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Abstract

Our general goal is to understand how different assumptions about the states and functioning of real economies may lead to different statements about the desirability of a tax reform. This seems to be an important research agenda since second best optimal tax theories have failed so far in providing consensual evaluations, free from uncertainty and controversy. We pursue this general goal considering a specific question: What would be the short to medium run impacts of an energy tax reform on activity and employment? Using a model of open-economy, constrained by international competition, energy dependency and unemployment, we show the sensitivity of evaluation to *i)* assumptions about the reactions of wages and external trade, and to *ii)* empirical diagnostics about the state of the economy.

Key words

Energy; Tax Reform; General Equilibrium; Uncertainty

JEL codes

D50; H20; Q43

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Introduction

In order to deal with resource scarcity and environmental amenities, Welfare and Environmental Economic Theories have advocated for an increase in the relative price of energy, either through marginal pricing rules or tax reforms. Nevertheless, the concrete implementation of those long term policies encounters resistance. An increase in energy price may have strong adverse impacts on competitiveness and on the purchasing power of households, in particular in nowadays globalised and energy dependent economies. Knowing whether and how those different objectives may be reconciled is therefore a critical issue.

Handling this question is not an easy task for economists. The issue does not exist at all in a well-defined "*first best*" model where A) there is a full set of efficient markets in all non-environmental and non-resource dimensions, and B) public intervention may correct environmental and resource externalities without disturbing the efficiency of markets. In this case, the optimal solution is consensual among economists: a Pigouvian tax or pricing, set at the marginal cost of externalities, and supplemented by a neutral lump-sum redistribution of its revenue. This solution completely offset the revenue-impacts of higher energy bills.

Economists have therefore studied the question using various models of *"second best"* economies, where assumptions A) and /or B) do not prevail. A major part of the literature has followed the neoclassical tradition keeping A) but relaxing B) by considering the existence of a "distortive" tax system. In this case, an optimal tax reform increase social welfare by limiting the environmental and resource externalities, but this reform generally increases the distortive impact of the tax system, and therefore, the economic burden borne by private agents (Goulder, 2013). But another branch of literature has shown that this result is less obvious when assumption A) is relaxed as well. Overall, the evaluation proved to be very sensitive to the choice of uncertain and controversial assumptions about *1)* the real sub-optimal functioning of the economy and *2)* the inefficiencies of the initial situation.

In this paper, we acknowledge from the outset this uncertainty about the right model of the economy and, accordingly, we follow a different approach. We neither assume a particular view of the economy, or a particular criterion of social welfare, and we do not try to find what would be *the* optimal tax system. Rather, following Ahmad and Stern (1984), we start from a given initial state (that may be sub-optimal) and we consider the impacts of a direction of reform. We then study *the sensitivity of the evaluation to various visions* about the initial situation and the functioning of markets. This approach is rather general in the sense that we try not to be tied up with the specific assumptions of a second best theory. Nevertheless, the analysis is limited to the range of second best world one can formalise with the set of parameters that is made available. In this paper, we limit our exploration to the case of fully energy-dependent and open economies, whose functioning is completely determined by two uncertain parameters: the reaction of wages and the response of trade.

We first present our simplified model of energy-dependent economy (section 1). This model is then adapted and reduced to study the impact of a change in the relative taxation of energy compared to labour (section 2). We are therefore allowed to compute the net impact on employment of a marginal reform that increases the relative taxation of energy (section 3), and we are able to examine the sensitivity of the evaluation to assumptions about the functioning of the economy (section 4) and the initial state (section 6). In addition, we provide further clarifications on the general equilibrium mechanisms in section 5.

1 A Model of Energy-Dependent and Open Economy

Tensions between long term policy agendas and short term economic realities are heightened in the short to medium run (few years). It is indeed when substitution possibilities are not yet available that the risks will be the stronger for the competitiveness of domestic firms and the purchasing power of households. We shall consider a model limited to this time horizon. But in this model, we will find that even in the short run the outcome of a tax reform on activity and employment is necessary negative. We will find in addition that the evaluation depends crucially on the combination of assumptions made on our two uncertain parameters: the reaction of wages and the response of trade.

Those different combinations of assumptions may refer to different visions of the constraints that globalisation applies on nowadays economies. Various visions of those constraints appear and confront in current debates about “fiscal consolidation”, “competitiveness”, “employment and wage policies”. The first parameter that will be crucial in our examination is the reaction of the relative level of domestic wages, compared to competitors. A high degree of exposure to international competition would tend to reduce the degree of autonomy of wage developments. But this is not, probably, independent from the vision one can have about what makes the relative competitive advantages of this economy. Nevertheless, we will not restrict our analysis. We shall consider any combination with our second parameter: the sensitivity of trade to relative production costs and prices. A high level of international trade combined with a low degree of specialisation in the globalised products markets would tend to increase this "cost-competitiveness" parameter.

