] i.e., reducing the effective tax rate on labour by 20 percentage points.

removal of each of the above assumptions. We thus characterise how *i)* the open economy dimension, *ii)* the households' valuation of government spending, and *iii)* the existence of labour market frictions lead Prescott (2004) to miss an important part of the picture. One original contribution of our paper is thus to identify the implications of each of these three dimensions for fiscal policy. Our work notably points out how their interaction plays a key role in shaping the optimal tax scheme, by altering the elasticities of hours and employment to the tax pressure in comparison with Prescott's (2004) analysis.

To this aim, we develop an analytic matching framework[4] with both the intensive and extensive margin of labour in an open economy environment, where households value public spending in their utility. In this setup, we characterise the optimal tax policy. We thus identify the conditions under which *i)* it is optimal to reduce the overall tax wedge, *ii)* this can be achieved by a switch from direct labour taxation to indirect taxes, *iii)* the welfare impact being conditional on the gap between the actual and the optimal size of the welfare state. Our paper also contributes to the literature from an applied economics perspective. We indeed provide a quantitative assessment of the optimal tax reform, using France as the benchmark economy.

Our analytical results may be summarised as follows. First, we show that *i)* the open economy dimension actually calls for *higher* labour taxes, due to a terms of trade externality. The intuition is straightforward. In a decentralised economy, private agents do not internalise the effect of their choices on the terms of trade. Accordingly, the decentralised economy works and produces too much, which drives the price of the home good down, thereby making imports too expensive compared to their first-best level. By reducing employment hence production, higher labour taxation drives the home price up (the foreign price down), thereby bringing the terms of trade closer to those chosen by the social planner. In this respect, by omitting the open economy dimension, Prescott (2004) might actually have *overstated* the gains from a reduced labour tax. In putting emphasis on the terms of trade externality inherent to the open economy dimension, the paper borrows from the international trade literature that follows the seminal contribution of Corben (1984).[5] Our paper echoes this

[4]We extend the basic model used by Hungerbuhler et al. (2006) to analyse optimal fiscal policies *à la* Mirless.

[5]As recalled by Costinot et al. (2013), the idea of exploiting the terms of trade externality is an old one in the international trade literature, notably going back to Mill (1844). Its implications in the analysis of optimal tariffs and challenges for the World Trade Organization have been studied in recent theoretical and empirical papers such as Staiger & Bagwell (1990), Staiger & Bagwell (1999), Broda et al. (2008) or Costinot et al. (2013). It has also opened discussion in the international finance literature, studying how domestic monetary policy can be used to exploit this terms of trade externality (Corsetti & Pesenti (2001),

literature as the terms of trade externality similarly comes from the Home social planner exploiting her monopoly power in the supply of the Home good. Our originality lies in studying how domestic taxes, rather than tariffs, can be used as a protectionist tool.[6]

Second, most of the existing literature has considered public spending as a nuisance (by crowding out private spending and giving rise to tax distortions). In this context, higher public spending, therefore higher taxes, can only be welfare decreasing. In our view, this is a partial conclusion, which we show by re-assessing the impact of the tax reform when households value public spending in their utility. Unlike Christiano & Eichenbaum (1992), Finn (1998), or Christiano et al. (2011) (among others) who adopt a purely positive approach, we characterise the role of public spending in normative terms.[7] We thus show that the optimal need to provide for public expenditures drives employment and production to higher levels, in comparison with an economy where public spending has no utility. Conversely, if in the decentralised economy the government size is too big (relative to efficient), private agents work too much for undesirable public goods. This provides a rationale to impose labour taxation, in order to restore the optimal level of production, even if the sharing between private and public goods is not optimal. In this respect, taking the utility of public spending into account may induce a gap with Prescott (2004)'s results.

Third, we show that the interactions between the intensive and the extensive margin of labour are crucial in the design of the optimal tax scheme. As shown in the seminal contributions of Diamond (1982), Mortensen (1982) and Pissarides (1985), LMF can lead to an inefficient unemployment level, thereby leaving scope for taxation. In line with Shimer's view (2009) , LMF therefore constitute a promising explanation for the "labour wedge". Accordingly, they are at the heart of our investigation. If the decentralised economy is characterised by under-work and under-production because of LMF, the gains from labour tax cuts could be larger than those found by Prescott (2004). However, one contribution of the paper is to show the inherent difficulty of the fiscal problem. We show indeed that the Ramsey tax policy cannot achieve the planner's allocation on both the intensive and

Tille (2001), and De Paoli (2009) among others).

[6]Since the terms of trade externality distorts the relative price of foreign vs home goods, only a tariff can correct it. Because this is typically forbidden by trade agreements, we preclude the possibility of fully correcting for the terms of trade externality by assuming that government tools only consist in labour and indirect consumption taxes. This differentiates us from related papers in the trade literature, such as Costinot et al. (2013). We therefore develop a second-best policy analysis.

[7]Epifani & Gancia (2009) is closest to us in this respect, as they study the optimal size of the government linked with the open economy dimension. In their setup, the failure of non-cooperative governments to internalise the trade externality induces an overprovision of public spending. We differentiate ourselves from this paper as we endogenise the government's fiscal policy, for a given government size.

extensive margin. Fundamentally, this comes from the employment and the hours worked which do not have the same elasticities with respect to the tax pressure, due to differentiated impacts of LMF on each margin.

In a nutshell, while the terms of trade externality and a sub-optimal government size call for higher taxes, labour market frictions may conversely require alleviating the tax pressure. We show that these opposing forces yield to a non-zero optimal tax burden. We then characterise how the (possibly lower) Ramsey tax wedge can be implemented by the decentralised government through the shift from direct to indirect taxation. Some countries, such as Denmark (in 1987), Germany (in 2007) or France (in 2012) have already implemented such a tax reform. If some economists have recently called attention to it,[8] little is yet known on its optimal design and its quantitative implications.[9] In this respect, our paper provides an additional argument in favour of implementing, in European countries, tax reform that promotes indirect taxation and reduces direct taxation on labour, if it decreases the tax wedge on labour.

Our paper also contributes to the literature from an applied economics perspective, as we provide a quantitative assessment of the optimal tax reform. This quantitative exercise has two noteworthy merits. First, it allows us to quantify our analytical results. Using a dynamic general equilibrium model (DGE) calibrated on the French economy, we thus show that there is room for reduced labour taxation, through a switch from direct labour taxation to indirect consumption taxation. Our model thus predicts an optimal tax wedge reduction of 9.5%, which is achieved by lowering the payroll tax rate to 0.025% (versus 34% in the benchmark calibration). We also offer a quantitative assessment of how the open economy dimension, labour market rigidities, and the size of the government affect the optimal tax scheme, in direct line with our analytical results. Second, our quantitative assessment of the optimal tax reform goes beyond our analytical findings. We show in particular that the transitional costs associated with implementing the tax reform affect the optimal tax design. Besides, and returning to the argument of Prescott (2004) (and others), we show that the welfare gains associated with labour tax cuts crucially depend on the budgetary adjustment accompanying the tax reform. When public spending provides no private utility, welfare gains are larger when the tax reform operates through reducing the relative size of the

[8]Cavallo and Cottani on VoxEU (`http://www.voxeu.org/index.php?q=node/4666`); and IMF (2011).

[9]Among notable exceptions, Correia et al. (2008), Farhi et al. (2011) and Adao et al. (2009) study fiscal devaluation in frameworks with product market imperfections and nominal price rigidities.[10] We depart from these papers by laying the stress on the role of labour market frictions (rather than good market rigidities) and their interaction with the terms of trade externality in shaping the optimal policy.

government than when it is maintained constant, in accordance with Prescott's (2004) view. However, taking the private valuation of public spending into account makes the picture more subtle. In this case, welfare gains are raised when the tax burden decrease serves to bring the government size to its optimal value.

The paper is organised as follows. In Section 2, we shed light on the key mechanisms underlying the optimal labour tax rate using a tractable analytical model. We abstract in particular from dynamics by adopting a pure static framework. In Section 3, we extend this analytic framework to a dynamic general equilibrium model which we calibrate to quantify the optimal scheme of the tax system in France. Section 4 concludes.

2 Optimal Labour Taxation in an Open Economy: a Theoretical Characterisation

In this section, we develop a static and tractable analytical model which accounts for the main characteristics of the French economy: *i)* the open economy dimension and its inherent terms of trade externality, *ii)* the government spending and the implied (in)efficient government-to-output ratio, and *iii)* the labour market frictions, inducing distortions (unemployment benefits and bargaining power) and bias in the substitution between the intensive and extensive margin.[11,12] After obtaining the equilibrium allocations in the decentralised and centralised cases respectively, we restrict our analysis to a second-best Ramsey tax scheme where the number of tax instruments is lower than the number of distortions. We then show that, if the economy initially features too low a level of labour (and output), increasing indirect taxation in exchange for reduced labour taxation is welfare enhancing up to a certain limit.

2.1 Main Assumptions

Following Hungerbuhler et al. (2006), we capture labour market frictions (LMF hereafter) in a static setting. Unlike Hungerbuhler et al. (2006), our framework incorporates both the

[11]We discard capital accumulation, international bond trading and government debt in order to get analytical results. More details underlying our analytical results are available in the online technical Appendix from the author's web pages. Physical capital is included in the dynamic general equilibrium model (Section 3).

[12]We thank Jean-Pascal Benassy for helpful input on the functional forms.

intensive (hours worked) and the extensive margin (the number of employees) of labour. Modeling both margins indeed turns out to have important implications in the design of the Ramsey tax scheme.