This introduction done, we shall make some drastic simplifications to keep the problem in its simplest form. We consider an economy constrained by international competition, energy dependency and unemployment. This economy has no substitution possibilities away from energy at all. All energy needs are imported, and productive systems produce only one aggregate quantity $\boldsymbol{Y}$ of non-energy goods and services. This domestic product is exhausted, without storage, by household consumption ***C***, public consumption ***G***, and net exports ***X***.

$$\boldsymbol{Y} = \boldsymbol{C} + \boldsymbol{G} + \boldsymbol{X} \qquad (1)$$

Investment and capital depreciation are omitted, as we take for given the state of productive capacities, infrastructures, and equipment in the short-mid run. The model thus mimics an extreme case of energy dependency (e. g. of industrialized economies on fossil fuels). The current state of techniques determines the quantities of energy and labour required to produce one unit of domestic product. For any small change we will consider, those two technical coefficients (e and l) will remain unchanged (constant returns to scale).

The domestic price of production is set by producers to cover the costs of energy and labour. These costs include the net costs of resources and the compulsory levies paid in accordance with the existing structure of a tax system. A unit of labour is provided at the nominal wage ***w***, a unit of energy at a constant import price p_E*. A rate of payroll taxation τ_L apply to the net labour income, and an energy tax τ_E is paid for each unit consumed.

$$\boldsymbol{p} = \left(1+\tau_L\right).\boldsymbol{w}.l + \left(p_E^* + \tau_E\right).e \qquad (2)$$

Households use their labour income to buy some energy and the quantity ***C*** of other products. Like producers, they are dependent on energy: they must cover a constant level of energy needs E. Like producers, they pay the uniform energy tax τ_E for each unit consumed.

$$\boldsymbol{w}.l\boldsymbol{Y} = \boldsymbol{p}.\boldsymbol{C} + \left(p_E^* + \tau_E\right).E \tag{3}$$

Public administrations use all tax revenues to finance the level of public consumption ***G***.

$$\tau_L.\boldsymbol{w}.l\boldsymbol{Y} + \tau_E\left(E + e.\boldsymbol{Y}\right) = \boldsymbol{p}.\boldsymbol{G} \tag{4}$$

Into this over simplified economic structure, only two assumptions on the functioning of markets are needed to determine the level of activity and employment:

1. The setting of wage
2. The balance of trade

Still to keep our problem in its simplest form, it is sufficient to assume very simple and general formulations. We shall take the following relations between endogenous variables.

A. The level of wage ***w*** responds to the level of unemployment ***z***

$$\boldsymbol{w} = \boldsymbol{w}(\boldsymbol{z}).p^* = \boldsymbol{w}(\boldsymbol{z}) \tag{5}$$

Assuming an exogenous level of active population L, the rate of unemployment correspond to the level of production in the product market (constant proportion). Taking the world price p^* as exogenous, and using it as *numéraire* for our model (with the normalisation p^*=1), wage relates only to the level of unemployment.

$$\boldsymbol{z} = 1 - \frac{l\boldsymbol{Y}}{L} \tag{6}$$

B. Net exports ***X*** respond to the domestic price of production ***p***

$$\boldsymbol{X} = X\left(\frac{\boldsymbol{p}}{p^*}\right) = X\left(\boldsymbol{p}\right) \tag{7}$$

The trade balance in the globalized product market is somewhat function of the terms of trade. The world price p^* being our *numéraire*, net exports relate only to the costs of domestic production.

Those macroeconomic formulations are general enough to be loosely consistent with various microeconomic theories of the labour market and international competition. A wide range of globalisation constraints on or beliefs about “wage flexibility” and “cost-competitiveness” may be described. For any small change in exogenous variables (for instance the tax structure), this range of different beliefs may be mapped in the domain defined by the values of the corresponding elasticities:

$$\varepsilon_w = -\frac{\boldsymbol{z}}{\boldsymbol{w}}.\frac{\partial \boldsymbol{w}}{\partial \boldsymbol{z}} \tag{8}$$

$$\varepsilon_X = -\frac{\boldsymbol{p}}{\boldsymbol{X}}.\frac{\partial \boldsymbol{X}}{\partial \boldsymbol{p}} \tag{9}$$

Other variables should be introduced in those relationships to get more realistic representations of wage-setting behaviours (unemployment benefits, bargaining powers, labour productivity, etc.) and trade behaviours (market powers, non-costs determinants of competitiveness, international demand potentials, etc.). All these real world complications must be considered in specific applications, in order to precise the wage and trade behavioural conditions that characterize a given country at a given period of time. But here, we shall not restrict the domain of exploration. Let us only consider that the signs of elasticities (ε_X, ε_W) are known and positive. It is consensual enough that *ceteris paribus* higher unemployment goes along with lower relative wage autonomy with respect to competitors (“wage moderation”), and higher production costs with lower competitiveness. Of course, different magnitudes of those elasticities - from zero to infinite – would reflect very different globalisation contexts or beliefs.

This formalisation is general enough to picture a wide range of inefficient states, arising not only from an existing sub-optimal tax system, but also from inefficient market prices. The current level of wage may not be the one that maximises demand in the product market. The current level of domestic price may not be the one that maximises net exports. A tax reform can either worsen or improve the initial state by changing this price system.

2 General Equilibrium and Tax Structure

The previous model has seven equations and seven unknowns (in bold letters): $\boldsymbol{p}, \boldsymbol{w}, \boldsymbol{z}$ ou $\boldsymbol{Y}, \boldsymbol{C}, \boldsymbol{G}, \boldsymbol{X}$. At any general equilibrium, equations (1) to (4) imply the respect of the accounting identity of the external balance of payments:

$$\boldsymbol{p}.\boldsymbol{X} = p_E^*.(e.\boldsymbol{Y} + E) = p_E^*.\boldsymbol{M}_E \qquad (10)$$

This indicates that net exports must finance the energy bill of the dependent economy if there is no possibility of current account deficit. In the international energy market, we assume no restriction in the international supply of energy ($\boldsymbol{M_E}$ is not upper bounded) and no impact of le level of domestic demand on the import price of energy (p_E* is exogenous). Some loop may be introduced, but it will only limit the production potential or magnify the effect of higher energy price we will see latter on. Here, it is worth considering the effect of the structure of the tax system on activity and employment at any general equilibrium.

Note that this formalisation could as well be applied to the description of a net importing economy (e.g. $\boldsymbol{X} < 0$). In that case, the country should also export some of its energy or natural resources to control its external trade balance.

It is useful to reduce the model a bit more to get an overall picture of the impact of the tax structure on the economy. A *price curve* is obtained from equations (2) and (4), and an *activity curve* from equations (1) and (3). The set of all general equilibria is described by the locus of the possible intersections of these curves. An equilibrium curve thus links the domestic production price with the level of domestic production ($\boldsymbol{p}$, $\boldsymbol{Y}$), or alternatively, as activity and employment are proportional, with the level of unemployment ($\boldsymbol{p}$, $\boldsymbol{z}$).

Looking now at the public finance, we may either take the structure of the tax system (τ_L, τ_E) or the level of public consumption $\boldsymbol{G}$ as given. In the latter case, public administrations follow a budgeting routine or pursue an objective of public good provision. Accordingly, they adjust the level of public consumption to the levels of price and activity. This budgetary rule takes the form of a new constraint, the function $\boldsymbol{g(p, Y)}$. In this case, if no public deficit is allowed, one of the tax rates must adjust to balance the public budget.

Price curve

$$\boldsymbol{p} \;=\; \frac{1}{1-\boldsymbol{g}(\boldsymbol{Y},\boldsymbol{p})}.\left[\; w(\boldsymbol{z}).l \quad + \quad p_E^{*}.e \quad - \quad \frac{\tau_E.E}{\boldsymbol{Y}} \;\right] \tag{11}$$

Activity curve

$$\boldsymbol{Y} \;=\; \frac{1}{1-\boldsymbol{g}(\boldsymbol{Y},\boldsymbol{p})}.\left[\; \frac{w(\boldsymbol{z}).l.\boldsymbol{Y}}{\boldsymbol{p}} \;-\; \frac{\left(p_E^{*}+\tau_E\right).E}{\boldsymbol{p}} \;+\; \boldsymbol{X}(\boldsymbol{p}) \;\right] \tag{12}$$

with: $$\boldsymbol{z} = 1 - \frac{l.\boldsymbol{Y}}{\boldsymbol{L}} \qquad \text{and} \qquad \boldsymbol{g}(\boldsymbol{p},\boldsymbol{Y}) = \frac{\boldsymbol{G}(\boldsymbol{p},\boldsymbol{Y},\tau_E,\tau_L)}{\boldsymbol{Y}} \tag{13}$$

Therefore, for any level of energy taxation τ_E, the level of labour taxation τ_L and the size of public consumption $\boldsymbol{g}$ are determined together. In other words, for any level of public goods requirement, or 'weight of the state', the impact of the tax structure on the equilibrium locus can be characterized only by looking at in equations (11) and (12).