Matching frictions on the labour market. Each firm opens a vacancy that can be filled by a searching worker. Matching workers with vacancies is a costly process, with $\overline{\omega}$ the cost of posting one vacancy. Hirings evolve according to a constant return to scale matching function: $M = \chi V^{\psi} U^{1-\psi}$ with V the total number of new jobs made available by firms, U the number of searching workers, $\chi > 0$ a scale parameter measuring the efficiency of the matching function and $0 < \psi < 1$ the weight of vacant jobs in the matching process.

The job finding rate p, defined by $p\left(\frac{V}{U}\right) \equiv \frac{M}{U} = \chi\left(\frac{V}{U}\right)^{\psi}$, is a function of labour market tightness $\frac{V}{U}$. The vacancy filling rate q is given by $q\left(\frac{V}{U}\right) \equiv \frac{M}{U} = \chi\left(\frac{V}{U}\right)^{\psi-1}$. The size of the population is normalised to 1. At the beginning of the period, all workers are looking for a job, $U = 1$. Therefore, with a static matching, we have $M = N = p$. Hence, the matching process in the economy is summarised by:

$$N = \chi V^{\psi} \tag{1}$$

The open economy dimension We model a small open economy which trades goods with the rest of the world (also referred to as the foreign country). The home country is specialised in the production of a homogenous good consumed domestically and abroad (Y, C_H and X respectively denoting the volumes of home production, domestic consumption of the home good, and home exports). The economy also consumes the homogenous good produced abroad, in quantity C_F, equal to domestic imports Z. Given that home exports (denoted by X) necessarily constitute the imports of the rest of the world Z^*, it comes that: $X = Z^*$. Symmetrically, we have: $Z = X^*$. In addition, we normalise prices by considering the home good as numéraire. The relative price of the foreign good $\phi \equiv P_F/P_H$ is also interpreted as terms of trade. Throughout the paper, we assume the following functional forms for foreign exports X^* and imports Z^*:

$$X^* = \phi^{\sigma^*-1} \tag{2}$$
$$Z^* = \phi^{\sigma^*} \tag{3}$$

with $\sigma^* > 1$ the price elasticity of foreign imports.[13] In the absence of international trading of financial assets, the home country (as well as the rest of the world) is featured by a zero trade balance $Z = X^* \quad \Leftrightarrow \quad Z = \phi^{\sigma^*-1}$.

Preferences. In each period, employed agents (N) work, while unemployed agents ($1-N$) spend their time enjoying leisure. Hence, after assuming separability between consumption and leisure, the representative household's programme is to maximise:

$$\mathcal{U} \;=\; \xi \log(C_H) + (1-\xi)\log(C_F) + \Phi \log(G) - N\sigma_L \frac{h^{1+\eta}}{1+\eta} \tag{4}$$

with $\eta > 0, \sigma_L > 0$ and $0 < \xi < 1$. The consumption bundle is made of home good (C_H) and foreign good (C_F) with respective weights in the expenditure function ξ and $1-\xi$ respectively. Besides, we allow for public spending G providing utility flows, as scaled by the parameter $\Phi \geq 0$.[14]

Technology. For each firm, the occupied job yields production using a decreasing production function Ah^α with $0 < \alpha < 1$ and h denoting the number of hours worked by an individual. As a result, at the aggregate level, with N the number of workers (i.e., of firms), the aggregate output Y is given by the following function:[15]

$$Y = ANh^\alpha, \qquad 0 < \alpha < 1 \tag{5}$$

2.2 The Decentralised Economy

Firms. Firms are in perfect competition in the production of the home good. They are subject to direct labour taxation, with τ_f denoting the payroll tax rate. Firms freely enter the goods market and, due to matching frictions, post vacancies as long as the return on vacancy posting exceeds its cost. The free entry condition then equalises the cost of posting

[13] In the online appendix (section A.1), we derive the microfoundations of such trade flows.

[14] To maintain the analytical simplicity of the model, we assume that public expenditures are only made in domestic goods. We consider the more general case of G made of both domestic and foreign varieties in Section 3.

[15] The aggregate production function thus exhibits increasing returns to scale. This does not jeopardise our assumption of perfect competition on the goods market though, as each firm is modeled as atomistic and does not internalise the effect of its job opening decision on aggregate employment. Also note that, even with a linear production function in N, the share of wages in the GDP wNh/Y is smaller than 1 in the presence of a non-zero vacancy cost (see the online appendix (section A.2.1)).

one vacancy to its after-tax return. Using the definition of the vacancy filling rate $q = \chi V^{\psi-1}$, we obtain:

$$\frac{\overline{\omega}}{q} = (Ah^{\alpha} - (1+\tau_f)wh) \quad \Rightarrow \quad V = \left(\frac{\overline{\omega}/\chi}{Ah^{\alpha} - (1+\tau_f)wh}\right)^{\frac{1}{\psi-1}} \tag{6}$$

Notice that this condition can also be interpreted as the zero-profit condition, with profits being given by $\pi = Ah^{\alpha}N - \overline{\omega}V - (1+\tau_f)whN$.

Workers. The household maximises its utility function (4) with respect to C_H, C_F subject to its budget constraint:

$$(1+\tau_c)(C_H + \phi C_F) = (1-\tau_w)[wNh + \widetilde{b}(1-N)] + \pi - T \tag{7}$$

with $\widetilde{b}$ the unemployment benefits net of social contributions $\widetilde{b} = b/(1+\tau_f)$,[16] π the firms' profit (equal to zero given the zero-profit condition) and T lump-sum taxes. Labour revenues are taxed at the employee tax rate τ_w, while consumption expenditures are subject to indirect taxation, with τ_c the indirect tax rate. The first-order conditions relative to home and foreign goods consumptions lead to the following arbitrage condition:

$$\frac{U'_{C_F}}{U'_{C_H}} = \phi \;\Leftrightarrow\; \frac{1-\xi}{\xi}\frac{C_H}{C_F} = \phi \tag{8}$$

which shows that the sharing rule between domestic and foreign consumption is simply driven by the terms of trade.

Nash bargaining. We assume that wages and hours worked are determined via generalised Nash bargaining as follows:

$$\max_{w,h} \left(\frac{1-\tau_w}{1+\tau_c}(wh - \widetilde{b}) - \Gamma(h)\right)^{1-\epsilon} (Ah^{\alpha} - (1+\tau_f)wh)^{\epsilon} \tag{9}$$

[16] If we do not make this assumption, a distortion is introduced in the taxation of work w versus non-work b. Discussing the impact of this distortion is beyond the focus of this paper. Furthermore, this hypothesis is consistent with the view that, in France for instance, unemployed workers pay a low social security contribution from their unemployment benefits. The Unemployment Agency pays for them. The total cost of unemployment benefits for the government must then include unemployment benefits with social security contributions. This is what appears in the government budget constraint, Equation (12).

with $0 < \epsilon < 1$ and $\Gamma(h) = \sigma_L \frac{h^{1+\eta}}{1+\eta}(C_H + \phi C_F)$. $(1-\epsilon)$ represents the workers' bargaining power. Solving this leads to the following negotiated values for w and h in the decentralised economy:

$$wh = \frac{1-\epsilon}{1+\tau_f} A h^{\alpha} + \frac{\epsilon}{1-\tau_w}\left[(1-\tau_w)\widetilde{b} + (1+\tau_c)\Gamma(h)\right] \quad (10)$$

$$\sigma_L h^{\eta}(C_H + \phi C_F) = \frac{1-\tau_w}{(1+\tau_c)(1+\tau_f)} \alpha A h^{\alpha-1} \quad (11)$$

As is standard in matching models (see Pissarides (1990)), the negotiated wage is a weighted average of the worker's outside option and the marginal product of a match, with the relative weights depending on the relative bargaining power of both players (Equation (10)). We also verify that the negotiated amount of hours worked is efficient, in that it equalises the marginal product of hours with the disutility of work given the tax scheme.

Equilibrium. The model is closed by taking the budget constraint of the government into account:

$$G + (1-\tau_w)\widetilde{b}(1-N) = \tau_c(C_H + \phi C_F) + (\tau_w + \tau_f) w N h + T \quad (12)$$

given the rule for public expenditures $G = \rho_g(Y - \varpi V)$ and lump-sum taxes $T = \rho_T(Y - \varpi V)$. We will also assume that unemployment benefits are proportional to the wage bill, i.e.: $\widetilde{b} = \rho_b w h$, with $0 < \rho_b < 1$. The home good equilibrium condition and the zero-trade balance equation are still given by Equations (18) and (19) respectively.

Using the definition of firms' profits and the budget constraint of the government, the budget constraint of the household becomes: $(1+\tau_c)(C_H + \phi C_F) = (1-\rho_g)(Y - \varpi V) + \tau_c(C_H + \phi C_F)$. The FOC relative to C_H and C_F can then be written as:

$$C_H = \xi(1-\rho_g)(Y - \varpi V) \quad (13)$$

$$\phi C_F = (1-\xi)(1-\rho_g)(Y - \varpi V) \quad (14)$$

The labour market equilibrium can be summarised by the system in $\{V, h\}$:

$$\frac{\overline{\omega}}{\chi}V^{1-\psi} = \epsilon\left[Ah^{\alpha} - b - \sigma_L\frac{h^{1+\eta}}{1+\eta}\frac{(1+\tau_c)(1+\tau_f)}{1-\tau_w}(1-\rho_g)(Y-\overline{\omega}V)\right] \tag{15}$$

$$\Leftrightarrow V = \left[\frac{\epsilon\chi}{\overline{\omega}}\left(\frac{(1+\eta)(1-\rho_b)-\alpha}{(1+\eta)(1-\rho_b\epsilon)}\right)Ah^{\alpha}\right]^{\frac{1}{1-\psi}} \tag{16}$$

$$h^{dec} = \left[\frac{\alpha A}{\sigma_L}\left(\frac{1-\tau_w}{(1+\tau_c)(1+\tau_f)}\frac{1}{1-\rho_g}\right)\frac{1}{\Theta}\right]^{\nu} \tag{17}$$

with superscript *dec* referring to the decentralised allocation, $\nu \equiv \frac{1-\psi}{(1-\psi)(1+\eta)+\alpha\psi}$ and $\Theta = \left(\frac{A\chi}{(1+\eta)(1-\rho_b\epsilon)}\right)^{\frac{1}{1-\psi}}\left[\frac{\epsilon}{\overline{\omega}}((1-\rho_b)(1+\eta)-\alpha)\right]^{\frac{\psi}{1-\psi}}\left[(1-\epsilon)(1+\eta)+\epsilon\alpha\right]$ (ρ_b being the exogenous unemployment benefit ratio). Notice the asymmetry in the effect of distortive taxation. Whereas the solution for hours worked directly depends on taxes (as well as labour market institutions), fiscal policy can only affect vacancies through their impact on the intensive margin of labour.