The two direct economic impacts of relative high energy taxation τ_E appears clearly in those equations. 1) On the one hand, higher energy taxation tends to *reduce the tax burden on production costs*. Equation 11 shows that this burden is alleviated by the amount of energy tax paid by households ($\tau_E.E$) apportioned between units of domestic production (***Y***). Indeed, producers pay higher energy tax, but this new burden is fully offset by the recycling-option: lower labour tax. 2) On the other hand, relative high energy taxation tends to *weight on the purchasing power of households* and to push down domestic consumption. Equation 12 shows that this second direct impact depends also on the energy dependence of households, but it may be offset by the adjustment of price, wage and domestic activity.

Beyond those direct impacts, the net consequences of high energy tax schemes on the levels of price and activity are not trivial. The "double dividend" literature of environmental tax reform have drawn attention to an indirect effect through which the energy tax may fall back on production costs, and therefore cancel out the positive effect of lower labour taxation. Consumers and workers may respond to higher energy bills by demanding higher wages. Or, alternatively, in a world where labour supply is assumed to be the limiting factor in the labour market, workers may further reduce their supply. This negative mechanism is sufficient to reject the double dividend hypothesis in models where the market economy is assumed to be spontaneously efficient and the pre-existing tax system "distortionary" (Goulder, 2013). But this result cannot be generalised to all plausible cases of second best economies, where the functioning of markets and the tax system are both sub-optimal.

3 Marginal tax reform

We analyse now the net impact of a marginal reform. Following Ahmad and Stern (1984), we start from a given initial state that may well be sub-optimal, and we study under what conditions a direction of improving reform may be found. This analysis of small movements from the *status quo* says nothing, however, about the size of the reform. It should be set side-by-side a non-marginal discussion, which may be conducted, for instance, with the help of a more specific numerical model. A non-marginal analysis should relax some of the omissions and simplifying assumptions made here to keep the problem in its general and simplest form. Nevertheless, the marginal analysis economises on assumptions and data and provides considerable analytical advantages since the problem is analytically tractable.

The marginal reform we consider is a substitution of labour for energy taxation. Starting from a given initial tax structure (τ_L, τ_E), we therefore consider a small increase in energy tax $d\tau_E$ and its impact on the economic system ($\boldsymbol{p}$, $\boldsymbol{Y}$). If we take as given the public budget constraint $g(\boldsymbol{p},\boldsymbol{Y})$, the labour tax τ_L must adjust to meet the required budgetary objective.

To avoid unnecessary complications at this stage of the analysis, we consider a particular budgetary constraint. We think of the public administrations as requiring a certain level of resources for some given public activities. However, instead of taking constant the level of public consumption $\boldsymbol{G}$ whatever the economic conditions are, we shall assume this consumption to be proportional to the size of the whole economy. Formally, we assume the ratio $\boldsymbol{G}$ to $\boldsymbol{Y}$ to be constant and equal to its initial value g. This is a difference from the double dividend literature which considers $\boldsymbol{G}$ as constant. But, as we shall see below, this assumption has the advantage of being neutral for the relative impact of the reform on household demand and net exports, on which we want to focus. On the opposite, a constant absolute level of public consumption may add some other complications, since this policy works as stabilization policy. In general, further investigation should compare various budgetary rules, since the general public finance context interacts with the reform.

Under those limitations, we study the marginal impacts of the reform by computing the total derivative of the system with respect to τ_E. We choose the unemployment rate and the domestic price as our two unknowns. This gives the following expression of the system:

$$\begin{cases} (1-\mathrm{g}).\boldsymbol{p} = w(\boldsymbol{z}).l + p_E^*.e - \dfrac{\tau_E.E.l}{L.(1-\boldsymbol{z})} \\ \\ (1-\mathrm{g}).\dfrac{L}{l}.\boldsymbol{p}.(1-\boldsymbol{z}) = L.w(\boldsymbol{z}).(1-\boldsymbol{z}) - \left(p_E^*+\tau_E\right).E + \boldsymbol{p}.X(\boldsymbol{p}) \end{cases}$$

and the total derivative with respect to τ_E:

$$\begin{cases} (1-\mathrm{g}).\left.\dfrac{\partial \boldsymbol{p}}{\partial \tau_E}\right|_{\boldsymbol{P}} = l.\dfrac{\partial w}{\partial \boldsymbol{z}}.\dfrac{\partial \boldsymbol{z}}{\partial \tau_E} - \dfrac{E.l}{L.(1-z_0)} - \dfrac{\tau_{E0}.E.l}{L.(1-z_0)^2}.\dfrac{\partial \boldsymbol{z}}{\partial \tau_E} \\ \\ (1-\mathrm{g}).\dfrac{L}{l}.\left[(1-z_0).\left.\dfrac{\partial \boldsymbol{p}}{\partial \tau_E}\right|_{\boldsymbol{D}} - p_0.\dfrac{\partial \boldsymbol{z}}{\partial \tau_E}\right] = L.\left[(1-z_0).\dfrac{\partial w}{\partial \boldsymbol{z}}.\left.\dfrac{\partial \boldsymbol{z}}{\partial \tau_E}\right|_{\boldsymbol{D}} - w_0.\left.\dfrac{\partial \boldsymbol{z}}{\partial \tau_E}\right|_{\boldsymbol{D}}\right] - E + X_0.\left.\dfrac{\partial \boldsymbol{p}}{\partial \tau_E}\right|_{\boldsymbol{D}} + p_0.\dfrac{\partial X}{\partial \boldsymbol{p}}.\left.\dfrac{\partial \boldsymbol{p}}{\partial \tau_E}\right|_{\boldsymbol{D}} \end{cases}$$

Where $\Big|_{\boldsymbol{P}}$ and $\Big|_{\boldsymbol{D}}$ stand for the partial derivatives of unknowns ***p*** and ***z*** along the price and activity curves.

Using the expression of elasticities (equations 8 and 9) and observing that, at the initial equilibrium, we have:

$$(1-g).\frac{L.(1-z)}{l} = (1-g).Y = C+X$$

we get the following matrix:

$$\begin{bmatrix} 1 & \Psi \\ -\Phi & \Gamma \end{bmatrix} . \begin{bmatrix} \dfrac{\partial \boldsymbol{p}}{\partial \tau_E} \\ \dfrac{\partial \boldsymbol{z}}{\partial \tau_E} \end{bmatrix} = \begin{bmatrix} -\Omega \\ E \end{bmatrix} \tag{14}$$

where : $$\Psi = \frac{1}{C_0+X_0}.\left(\frac{\tau_{E0}.E}{1-z_0} + w_0.L.\frac{1-z_0}{z_0}.\varepsilon_w\right)$$

$$\Omega = \frac{E}{C_0 + X_0}$$

$$\Phi = C_0 + X_0.\varepsilon_X$$

$$\Gamma = p_0.\frac{C_0 + X_0}{1 - z_0} - w_0.L.\left(1 + \frac{1 - z_0}{z_0}.\varepsilon_w\right)$$

And inverting the matrix, we get:

$$\begin{bmatrix} \frac{\partial \boldsymbol{p}}{\partial \tau_E} \\ \frac{\partial \boldsymbol{z}}{\partial \tau_E} \end{bmatrix} = \frac{1}{\Delta}.\begin{bmatrix} \Gamma & -\Psi \\ \Phi & 1 \end{bmatrix}.\begin{bmatrix} -\Omega \\ E \end{bmatrix}$$

With the determinant: $\Delta = \Gamma + \Psi.\Phi$

Thus, the marginal impacts of the reform on production price and unemployment are given by:

$$\frac{\partial \boldsymbol{p}}{\partial \tau_E} = -\frac{\Gamma.\Omega + \Psi.E}{\Delta} \qquad (15)$$

$$\frac{\partial \boldsymbol{z}}{\partial \tau_E} = \frac{E - \Omega.\Phi}{\Delta} \qquad (16)$$

Looking at the expression 16, we see that the net impact of the reform on unemployment (and activity) is ambiguous. It depends on 1) the assumptions on the response of wages and trade (ε_X, ε_W), and on 2) some characteristics of the initial state.

4 Net impact on employment: A sensitivity to two controversial parameters

For which values of our two uncertain parameters of the functioning of the economy (ε_X, ε_W) it is likely to get a net employment gain or a net employment loss? To answer this question, we shall study the sign of expression 16:

$$\frac{\partial \boldsymbol{z}}{\partial \tau_E} = \frac{E}{\left(\frac{\tau_{E0}.E}{1-z_0} + w_0.L.\frac{1-z_0}{z_0}.\varepsilon_w\right)}.\frac{1-\boldsymbol{u}(\varepsilon_X)}{\boldsymbol{u}(\varepsilon_X)-\boldsymbol{v}(\varepsilon_w)}$$

with: $$\boldsymbol{u}(\varepsilon_x) = \frac{C_0 + X_0.\varepsilon_X}{C_0 + X_0}$$

and $$\boldsymbol{v}(\varepsilon_w) = -\frac{p_0.\frac{C_0+X_0}{1-z_0} - w_0.L.\left(1+\frac{1-z_0}{z_0}.\varepsilon_w\right)}{\frac{\tau_{E0}.E}{1-z_0} + w_0.L.\frac{1-z_0}{z_0}.\varepsilon_w}$$