2.3 The Centralised Economy

The planner's program As goods are imperfect substitutes at the international level, the planner of the home country can compute a "fictitious" allocation by acting as a monopoly vis-à-vis the foreign country. That is, the home planner makes use of information about the import and export functions coming from Equations (2) and (3) to extract a positive markup. In this respect, we adopt a similar modeling of the centralised small open economy allocation as in related trade papers (Costinot et al. (2013)).

Using the production function (5), the resource constraint on the home good and the trade balance equilibrium condition that the planner takes into account are respectively given by:

$$C_H = ANh^{\alpha} - \phi^{\sigma^*} - G - \overline{\omega}V \tag{18}$$

$$C_F = \phi^{\sigma^*-1} \tag{19}$$

The programme of the social planner is to maximise the utility function (4) with respect to C_H, C_F, G, h, V and V, subject to the resource constraints (18) and (19), as well as the matching process equation (1). By replacing private consumptions (18) and (19) in the objective function (4), this is equivalent to choosing $\{\phi, G, h, V\}$ so as to maximise:

$$\max_{\phi,G,V,h} \mathcal{U} \quad = \quad \max \left\{ \begin{array}{l} \xi \log(A\chi V^{\psi} h^{\alpha} - X(\phi) - G - \overline{\omega} V) \\ +(1-\xi)\log(Z(\phi)) + \Phi \log(G) - \chi V^{\psi} \sigma_L \frac{h^{1+\eta}}{1+\eta} \end{array} \right\}$$

given the foreign import and export functions (2) and (3). The first-order conditions with respect to ϕ, G, h and V are respectively:

$$\frac{U'_{C_F}}{U'_{C_H}} = \frac{\epsilon_{Z^*/\phi}}{\epsilon_{X^*/\phi}} \frac{Z^*}{X^*} \quad \Leftrightarrow \quad \frac{1-\xi}{\xi} \frac{C_H}{C_F} = \mu^* \phi \tag{20}$$

$$U'_{C_H} = U'_G \quad \Leftrightarrow \quad G = \frac{\Phi}{\xi} C_H \tag{21}$$

$$-\frac{U'_{C_H}}{U'_h} = Y'_h \quad \Leftrightarrow \quad \sigma_L h^{1+\eta} = \alpha \frac{Y}{C_H} \tag{22}$$

$$U'_{C_H} \left[Y'_V - \overline{\omega} \right] = N'_V \sigma_L \frac{h^{1+\eta}}{1+\eta} \quad \Leftrightarrow \quad \psi \left[A h^{\alpha} - \frac{\sigma_L \frac{h^{1+\eta}}{1+\eta}}{U'_{C_H}} \right] = \frac{\overline{\omega}}{\chi} V^{1-\psi} \tag{23}$$

with $\epsilon_{Z^*/\phi}$ the elasticity of foreign imports (i.e., home exports $X = Z^*$) and $\epsilon_{X^*/\phi}$ the elasticity of foreign exports (i.e., home imports) with respect to terms of trade ϕ.

Equation (20) determines the optimal arbitrage between home and foreign goods. The social planner, in choosing the terms of trade, acts as a monopolist who is able to take the impact of her price setting on the relative demand for goods coming from abroad into account. By doing so, she extracts a part of the surplus of the foreign agents, whose magnitude is scaled by the foreign demand price elasticity. Using our functional forms, this markup is equal to $\mu^* = \frac{\sigma^*}{\sigma^*-1} > 1$, decreasing with the price elasticity of foreign demand σ^*. The optimal level of government expenditures equalises the marginal gain to the marginal cost (Equation (21)). Equation (22) equalises the marginal rate of substitution between hours and consumption of the home good to the marginal product of labour, while Equation (23) determines the optimal value of job vacancies.

Solving the model Using functional forms and given the resource constraints (18) and (19), we obtain:

$$\begin{aligned} C_H &= \frac{\xi}{\xi + (1-\xi)/\mu^*}(1-\rho_g^{sp})(Y - \overline{\omega}V) \\ \mu^*\phi C_F &= \frac{(1-\xi)}{\xi + (1-\xi)/\mu^*}(1-\rho_g^{sp})(Y - \overline{\omega}V) \\ G &= \rho_g^{sp}(Y - \overline{\omega}V) \end{aligned}$$

where superscript *sp* refers to the social planer's allocation. The markup μ^* reduces the share of foreign goods in the total basket, which is $(1-\xi)/\mu^*$ for the planner, vs $(1-\xi)$ at the decentralised equilibrium. The optimal size of the government, denoted by ρ_g^{sp}, and measured by the ratio of public spending to output (net of the cost of vacancies), is:

$$\rho_g^{sp} \equiv \frac{\Phi}{\xi + \Phi + (1-\xi)/\mu^*}$$

Notice that, the greater the market power of the planner μ^*, the larger the optimal size of the government. As public spending is domestic goods, its optimal provision is positively affected by the markup involved in the process of reallocating expenditures towards domestic products. This result is in line with Epifani & Gancia (2009), who also underline the link between trade externality and government size.

For the labour market aggregates, the planner's allocation is summarised by:

$$\frac{\overline{\omega}}{\chi}V^{1-\psi} = \psi\left[Ah^{\alpha} - \sigma_L \frac{h^{1+\eta}}{1+\eta}\left(\frac{1}{\xi + (1-\xi)/\mu^*}\right)(1-\rho_g^{sp})(Y - \overline{\omega}V)\right] \quad (24)$$

$$\Leftrightarrow V = \left(\psi\frac{\chi}{\overline{\omega}}\frac{1+\eta-\alpha}{1+\eta}Ah^{\alpha}\right)^{\frac{1}{1-\psi}} \quad (25)$$

$$h^{sp} = \left[\frac{\alpha A}{\sigma_L}\left([\xi + (1-\xi)/\mu^*]\frac{1}{1-\rho_g^{sp}}\right)\frac{1}{\Psi}\right]^{\nu} \quad (26)$$

with $\Psi = \left(\frac{\chi A}{1+\eta}\right)^{\frac{1}{1-\psi}}\left(\frac{\psi}{\overline{\omega}}(1+\eta-\alpha)\right)^{\frac{\psi}{1-\psi}}[(1-\psi)(1+\eta)+\psi\alpha]$.

2.4 Implementing the Ramsey Policy

This section aims at characterising the optimal tax scheme that may be implemented by the government in the decentralised economy. We assume here that the objective is to find the optimal mix of distortive tax rates τ_c, τ_f for given values of the ratios of public expenditures and lump-sum taxes (or transfers) ρ_g and ρ_T, as well as the unemployment benefit ratio ρ_b (with $\widetilde{b} = \rho_b wh$), and the employee's tax rate τ_w. Contemplating the whole set of equations characterising the decentralised economy, it must be noted that the three tax rates (τ_c, τ_f, τ_w) affect the decentralised equilibrium only in a joint manner through the tax wedge $TW = \frac{(1+\tau_c)(1+\tau_f)}{1-\tau_w}$, with $TW = 1$ for $\tau_f = \tau_c = \tau_w = 0$, and increasing above 1 with each (positive) tax rate.

2.4.1 A Second-Best Policy

Given that the fiscal tools available to the government (i.e., the tax wedge) have a direct effect on quantities (more precisely, hours) but not on prices (ϕ), we can infer that the Ramsey tax policy is likely to fail in offsetting the trade externality, measured by the discrepancy between the decentralised and the planner's sharing rules between home and foreign goods. This is formally stated in Proposition 1.

Proposition 1. *$\forall \tau_i$, $i = c, f, w$, and as long as $\sigma^* < \infty$, the share of foreign goods is too large in the decentralised economy. Everything else equal, this induces an excessive price of imports in the decentralised economy ($\phi^{dec} > \phi^{sp}$). The magnitude of the gap is inversely related to the price elasticity of foreign imports (σ^*).*

Proof. Recalling here Equations (8) and (20), and with $\mu^* = \frac{\sigma^*-1}{\sigma^*} \in [0, 1]$, it comes that:

$$\frac{C_H}{\phi C_F} = \begin{cases} \frac{\xi}{1-\xi} & \text{if decentralised economy} \\ \frac{\xi}{(1-\xi)/\mu^*} & \text{if planner} \end{cases}$$

implying that $\frac{C_H^{dec}}{\phi^{dec} C_F^{dec}} < \frac{C_H^{sp}}{\phi^{sp} C_F^{sp}}$, by noticing that $\mu^* > 1$ as long as domestic and foreign goods are imperfect substitutes ($\sigma^* < \infty$). Given that $C_F = \phi^{\sigma^*-1}$, we deduce that:

$$\phi = \begin{cases} [(1-\xi)(1-\rho_g)(Y - \varpi V)]^{\frac{1}{\sigma^*}} & \text{if decentralised economy} \\ \left[\frac{1-\xi}{\mu^*\xi + (1-\xi)}(1-\rho_g^{sp})(Y - \varpi V)\right]^{\frac{1}{\sigma^*}} & \text{if planner} \end{cases}$$

implying, assuming that everything else equal quantities are at their first-best values, that $\phi^{dec} > \phi^{sp}$ as $\frac{1-\xi}{\mu^*\xi+(1-\xi)}$ is decreasing in μ^*. □

The consequences of a terms of trade externality, arising in an open economy facing a less-than-infinite price elasticity of foreign demand, is well documented in the trade literature, as discussed by Corben (1984) and recently debated in the context of the World Trade Organization (Staiger & Bagwell (1990), among others). This externality has also opened discussion in the international finance literature, studying how domestic monetary policy can be used to exploit this terms of trade externality (see notably De Paoli (2009)). We differentiate ourselves from these papers by studying the implications of the terms of trade externality for tax policy in a general equilibrium setting, in connection with other distortions such as labour market imperfections. In contrast to the international trade literature (Costinot et al. (2013)), we exclude trade taxes from the analysis to focus on "domestic" fiscal tools. Proposition 1 thus has important implications regarding tax policy, stated in the following corollary.