We get a net employment loss if and only if:

$$\frac{\partial \boldsymbol{z}}{\partial \tau_E} > 0 \leftrightarrow \left| \begin{array}{l} \boldsymbol{v}(\varepsilon_w) < \boldsymbol{u}(\varepsilon_x) < 1 \\ \boldsymbol{or} \\ 1 < \boldsymbol{u}(\varepsilon_x) < \boldsymbol{v}(\varepsilon_w) \end{array} \right. \qquad \text{because:} \qquad \frac{\tau_{E0}.E}{1-z_0} + w_0.L.\frac{1-z_0}{z_0}.\varepsilon_w > 0$$

Restricting our analyses to the cases where ε_W is positive (negative correlation between net wage and employment), this condition is in fact equivalent to:

$$\boldsymbol{v}(\varepsilon_w) < \boldsymbol{u}(\varepsilon_x) < 1 \qquad \text{because:} \qquad \forall\, \varepsilon_w \in \boldsymbol{R}^+,\ \boldsymbol{v}(\varepsilon_w) < 1$$

Indeed, for positive values of ε_W, $\boldsymbol{v}(\varepsilon_W)$ is an increasing monotone function, bounded by 1:

$$\boldsymbol{v}(\varepsilon_w) \xrightarrow[\varepsilon_w \to \overline{\varepsilon_w}^+]{} -\infty \qquad \text{and} \qquad \boldsymbol{v}(\varepsilon_w) \xrightarrow[\varepsilon_w \to +\infty]{} \frac{w_0.L.\frac{1-z_0}{z_0}.\varepsilon_w}{w_0.L.\frac{1-z_0}{z_0}.\varepsilon_w} = 1$$

The analysis is further restricted to the cases where $\varepsilon_w \succ \overline{\varepsilon_w}$ because the value $\overline{\varepsilon_w}$ for which the denominator of $\boldsymbol{v}(\varepsilon_W)$ is zero is always negative:

$$\overline{\varepsilon_w} = -\frac{\tau_{E0}.E}{w_0.L.(1-z_0)}.\frac{z_0}{1-z_0} < 0$$

And $\boldsymbol{v}(\varepsilon_w) \xrightarrow[\varepsilon_w \to \overline{\varepsilon_w}^+]{} -\infty$ because the numerator of $\boldsymbol{v}(\overline{\varepsilon_w})$ is negative as well.

Indeed: $$w_0.L.\left(1+\frac{1-z_0}{z_0}.\overline{\varepsilon_w}\right) - p_0.\frac{C_0+X_0}{1-z_0} = w_0.L - \frac{1}{1-z_0}\left[\tau_{E0}.E + p_0 C_0 + p_0 X_0\right]$$

And, at the initial state, the identities of the balance of payments and household budget (equations 3 and 10) give:

$$p_0.C + p_0.X = \left[w_0.L.(1\text{-}z_0) - p_E^*E - \tau_E.E \right] + \left[p_E^*.e.Y_0 + p_E^*E \right] \tag{17}$$

After combining those expressions and simplifying, we get a new expression and the sign of the numerator of $\boldsymbol{v}(\varepsilon_w)$: $\quad -\dfrac{p_E^*.e.Y_0}{1\text{-}z_0} < 0$

Graphic representation of the net impact on employment on the (ε_w ***,*** ε_x ***) plane***

For any given initial state of the economy, the previous condition may be used to display the sensitivity of the net macroeconomic impact to the two uncertain parameters that govern the functioning of our stylized economy. This condition is equivalent to:

$$\frac{\partial \boldsymbol{z}}{\partial \tau_E} > 0 \;\leftrightarrow\; \boldsymbol{h}(\varepsilon_w) < \varepsilon_x < 1 \qquad \text{with} \qquad \boldsymbol{h}(\varepsilon_w) = \boldsymbol{u}^{-1} \circ \boldsymbol{v}(\varepsilon_w) = -\frac{C_0}{X_0} + \left(\frac{C_0}{X_0} + 1 \right).\boldsymbol{v}(\varepsilon_w)$$

Indeed: $\quad \forall\, \boldsymbol{x} \in \boldsymbol{R}^+,\; \boldsymbol{u}^{-1}(\boldsymbol{x}) = -\dfrac{C_0}{X_0} + \left(\dfrac{C_0}{X_0} + 1 \right).\boldsymbol{x} \quad$ and $\quad \boldsymbol{u}^{-1}(1) = 1$

Therefore, to view this condition on the (ε_X, ε_W) plane, we draw the function ***h*** *(ε_W)*.

$$\boldsymbol{h}(\varepsilon_{\boldsymbol{w}}) \xrightarrow[\varepsilon_w \to \overline{\varepsilon_w}^+]{} -\infty \quad \text{and} \quad \boldsymbol{v}(\varepsilon_{\boldsymbol{w}}) \xrightarrow[\varepsilon_{\boldsymbol{w}} \to +\infty]{} -\frac{C_0}{X_0} + \left(\frac{C_0}{X_0} + 1 \right). \lim_{\varepsilon_{\boldsymbol{w}} \to +\infty} \boldsymbol{v}(\varepsilon_{\boldsymbol{w}}) = 1$$

With $\quad \overline{\varepsilon_w} = -\dfrac{\tau_{E0}.E}{w_0.L.(1-z_0)}.\dfrac{z_0}{1-z_0}$

And $\quad \overline{\varepsilon_X} = \boldsymbol{h}(0) = -\dfrac{C_0}{X_0} + \left(\dfrac{C_0}{X_0} + 1 \right).\left[1 - \dfrac{p_E^*.e.Y_0}{\tau_{E0}.E} \right]$

Indeed, using once again the identities of the balance of payments and household budget (equation 17), we have: $\boldsymbol{v}(0) = \dfrac{w_0.L.(1-z_0) + p_0C_0 + p_0X_0}{\tau_{E0}.E} = 1 - \dfrac{p_E^*.e.Y_0}{\tau_{E0}.E}$

Diagram I displays the three different domains we get on the (ε_X, ε_W) plane.

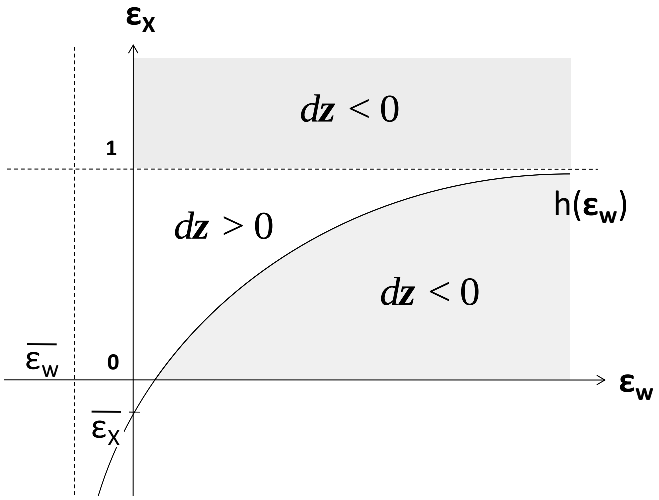

Diagram I **Net impact on unemployment of the marginal reform**
Sensitivity to hypotheses on wage and trade elasticities (ε_X, ε_W)

We now summarise the result. At the neighbourhood of any known initial state, the evaluation of the net impact of our marginal reform on employment is sensitive to the combination of assumptions made about the responses of net wages and external trade. More precisely, we get the following cases:

Case 1: **a net employment gain if $\varepsilon_X > 1$**. The reform increase activity and employment if net exports vary by more than 1% in response of a variation of 1% in domestic costs and price. This result is insensitive to the assumption made about the response of wages (ε_W).

Case 2: **a net employment loss if $h(\varepsilon_W) < \varepsilon_X < 1$**. The reform decrease activity and employment if net exports vary by less than 1% when domestic costs and production price decrease by 1%, but in addition if net exports are sufficiently sensitive to price. The extent to which exports have to be "sensitive" depends now on the assumption made about wage. The reform actually reduces employment if wage response is rather low; the interdependence between wage and trade responses being given by the shape of function ***h***.

Case 3: **a net employment gain if $\varepsilon_X < h(\varepsilon_W)$**. The reform increases activity and employment for rather low sensitivity of net exports to production price when the sensitivity of net wage is sufficiently high. The shape of function, on which will shall have later a closer look, determine the limit between this case (employment gain) and the previous one (loss).

5 General equilibrium mechanisms

We clarify the underlying mechanisms by looking now at the signs of the other derivatives. Given the previous examination, this task may be limited to the analysis of the production price variation. This variable is central in our system. Net exports evolve in the opposite direction. Wages and production evolve in the opposite of unemployment. It is less trivial to get the variation of consumption. We shall deduce it later from the price variation.