Corollary 1.1. *Given the absence of any fiscal tool that directly affects the relative price of imports (such as trade taxes and tariffs), the optimal sharing rule between home and foreign goods, and consequently the first-best value of the terms of trade, cannot be reached. Accordingly, the optimal Ramsey taxation can only achieve a second-best allocation where the sharing rule between foreign and home goods is biased in favour of foreign goods.*

2.4.2 Characterising the Ramsey Tax Wedge

We now turn to characterising the (second-best) Ramsey tax policy. To do so, we adopt a two-step reasoning. We first determine the Ramsey tax wedge TW. We then use this result to derive the optimal payroll tax rate τ_f given the exogenous values of the employee's tax rate (τ_w) as well as ρ_g, ρ_T and ρ_b, and given the government's budget constraint that determines the endogenous required adjustment of the indirect tax rate τ_c.

Consider first the Ramsey problem relative to the overall tax wedge TW. The Ramsey problem consists in choosing the tax wedge TW so as to maximise the welfare function (4), subject to technological constraints (Equations (1) and (5), the optimal behaviours of the agents and market equilibria, as summarised by the two key relations: *i°)* between hours worked h and TW as given by Equation (17), and *ii°)* the relation between vacancies and hours worked as given by Equation (16):[17]

$$\widetilde{\mathcal{U}} = \max_{TW} \left\{ \left[\xi + (1-\xi)\frac{1}{\mu^*} + \Phi \right] \log(Ah^\alpha \chi V^\psi - \varpi V) - \chi V^\psi \sigma_L \frac{h^{1+\eta}}{1+\eta} \right\} \tag{27}$$

$$\text{s.t.} \quad \frac{\varpi}{\chi} V^{1-\psi} = \epsilon \left[\frac{1+\eta-\alpha}{1+\eta} Ah^\alpha - b \right] \tag{28}$$

$$\sigma_L \frac{h^{1+\eta}}{1+\eta}(1-\rho_g) TW (Ah^\alpha \chi V^\psi - \varpi V) = \frac{\alpha}{1+\eta} Ah^\alpha \tag{29}$$

The first constraint (28) implicitly defines $V = \mathcal{V}(h)$, whereas the second constraint (29) is such that $h = \widetilde{\mathcal{H}}(TW, \mathcal{V}(h))$ which implicitly define a relation between h and TW, denoted by $h = \mathcal{H}(TW)$. The Ramsey problem is then:

$$\max_{TW} \widetilde{\mathcal{U}}(\mathcal{V}(\mathcal{H}(TW)), \mathcal{H}(TW))$$

where $TW = TW(\tau_f, \tau_c)$. Given the previous notations, the FOC of the Ramsey problem can be reformulated as:

$$\mathcal{H}'(TW^R) \times \left[\mathcal{V}'(h) \widetilde{\mathcal{U}}'_V + \widetilde{\mathcal{U}}'_h \right] = 0 \tag{30}$$

where:

$$\widetilde{\mathcal{U}}'_V = \psi \left(Ah^\alpha - \sigma_L \frac{h^{1+\eta}}{1+\eta} \frac{1}{\xi + (1-\xi)/\mu^*} (1-\rho_g^{sp})(Y - \varpi V) \right) - \frac{\varpi}{\chi} V^{1-\psi} \tag{31}$$

$$\widetilde{\mathcal{U}}'_h = \alpha A h^{\alpha-1} - \sigma_L h^\eta \frac{1}{\xi + (1-\xi)/\mu^*} (1-\rho_g^{sp})(Y - \varpi V) \tag{32}$$

These two components of the FOC (30) are identical to the FOC of the planner problem (Equations (24) and (26)). But, for the planner, they are simultaneously equal to zero, whereas for the Ramsey problem, a linear combination of them is a sufficient condition for the optimality.

Proposition 2. *The optimal tax scheme lies between the fiscal policy that reduces the gap with respect to the intensive margin of labour (hours worked, $\widetilde{\mathcal{U}}'_h = 0$) and the one that reduces the gap with respect to employment (through vacancies, $\widetilde{\mathcal{U}}'_V = 0$).*

Proof. Recall that constraints (28) and (29) of the Ramsey problem can be rewritten as

[17] Notice that this expression is not the welfare function strictly speaking, as terms that are independent of TW, V and h have been omitted.

follows:

$$
\begin{aligned}
0 &= \epsilon\left[Ah^{\alpha} - b - \sigma_L \frac{h^{1+\eta}}{1+\eta} TW^R(1-\rho_g)(Y-\overline{\omega}V)\right] - \frac{\overline{\omega}}{\chi}V^{1-\psi} \\
0 &= \alpha A h^{\alpha-1} - \sigma_L h^{\eta} TW^R (1-\rho_g)(Y-\overline{\omega}V)
\end{aligned}
$$

As the Ramsey tax wedge TW^R is such that these two constraints and (30) are simultaneously verified, it is not possible to also satisfy $\widetilde{\mathcal{U}}'_h = 0$ or/and $\widetilde{\mathcal{U}}'_V = 0$. These constitute two additional restrictions which cannot be simultaneously tackled by a single fiscal tool. □

Hence, in the general case with labour market distortions, the Ramsey tax scheme cannot simultaneously eliminate the two biases on the extensive and the intensive margin of labour. Beyond its inability to manage the terms of trade externality, the government can thus only reduce the employment and hour gaps, without being able to eliminate them both.

These results have fruitful implications for tax policy. Given that distortive taxation simultaneously affects hours worked and vacancies (by decreasing them both), it may indeed be optimal to manipulate taxes to correct for labour market inefficiencies. Things are not so clear-cut though, as labour market frictions do not affect the extensive and the intensive margin of labour in a similar direction. From Equation (17), it can be shown that labour market frictions, either through unemployment benefits ($\rho_b > 0$) or too strong a bargaining power for workers ($\epsilon < \psi$), increase the equilibrium value of hours worked relative to their first-best level (i.e., $h^{dec} > h^{sp}$)[18]: when the number of employees is restricted by labour market frictions, the market allocation compensates for this inefficiency by an over-adjustment of the hours per worker. If we assume the government only focuses on this intensive margin, it calls for an increase in the tax wedge.[19] By contrast, it is clear from Equation (16) that either $\rho_b > 0$ or $\epsilon < \psi$ have a dampening effect on vacancies (everything else equal for a given h), thereby calling for a reduced tax wedge. Given the contradictory effect of labour market frictions on the intensive and extensive margin of labour, this suggests that an optimal tax scheme may exist.

Nevertheless, a first special case is the one where the Hosios conditions hold on the labour market. Assuming that $\rho_b = 0$ and $\epsilon = \psi$, the optimal Ramsey tax, denoted TW^H, can be devoted to one objective: restoring the efficiency of the hours worked.

[18]See some elements of demonstration in the online Appendix (Section A.4).

[19]If we rather assume a less restrictive objective, like e.g. output, it is clear that it would be rational to subsidise the hours per worker in order to compensate for the over-unemployment.

Proposition 3. *In the absence of labour market distortions ($\epsilon = \psi$ and $b = 0$), the optimal policy allowing the government to reach the first best with respect to the aggregates ($h^{dec} = h^{sp}$, $V^{dec} = V^{sp}$, $N^{dec} = N^{sp}$ and $Y^{dec} = Y^{sp}$) is:*

$$TW^H = \frac{1-\rho_g^{sp}}{1-\rho_g}\frac{1}{\xi + (1-\xi)/\mu^*} \Rightarrow \tau_c + \tau_f + \tau_w \approx \rho_g - \rho_g^{sp} + t^* \tag{33}$$

with $1 + t^* = \frac{1}{\xi+(1-\xi)/\mu^*}$.

Proof. If $\epsilon = \psi$ and $b = 0$, then $\Theta = \Psi$. Using this result and Equations (26) and (17), we deduce (33) insuring $h^{dec} = h^{sp}$. From Equation (16), we then deduce that $V^{dec} = V^{sp}$ and from Equations (1) and (5), that $N^{dec} = N^{sp}$ and $Y^{dec} = Y^{sp}$. □

These results drive the following interpretation. First, if $\rho_g^{sp} < \rho_g$, then $TW^H > 1$. The corollary of a large government size is too big a lump-sum tax, and individuals compensate for this negative wealth effect by an increase in the hours worked. This inefficiency may be corrected by imposing a positive distortive taxation. Second, even when public spending is efficient ($\rho_g^{sp} = \rho_g$), $TW^H > 1$ as the trade externality ($t^* > 0$) requires positive distortive tax rates: taxes are used to reduce the quantities exchanged.[20] Hence, because there is no conflicting arbitrage between the extensive and the intensive margin when the Hosios condition is satisfied, it is then possible to manipulate the tax wedge to remove the trade externality and the inefficient government size, so as to reach the first-best value of the hours worked, thus vacancies, employment and aggregate output.

A second special case occurs when the number of hours worked is exogenously fixed. In this case, the optimal Ramsey tax, denoted TW^V, can be devoted to restore the efficiency of employment.

Proposition 4. *If the hours worked are fixed at an exogenous level $\overline{h}$, then $\widetilde{\mathcal{U}}'_h$ does not exist. In this case, the optimal taxation is:*

$$TW^V = \frac{1-\rho_g^{sp}}{1-\rho_g}(1+t^*) - \frac{\left(\frac{1}{\epsilon} - \frac{1}{\psi}\right)\omega(V^{sp}|_{\overline{h}})^{1-\psi} + b}{\sigma_L \frac{\overline{h}^{1+\eta}}{1+\eta}(1-\rho_g)(Y^{sp}|_{\overline{h}} - \omega V^{sp}|_{\overline{h}})} \tag{34}$$

with $Y^{sp}|_{\overline{h}}$ and $V^{sp}|_{\overline{h}}$ the (known) first-best values of output and vacancies for given hours

[20] This theoretical result finds some empirical support in the data. Epifani & Gancia (2009) thus document that trade openness is associated with a larger government size. However, this is only indirect evidence as the direct link between trade and taxation *per se* is not studied.

worked $\overline{h}$. When $\epsilon \neq \psi$ and $b \neq 0$, TW^V can be lower than 1 if and only if the labour market frictions induce higher distortions than the government size and the trade externality.

Proof. We have $V_R = V_{sp}$ (conditional on $\overline{h}$) if and only if:

$$(\epsilon - \psi)A\overline{h}^{\alpha} - \epsilon b + \psi\sigma_L \frac{\overline{h}^{1+\eta}}{1+\eta} \frac{Y - \overline{\omega}V}{\left[\xi + (1-\xi)\frac{1}{\mu^*} + \Phi\right]} = \epsilon\ TW\ \sigma_L \frac{h^{1+\eta}}{1+\eta}(1-\rho_g)(Y - \overline{\omega}V)$$

One can then derive the optimal tax wedge value as stated in Proposition 4. □

This solution for the optimal taxation in an economy without an intensive margin shows the constraints faced by the government on the extensive margin of labour. On the one hand, the trade externality ($t^* > 0 \Leftrightarrow \sigma^* < \infty$) and sub-optimal public spending ($\rho_g > \rho_g^{sp}$) call for increased taxation. On the other hand, labour market frictions ($b > 0$ or $\epsilon < \psi$) require a lower tax burden. From Equation (34), it is clear that the optimal tax burden is strictly positive as long as the first two dimensions dominate the inefficiency induced by labour market frictions.

2.4.3 Indirect Versus Direct Taxation

If we now reformulate the Ramsey problem in terms of optimal labour taxation, the FOC of the Ramsey problem with respect to τ_f is:

$$\mathcal{H}'(TW)\left[\frac{\partial TW}{\partial \tau_f} + \frac{\partial TW}{\partial \tau_c}\frac{\partial \tau_c}{\partial \tau_f}\right] \times \left[\mathcal{V}'(h)\widetilde{\mathcal{U}}'_V + \widetilde{\mathcal{U}}'_h\right] = 0 \tag{35}$$

In view of Equation (35), two cases should be considered. First, if $\left[\frac{\partial TW}{\partial \tau_f} + \frac{\partial TW}{\partial \tau_c}\frac{\partial \tau_c}{\partial \tau_f}\right] = 0$. In this case, any change in the payroll tax is offset by the opposite change in the indirect tax, such that it does not affect the tax wedge. Consequently, changing the payroll tax rate has no impact on hours worked or vacancies and more broadly on the decentralised equilibrium allocation. Secondly, if $\left[\frac{\partial TW}{\partial \tau_f} + \frac{\partial TW}{\partial \tau_c}\frac{\partial \tau_c}{\partial \tau_f}\right] \neq 0$. In this case, under the Ramsey allocation the government is able to manipulate the payroll tax rate such that it improves the decentralised allocation. It is the government budget constraint that determines the condition under which changes in direct taxation are offset or not by the opposite change in indirect taxation. This leads to Proposition 5, which we refer to as the "tax base" effect.

Proposition 5. *Starting from an initial allocation with an excessive tax burden, it is optimal to switch from direct labour taxation to indirect taxation if the wage share of output is lower than the consumption share of output. Indeed, for non-negative labour tax rates* τ_w, τ_f *and with* $C \equiv C_H + \phi C_F$ *aggregate consumption, the condition* $\frac{C}{Y-\varpi V} > \frac{wNh}{Y-\varpi V}$ *is a sufficient condition for* $\frac{dTW}{d\tau_f} > 0$ *given the required adjustment in* τ_c*.*

Proof. Using the decision rules, the budgetary constraint of the government is:

$$\tau_c(1-\rho_g) + \frac{\tau_f + \tau_w}{1+\tau_f} + \rho_T = \rho_g + (1-\tau_w)\rho_b \frac{1-N}{N}$$

where we assume that $\frac{b}{1+\tau_f} = \rho_b wh \Rightarrow \frac{b}{1+\tau_f}N = \rho_b(Y - \omega V)$. We thus deduce that a sufficient condition for $\left|\frac{d\tau_c}{d\tau_f}\right| < 1$ is

$$\frac{1-\tau_w}{1+\tau_f}\frac{whN}{Y-\omega V} < \frac{C_H + \phi C_F}{Y - \omega V} + \rho_b \varepsilon \frac{\tau_f - \tau_c}{TW}$$

where $\varepsilon \equiv -N'(TW)\frac{TW}{N}$ stands for the elasticity of employment to the tax burden. If $\frac{whN}{Y-\omega V} < \frac{C_H+\phi C_F}{Y-\omega V}$, then $\left|\frac{d\tau_c}{d\tau_f}\right| < 1$ because $\frac{1-\tau_w}{1+\tau_f} < 1$ and $\rho_b \varepsilon \frac{\tau_f - \tau_c}{TW} > 0$.

□

Thus, the tax base condition stated in Proposition 5 is a sufficient condition for a decrease in τ_f to be compensated for by a less than proportional increase in τ_c, in which case the overall size of the tax distortion TW decreases. Importantly, one has to note that the tax base condition is satisfied empirically.[21] In this respect, asking the question of direct versus indirect taxation is more than of theoretical interest. If the single source of consumption expenditures came from labour revenues, the question would be pointless. However, in a (realistic) environment where households have other sources of revenues, our results demonstrate the relevance of switching from direct to indirect taxation: as long as the tax base condition holds, which is the case in the data, it is optimal to do so, as long as implementing the Ramsey tax policy requires alleviating the overall tax burden in the economy. In this respect, these analytical results call for a quantitative assessment. This is the purpose of next section.

[21] We have verified that this holds for a large number of countries over the recent decades, using OECD data on national accounts. Results are available upon request.

3 Optimal Labour Taxation: a Quantitative Assessment in a DGE Model

The dynamic general equilibrium (DGE) model remains close to our analytical setup in many respects. The open economy dimension in particular is similarly modeled, as we stick to the analytical import and export functions and we still discard foreign debt analysis. As in the analytical setup, we also preserve the assumption of a balanced budget.[22] The main extension consists in including capital dynamics, which enables us to quantify the role of transitional dynamics in shaping the optimal tax scheme. In addition, with the DGE, we can assess the impact of alternative fiscal adjustments, as in Prescott (2004).

3.1 The Model

In what follows, we provide a brief overview of the model, putting particular emphasis on the aspects that differ from the analytical setup. A more detailed presentation of the DGE model is made in the online appendix (Section B).

Labour market modeling Employment is predetermined at each time and changes only gradually as workers separate from jobs, at the exogenous rate s $(0 < s < 1)$, or unemployed agents find jobs. The matching function is identical to that in the previous section, except that we now introduce an endogenous search effort, denoted by e_t. Thus, at each date t, the number of unemployed workers in efficiency units is $e_t(1 - N_t)$ and thus employment evolves as follows:

$$N_{t+1} = (1 - s)N_t + M_t \quad \text{with } M_t = \chi V_t^{\psi} \left[e_t(1 - N_t)\right]^{1-\psi}, \quad 0 < \psi < 1 \tag{36}$$

The labour force is constant and normalised to one, then $1 - N_t$ is also the unemployment rate.

[22] Public debt introduces an additional instrument for the government that affects the intertemporal trade-off. Foreign debt also introduces an additional externality in the Euler equation, thereby affecting the mechanisms allowing the small open economy to have a saddle path. The study of the impact of tax policies on this dynamic inefficiency is left for future research.

The household The representative household's preferences are now given by:

$$\mathcal{U} = \sum_{t=0}^{\infty} \beta^t \left[U(C_t, h_t, e_t) + \Phi \log G_t \right] \tag{37}$$

$$\text{with} \quad U(C_t, h_t, e_t) = \log C_t + N_t \Gamma_t^n(h_t) + (1 - N_t)\Gamma_t^u(e_t) \tag{38}$$

with $\Gamma_t^n(h_t) \equiv -\sigma_L \frac{h_t^{1+\eta}}{1+\eta}$ and $\Gamma_t^u(e_t) \equiv -\sigma_u \frac{e_t^{1+\eta}}{1+\eta}$ the disutility of working and searching for a job respectively. The aggregate current consumption (C_t) is spread over domestic goods (C_{Ht}) and imports (C_{Ft}), given CES preferences with elasticity of substitution η:

$$C_t = \left[\xi^{\frac{1}{\eta}} C_{Ht}^{\frac{\eta-1}{\eta}} + (1-\xi)^{\frac{1}{\eta}} C_{Ft}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \qquad \eta > 1 \tag{39}$$

As in the analytical setup, the household is subject to lump-sum taxes T and distortive taxation (with a direct labour tax τ_w and an indirect tax τ_c). Unemployed people still receive unemployment benefits b.

Firms There are many identical firms in the economy producing a homogeneous good at price 1. Each firm has access to a Cobb-Douglas production technology to produce output:

$$Y_t = A K_t^{1-\alpha} (N_t h_t)^{\alpha}, \quad 0 < \alpha < 1 \tag{40}$$

A is the global productivity of factors in the economy (assumed to be constant) and K_t the physical capital stock, whose law of motion is:

$$K_{t+1} = (1 - \delta) K_t + I_t \tag{41}$$

with $0 < \delta < 1$ the capital depreciation rate and I_t the aggregate investment. To preserve homogeneity in the aggregate demand, the investment is assumed to be a CES aggregator with the same elasticity of substitution as the consumption basket (Equation (39)).[23] Search frictions require firms to post vacant jobs to be matched by unemployed workers. Accordingly, each firm chooses a number V_t of job vacancies, the unit cost of maintaining an open vacancy being $\overline{\omega}$. As in the analytical model, firms are subject to direct labour taxation, scaled by the payroll tax rate τ_f.

[23]For the same reason, we also make this assumption for public spending G_t and the cost of job posting in the search model $\overline{\omega} V_t$.

Wages, hours and search effort In the presence of labour market search frictions, the match between a worker and a firm gives rise to a rent, which is shared by both players through a bargaining process. We assume that wages and hours are determined via generalised Nash bargaining according to $\max_{w_t,h_t}(\lambda_t \mathcal{V}_t^F)^\epsilon (\mathcal{V}_t^H)^{1-\epsilon}$, with $\mathcal{V}_t^F$ the marginal value of a match for a firm and $\mathcal{V}_t^H$ the marginal value of a match for a worker. The negotiated values for hours worked and wages are respectively given by:

$$\alpha \frac{Y_t}{N_t h_t} = TW_t \sigma_L h_t^\eta P_t C_t \tag{42}$$

$$(1+\tau_t^f) w_t h_t = \epsilon \left[b_t + TW_t \left(\Gamma_t^u - \Gamma_t^n\right) P_t C_t\right] + (1-\epsilon)\left[\alpha \frac{Y_t}{N_t} + SC_t\right] \tag{43}$$

$$\text{with} \qquad SC_t \equiv \overline{\omega}\left[\frac{1-s}{q_t}\left(1 - \frac{1+\tau_t^f}{1+\tau_{t+1}^f}\frac{1-\tau_{t+1}^w}{1-\tau_t^w}\right) + e_t \theta_t \left(\frac{1+\tau_t^f}{1+\tau_{t+1}^f}\frac{1-\tau_{t+1}^w}{1-\tau_t^w}\right)\right]$$

where SC_t refers to search costs and θ_t is the labour market tightness (standardly defined as $\theta_t = V_t/(e_t(1-N_t))$. As shown by Equation (42), with an efficient bargaining process over wages and hours, the optimal choice of hours worked by the employee is close to the Walrasian case (up to payroll tax rates). By contrast, according to Equation (43), the wage contract is a weighted average of the worker's outside option and the marginal product of a match, where the relative weights depend on the relative bargaining power of both players, distorted by the tax rates. Finally, given the sharing rule determined by the Nash programme, the optimal search effort level is given by:

$$\frac{1-\epsilon}{\epsilon}\overline{\omega}\theta_t = TW_t \sigma_u e_t^\eta C_t \tag{44}$$

Government budget constraint and market equilibria As in the analytical framework, we assume a balanced budget for each period with $P_t G_t = \rho_g Y_t$ and $P_t T_t = \rho_T Y_t$. In Section 3.2.2, we will measure how our results change if we modify this assumption. The model is closed by taking the equilibrium conditions on the home and foreign good markets into account, as well as the zero-trade balance condition. The functional forms for the export and import functions are kept identical to the analytical framework (Equations (2) and (3)).

3.2 The Optimal Tax Scheme: a Quantitative Assessment

We consider France as the benchmark economy, as it exemplifies a rigid labour market. We thus proceed to a careful calibration of the deep parameters of the model (full details are provided in Appendix A). We briefly detail the calibration of the key parameters here, as highlighted in Section 2. At the benchmark equilibrium, the model matches the tax base difference in consumption and payroll taxes. The initial taxes are $\{\tau^f = 0.34, \tau^c = 0.22, \tau^w = 0.13\}$. The Hosios condition does not hold as $\rho_b = 0.37$, which is consistent with French data over the recent decades. The price elasticity of foreign demand for domestic goods σ^* is set equal to 1.5, as for η, thus following Backus et al. (1995).[24] The calibration for Φ, which captures the valuation of public spending in the utility, is an open question. In contradiction with Prescott (2004) and others, we believe that it is essential to discuss the optimal tax design in an environment where taxes are used to finance valuable public spending. In terms of calibration, this imposes $\Phi > 0$. There is however no clear benchmark value in the related literature.[25] We adopt the ad-hoc value $\Phi = 0.1$ as the benchmark calibration and we will discuss the case of $\Phi = 0$ in Section 3.2.2.[26]

3.2.1 Taking the Dynamics of the Tax Reform into Account

In the spirit of Lucas (1987) and (2003), the welfare gain (or loss) from a given reform is evaluated by the compensation ζ such that:

$$\mathcal{W}\left[\left\{(1+\zeta)C^0, h^0, G^0\right\}_{t=0}^{\infty}\right] = \mathcal{W}^*\left[\{C_t^*, h_t^*, G_t^*\}_{t=0}^{\infty}\right]$$

A positive (negative) value of ζ means that the reform is welfare improving (welfare deteriorating). To determine the optimal tax policy, we derive the values of ζ associated with various ranges of tax rates (τ^f, τ^c), the optimal tax scheme being reached when ζ is maximised. The results are shown in Figure 1, right-hand panel (b). To better illustrate the role of transition dynamics, we also compute the optimal tax scheme in steady state, as reported in Figure 1, right-hand panel (a).[27]

Consider first the optimal tax reform when we abstract from the transition (Figure 1,

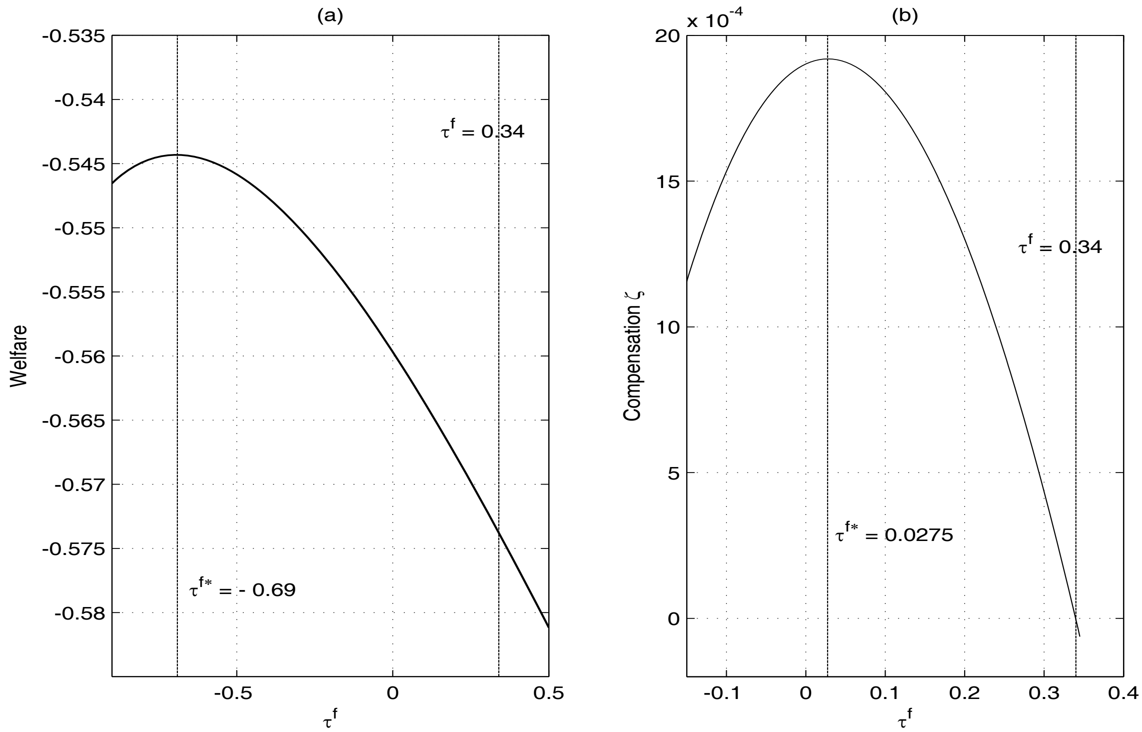
[24] This calibration lies within the range of values commonly used in the international macroeconomic literature, typically between 1 and 2.

[25] Without any focus on the optimal size of the government, Christiano & Eichenbaum (1992) or Finn (1998) study the two polar cases where public spending is either not valued, or a perfect substitute to private consumption. At the opposite end of the spectrum, Christiano et al. (2011) or Coenen et al. (2013) pick Φ such that the model replicates the observed PG/Y ratio, and thus assume that the actual size of the government is optimal.

[26] This value for Φ may appear quite conservative, as it implies an optimal ratio of public to private consumption (0.1) which is lower than what is observed in most developed countries.

[27] In this case, we do not report the compensation ζ but the long-run welfare level. The optimal tax scheme corresponds to the maximum of the welfare curve.

Figure 1: Assessing the optimal tax reform



Panel (a)). In accordance with our analytical results (Section 2), the welfare curve is hump-shaped. Starting from the benchmark value of $\tau^f = 0.34$, the shift from direct to indirect taxes (moving to the left on the x-axis) first improves welfare by reducing fiscal distortions ($TW \downarrow$). In this case, the rise in consumption largely dominates the increase in the disutility of work. Our simulations indicate that the steady-state optimal tax scheme is reached for $\{\tau_f^R = -0.69, \tau_c^R = 2.63\}$.

To what extent is the optimal tax scheme modified by taking transition dynamics into account? The optimal tax reform when including the transition of the tax reform is reported in Figure 1, Panel (b). As in the long-run case, we obtain a hump-shaped welfare curve for the tax reform. However, the quantitative results are very different. Starting from the benchmark current tax policy ($\tau^f = 0.34$ and $\tau^c = 0.22$), the optimal tax reform is reached for $\tau_f^R = 0.0275$ and $\tau_c^R = 0.440$. This contrasts with the analysis focusing only on the steady state. The difference with the steady-state optimal tax reform comes from the bigger responses of hours worked in the short run. Indeed, workers prefer to smooth their consumption and work more in order to accumulate and then reach the (higher) level of capital which characterises the final steady state. Even if the decrease in the payroll tax can be welfare improving in the long run (Panel (a)), these potential gains are counteracted by the short-run effort necessary for the accumulation process. Transition dynamics shifts the hump shape leftward.[28]

For the benchmark calibration (Column (1) of Table 1), **the optimal tax reform consists in a tax wedge reduction of 9.5%, which is achieved by shifting from direct to indirect taxation (**$\tau_f^R = 0.025\%$**, versus 34% in the benchmark calibration and** $\tau_c^R = 0.44$ **vs 0.22 initially). In terms of welfare gains, implementing the optimal tax reform results** in an increase in lifetime consumption of 0.19 %: The gains from the tax policy are small. They are much lower in particular than those advocated by Prescott (2004), who obtains a 20 percent increase in lifetime consumption for a decrease in the tax burden of 20 percentage points. We thus go further in examining this difference in results in the next section.

3.2.2 Optimal Taxation: the Role of Budgetary Adjustments

The optimal tax reform $\{\tau_f^R, \tau_c^R\} = \{0.0275, 0.440\}$ has been obtained under the assumption of constant ratios of public spending and transfers to GDP. In this section, we investigate the implications of implementing the optimal tax reform for alternative budgetary adjustments. The results are displayed in Table 1. First, we compare scenarios in which the government size is constant in *level* rather than constant in *relative size* (Columns (2) to (6)). Second, we evaluate a reform which implements the optimal tax scheme and the optimal government size simultaneously (Column (7)).

In Column (1), we recall the benchmark results, where both T and G are kept proportional to the GDP in value, which we identify as scenario (a). The welfare gains of the tax reform are low (0.19%). In this respect, one may argue that shifting from direct to indirect -but still distortive- taxation is not the most efficient reform. Comparing Column (2) to Column (1), maintaining G and T constant in level rather than relative to the GDP does not significantly increase the welfare gains from the tax reform (which rise from 0.19% to 1.46% only). By contrast, as reported in Columns (3) and (4), the welfare gains are much higher when the payroll tax cut is compensated for by an increase in lump-sum taxation (with no distortive effect, Column (3)) or even more, by reducing the government size (Column (4), scenario (d)).

[28] In the online appendix (Section C), we present the impulse response functions of the aggregate variables when the optimal tax reform is implemented.

Table 1: Impact of alternative budget adjustments (with transition)

	1	2	3	4	5	6	7
Budget adjustment	(a)	(b)	(c)	(d)	(d)	(a)(*)	(e)(*)
Φ	0.1				0		0.1
τ_f^0	0.34	0.34	0.34	0.34	0.34	0.34	0.34
τ_f^1	0.0275	0.0275	0.0275	0.0275	0.0275	0.3675	-0.0875
τ_c^0	0.22	0.22	0.22	0.22	0.22	0.22	0.22
τ_c^1	0.4396	0.4074	0.22	0.22	0.22	0.2156	0.2219
$\Delta TW \times 100$	-9.519	-11.540	-23.321	-23.321	-23.321	0.831	-0.318
$\Delta PG/Y \times 100$	0	-4.3719	-9.2745	-43.171	-43.171	0	-0.683
$\Delta PT/Y \times 100$	0	-4.372	-102.87	-4.372	-4.372	0	0
$\zeta \times 100$	0.1919	1.4635	2.6266	11.37	17.431	0.0008	14.123

In all experiments, τ_w maintained constant equal to 0.13.
^{0} and ^{1}: For the pre-reform and the post-reform tax rates values respectively.
*: Identifies the optimal tax reform in this scenario.
(a) PG/Y and PT/Y kept constant (in ratios); (b) G and T kept constant (in levels);
(c) G and τ^c constant, T adjusts; (d) T and τ^c constant, G adjusts;
(e) Reforming both $G/C(= \Phi)$ and τ_f, PT/Y constant and τ^c adjusts.

Welfare gains from tax reform: the role of Φ. The above conclusion is likely to be strongly sensitive to the magnitude of the valuation of public spending (Φ). This is confirmed in Column (5). The drop in government expenditures associated to the decrease in τ_f from 0.34 to 0.0275 (scenario (d)) indeed leads to greater welfare gains in an economy where public spending does not provide utility (17.43% increase in lifetime consumption when $\Phi = 0$, vs 11.71% when $\Phi = 0.1$): the tax reform makes the economy shift to a state with a much lower crowding-out effect of government expenditures, with larger welfare gains when public spending is not valued.

The significant welfare gains in Columns (3), (4) and (5) are reminiscent of Prescott's (2004) results on the benefits from lowering labour taxation. In his exercise, using a closed economy Walrasian model where public expenditures are wasteful, the decrease in proportional taxes is compensated for by an increase in lump-sum taxation (which has no distortive effect) while maintaining the *level* of public spending constant.[29] Table 1 contributes to putting these results into perspective. First, in contrast to Prescott's (2004) case, in benchmark scenario (a), the tax scheme is designed to preserve the size of welfare state programmes, i.e. with constant *ratios* of public spending and transfers relative to GDP. This difference in budgetary adjustment undoubtedly moderates the decrease in tax distortions in comparison with Prescott's exercise, hence the welfare gains associated with the tax reform.

[29] In this respect, Scenario (c) (reported in Column (3)) is the closest to Prescott's case.

Second, the large welfare gains obtained by Prescott (2004) rely on the assumption that public spending is wasteful. Acknowledging its role as providing utility mitigates the welfare gains from the tax cut, as shown by comparing Columns (5) and (4).

Comparing Columns (6) and (1) also draws attention to the key role of the valuation of public spending (Φ) in shaping the optimal tax reform. While the Ramsey policy consists in reducing the tax wedge under $\Phi > 0$, it is the opposite when public spending is wasteful. In this case, it is optimal to *increase* the tax burden (Column (6)). This result can be rationalised using our analytical findings. Switching from $\Phi = 0$ to $\Phi > 0$ mechanically enlarges the gap between the observed public spending to GDP ratio and the optimal one. As notably stated in Proposition 3, this calls for increasing the Ramsey tax wedge.

Reforming the tax burden and public spending when $\Phi > 0$. The above results suggest that substantial welfare gains may be achieved when the tax reform is combined to budget adjustment. We thus assume that, at the date of the tax reform, the government decides to bring the economy to the optimal ratio of government spending to consumption: $G/C = \Phi$, in parallel with reforming labour taxation. In Column (7) of Table 1, we report the effects of the optimal tax reform in this scenario (labeled (e)).[30] In comparison with the benchmark scenario, the Ramsey labour tax is lower (and even slightly negative, equal to -0.0875). As the reform consists in aligning the government size to the optimal one, it suppresses a motive to impose distortive taxation (See Propositions 3 and 4). As a consequence, the Ramsey tax wedge is lower. Besides, in accordance with our intuition, the welfare gains from the reform are significantly increased, up to 14.12 % in terms of lifetime consumption.

3.2.3 Optimal Taxation: Sensitivity Analysis

We study the sensitivity of the optimal tax reform (under benchmark scenario (a)) to the key dimensions identified in Section 2. Besides public spending (discussed in the section above), the shape of the optimal tax scheme also crucially depends on the open economy dimension and labour market frictions. They can respectively be captured by *i°)* σ^*, which measures the sensitivity of the trade balance to the terms of trade, and *ii°)* ρ_b and $\epsilon \neq \psi$, which govern labour market frictions. The results are reported in Table 2.[31] For the sake of

[30]More precisely, the deterministic simulation is performed under the following assumptions. Starting from the benchmark initial steady state, the economy benefits from a drop in τ^f *and* a shift in the government spending-to-consumption ratio G/C set to Φ, consistently with the planner's optimal choice of G.

[31]Note that in all experiments, the indirect tax rate in the initial steady state has been adjusted to the new environment.

comparison, Column (1) recalls the benchmark results.

Table 2: Sensitivity Analysis

	1		2		3		4	
	Benchmark		High σ^*		Low ρ_b		$\epsilon < \psi$	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
τ^f	0.34	0.0275	0.34	-0.1825	0.34	0.1675	0.34	-0.01
τ^c	0.22	0.44	0.222	0.684	0.198	0.301	0.227	0.485
TW	1.879	1.70	1.882	1.582	1.845	1.747	1.890	1.690
$\Delta TW \times 100$	-9.519		-15.921		-0.0536		-0.1059	
$\zeta \times 100$	0.1919		0.6180		0.0570		0.2436	

Note: In all experiments, τ_w maintained constant equal to 0.13.
Note: In all experiments, the final steady state corresponds to the Ramsey tax policy.

Sensitivity to the open economy dimension. As shown in Section 2, when foreign demand is strongly sensitive to the terms of trade (high σ^*), the centralised allocation converges to the one in a perfect competitive market. Accordingly, the tax reform is not slowed down by the opportunity to keep a markup on tradable goods (Proposition 2). To put it differently, the magnitude of the tax cut rises with σ^*. In this case, labour market inefficiencies are likely to play a dominant role, calling for a reduced labour cost. According to this reasoning, the higher σ^*, the lower the optimal tax rate τ_f^R.

The results shown in Table 2, Column 2 confirm the relevance of the previous reasoning. In an economy with LMF and with $\sigma^* = 2$ (versus 1.5 in the benchmark calibration), the optimal tax policy is reached for a negative payroll tax rate ($\tau_f^R = -0.18$). Besides, the magnitude of welfare gains is significantly affected by this parameter, thereby illustrating the importance of the open economy dimension in the evaluation of a tax reform in the French economy. This result is consistent with related papers (De Paoli (2009), Epifani & Gancia (2009)), in which the elasticity of substitution between home and foreign goods scales the terms of trade externality.

Sensitivity to labour market institutions. First, we investigate the sensitivity of the result to the generosity of the unemployment benefit system. In Column 3 of Table 2, we determine the optimal tax scheme for a lower unemployment benefit ratio $\rho_b = 0.15$, which corresponds to the values observed in the United States and the United Kingdom in recent decades (1993-2003).[32]

[32] This calibration is based on OECD data as provided in Nickell's (2006) CEP database.

The optimal tax policy is reached for $\tau_f^R = 0.1675$, vs 0.0275 when $\rho_b = 0.37$. That is, the optimal need to reduce the tax burden decreases when the unemployment benefit system is not very generous. This result is fully consistent with analytical insights (Equation (34)). The direct effect of the unemployment benefit ratio is to increase labour costs, which reduces labour market tightness below its first-rank level. A large ρ_b also reduces the unemployed search effort. This effect suggests that a large ρ_b must be compensated for by lower fiscal distortions, so as to entice both firms and workers to search more intensively. This is achieved by lowering the payroll tax. On the contrary, with low unemployment benefits, the call for increased taxation attributable to the open economy dimension and the inefficient government size is more likely to dominate, in which case it is optimal to increase the tax pressure, as reported in Column 2 of Table 2. However, for $\rho_b = 0.15$, the magnitude of the change in tax pressure remains modest hence the associated welfare gains.

Our modeling allows for another labour market inefficiency, whenever the firm's bargaining power (ϵ) differs from its contribution to the matching process (ψ). Table 2, Column 4 reports the results in the case where the firm's bargaining power is lower than under Hosios ($\epsilon < \psi$). In this case, the optimal tax reform consists in lowering the payroll tax rate, with a null (and even slightly negative) $\tau_f^R = -0.01$ for $\epsilon = 0.5$ and $\psi = 0.6$. Indeed, the low share of the matching rent attributed to firms (in comparison with their contribution to the matching process) reduces their incentives to search for workers. Thus, the distortion induced by $\epsilon < \psi$ implies that increasing the firm's search effort should be a priority for the tax policy, which is achieved by lowering the payroll tax (See Equation (34)) and results in greater welfare gains than in the benchmark case with $\epsilon = \psi$ (Column (1) of Table 2).

4 Conclusion

In this paper, we propose a re-assessment of the welfare gains from reduced labour taxation. The originality of our work lies in introducing three dimensions that are absent from previous papers: *i)* the open economy setting, *ii)* households' valuation of public spending, and *iii)* labour market frictions with the extensive and intensive margin of employment. An original contribution of the paper is thus to identify the role of each of these three dimensions in the optimal tax scheme. We also put forward the strong interaction between the three dimensions. This relies on both analytical and quantitative results. On the analytical side, we identify the conditions under which *i)* it is optimal to reduce the overall tax wedge, and *ii)* this can be achieved by a switch from direct labour taxation to indirect taxes. As for the first point, we demonstrate that, while the terms of trade externality calls for higher taxes, the households' valuation of public spending and labour market frictions require rather alleviating taxes. These opposing forces thus yield to a non-zero optimal tax burden. Regarding the second point, our paper provides an additional argument in favour of implementing tax reform in European countries which promotes indirect taxation and reduces the direct taxation on labour, if it decreases the tax wedge on labour. Our contribution to the literature is also on quantitative grounds. We indeed provide a quantitative assessment of the optimal tax reform, using France as the benchmark economy. Our calibrated DGE on the French economy indicates that there is room for a lower payroll tax in France, as our model predicts an optimal payroll tax rate of 0.0275% (versus 34% in the benchmark (current) situation). However, one may expect greater benefits from the tax reform when it comes along, aligning the size of the welfare state to its optimal value.

We somewhat understate the inefficiency associated with the open economy dimension as, in the paper, we preclude any change in the external balance and we assume a balanced government budget. One might also wonder about the fiscal policy response from the foreign country to the change in tax scheme in the home country. All these elements raise interesting questions that are left for future research.

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A The DGE Model: Calibration

A.1 Calibration of the Search Model

Step 1: The calibrated parameters using external information. We calibrate a first set of parameters using econometric studies. Table 4 gives the references used and the parameter values retained. All these parameters are in the range of the values commonly retained. Without any robust information for the bargaining power on French data, we assume, as usual $\epsilon = \psi$.

Table 3: Calibrated parameters (Step 1)

Parameter		Value	Reference
Label	Notation		
Labour market features			
Firms' weight in match	ψ	0.6	Fève & Langot (1996)
Firms' bargaining power	ϵ	0.6	$\epsilon = \psi$
Open economy dimension			
Home elasticity of subst. between goods	η	1.5	Backus et al. (1995)
Foreign elasticity of subst. between goods	σ^*	1.5	Backus et al. (1995)
Preferences and technology			
TFP level	A	1	Normalisation
Discount rate	β	0.99	Annual real interest rate of 4%, France, 1995-2008(^{a})

(^{a}): Authors' calculations, based on OECD data.

Step 2: Calibrated parameters using model and aggregate data. In Table 4, we report the targets of our calibration. Since the consumption tax applies to all consumption expenditures, the consumption aggregate includes non-durables and durables, which implies $PC/Y = 62\%$ and $PI/Y = 13\%$. This low value of investment to output ratio will result in a low depreciation rate of capital δ. Secondly, in the French data we observe $(1+\tau^f)wNh/Y$ and wNh/Y, which yields τ^f. We also observe tax revenues from indirect taxation $\tau^c\frac{PC}{Y}$ and employers' social security contributions $\tau^f\frac{wNh}{Y}$ (Landais et al. (2011)), which yields τ^c given τ^f. In addition, National Accounts yield the macroeconomic ratios PC/Y, PI/Y and PG/Y, where the purchases of durable goods by households (purchases by firms) are included in C (in I). Thus, in the data, the tax base for indirect taxation ($PC/Y = 62\%$) is larger than that for payroll taxation ($wNh/Y = 50\%$). Finally, we want our model to be consistent with the main labour market features: the unemployment rate, the vacancy filling probability and the job finding rate observed in France, such that the mean duration of unemployment is 14 months. We also calibrate the parameters of the model so as to match the unemployment benefit ratio observed in France over the recent decades (1995-2003), based on Nickell's (2006) CEP database.[33]

Table 4: Empirical targets (Step 2)

Empirical Target		Value	Reference
Label	Notation		
Labour market features			
Unemployment rate	$1-N$	0.1	France, 1995-2008(^{a})
Working time	h	0.33	Andolfatto (1996)
Search effort time	e	$h/2$	Andolfatto (1996)
Job finding rate	$\widetilde{p}=ep$	0.22	France, 1995-2008(^{a})
Search costs	$P\varpi V/Y$	0.01	Hairault (2002)
Vacancy finding rate	q	0.7	Krause & Lubik (2007)
Unemployment benefit ratio	ρ_b	0.38	France, 1995-2003(^{b})
Key ratios (relative to GDP) and fiscal policy			
Consumption ratio	PC/Y	0.62	France, 1995-2008(^{c})
Investment ratio	PI/Y	0.13	France, 1995-2008(^{c})
Public spending ratio	$PG/Y \equiv \rho_g$	0.25	France, 1995-2008(^{c})
Imports-to-output ratio	Z/Y	0.3	France, 1995-2008(^{c})
Labour share	$(1+\tau^f)wNh/Y$	0.67	France, 1995-2007, Cotis (2009)
Gross labour cost	wNh/Y	0.5	France, 1995-2007, Cotis (2009)
Employee's labour tax	τ^w	0.13	France, 1995-2008, OECD data
Payroll tax rate	τ^f	0.34	France, 1995-2008(^{c})
Indirect tax rate	τ^c	0.22	France, 1995-2008(^{c})

(^{a}): Authors' calculations, based on OECD data.
(^{b}): Nickell's (2006) database
(^{c}): Authors' calculations, based on National Accounts (INSEE)

In Table 5, we present the parameter values that allow the model to match these targets.

[33] More precisely, the empirical target is the average across the first five years of unemployment for three family situations and two money levels (*brroecd* in Nickell's database.)

Table 5: Calibration results (Step 2)

Parameters		Value	Parameters		Value
Label	Notation		Label	Notation	
Separation rate	s	0.024	Share of imports	$1-\xi$	0.3
Matching efficiency	χ	0.941	Disutility of work	σ_L	5.698
Cost of job posting	$\overline{\omega}$	0.4558	Disutility of search	σ_u	1.740
Depreciation rate	δ	0.006	Labour supply preference	η	0.8
Technology parameter	$1-\alpha$	0.32	Transfers to GDP ratio	$\rho_T \equiv PT/Y$	-0.103