Combining expressions 15 and 16, we can get the sign of price variation the sign of unemployment variation:

$$\frac{\dfrac{\partial \boldsymbol{p}}{\partial \tau_E}}{\dfrac{\partial \boldsymbol{z}}{\partial \tau_E}} = -\frac{\Gamma.\Omega + \Psi.E}{E - \Omega.\Phi}$$

Which is equivalent to:

$$\frac{\dfrac{\partial \boldsymbol{p}}{\partial \tau_E}}{\dfrac{\partial \boldsymbol{z}}{\partial \tau_E}} = -\frac{1}{1-z}.\frac{p_E.e.Y_0}{X_0.(1-\varepsilon_X)}$$

Therefore, we get to cases:

- **if $\boldsymbol{\varepsilon_X} > 1$**, the production price evolves in the same direction as the unemployment rate: when the price decrease, activity increase, and *vice versa*;

- **if $0 < \boldsymbol{\varepsilon_X} < 1$**, the two variables evolve in the opposite direction: when the price decrease, activity and employment decrease, and *vice versa*.

Looking now at consumption, it is easy to get the sign of variation with a quite acceptable empirical restriction on our problem. We start from the balance of payments and the supply-use balance in the product market:

$$\boldsymbol{p}.\boldsymbol{X}(\boldsymbol{p}) = p_E^*.(e.\boldsymbol{Y} + E) \qquad \text{and} \qquad \boldsymbol{Y} = \frac{\boldsymbol{C} + \boldsymbol{X}(\boldsymbol{p})}{(1-g)}$$

Thus $$\boldsymbol{p}.\boldsymbol{X}(\boldsymbol{p}) = p_E^*.\left(\frac{e}{(1-g)}\left(\boldsymbol{C}+\boldsymbol{X}(\boldsymbol{p})\right)+E\right)$$

Total differentiation of this expression gives:

$$\frac{\partial \boldsymbol{p}}{\partial \tau_E}.X \ - \ X.\varepsilon_X.\frac{\partial \boldsymbol{p}}{\partial \tau_E} \ = \ \frac{p_E^* e}{(1-g)}\left(\frac{\partial \boldsymbol{C}}{\partial \tau_E} \ - \ \frac{X}{p}.\varepsilon_X.\frac{\partial \boldsymbol{p}}{\partial \tau_E}\right)$$ provided that: $$\frac{\partial \boldsymbol{X}}{\partial \boldsymbol{p}} = -\frac{X}{p}.\varepsilon_X$$

After combining and rearranging, we get:

$$\frac{\dfrac{\partial \boldsymbol{C}}{\partial \tau_E}}{\dfrac{\partial \boldsymbol{p}}{\partial \tau_E}} = \frac{X\left[1 + \left(\dfrac{p_E^* e}{p(1-g)} - 1\right)\varepsilon_X\right]}{\dfrac{p_E^* e}{(1-g)}}$$

Therefore, the signs of consumption and price variations are the same if and only if:

$1 + \left(\dfrac{p_E^* e}{p(1-g)} - 1\right)\varepsilon_X \ > \ 0$ because, indeed, $\dfrac{p_E^* e}{(1-g)}$ and X are positive numbers.

This is equivalent to the following condition: $1 \ > \ \varepsilon_X\left(1 - \dfrac{p_E^* e}{p(1-g)}\right)$

Taking ε_X as variable, different cases are mathematically possible depending on the value taken by $\dfrac{p_E^* e}{p(1-g)}$ at the initial state. Nevertheless, as announced, one may quite well restrict the analysis, without much loss of generality, to the economic cases where $\dfrac{\boldsymbol{s_E}}{(1-g)} \ = \ \dfrac{p_E^* e}{p(1-g)} \ < \ 1$. Indeed, otherwise, the analysis would concern economies characterised by *A)* a share s_E of net-of-tax energy costs in total production costs exceptionally high and/or *B)* a volume of public expenditure exceptionally high compared to the volume of private expenditures (*C* and *X*). To give an idea of the order of magnitude involved: in the case of France, we observe with 2004 data that pre-tax energy accounted for 0.4% of total costs on average, whereas public consumption and investment accounted for 15% of total production. Thus, in this case, the ratio being equal to 0.005 is far below unity. Therefore, for reasons of empirical likelihood, we assume that $\dfrac{\boldsymbol{s_E}}{(1-g)} \ = \ \dfrac{p_E^* e}{p(1-g)} \ < \ 1$.

With this restriction, the signs of the consumption and price variation are the same if and only if:

$\dfrac{1}{\left(1-\dfrac{p_E^* e}{p(1-g)}\right)} > \varepsilon_X$. This condition is always satisfied if $\varepsilon_X < 1$, because $\dfrac{p_E^* e}{p(1-g)} > 0$

Consequently, consumption varies in the same direction as price when $\varepsilon_X < 1$, and in the opposite direction when $\varepsilon_X > 1$.

Table 1 summarises the directions of change of all the variables of our model.

Domaines	**dz**	**dY**	**dw**	**dp**	**dC**	**dX**
$\varepsilon_X > 1$	-	+	+	-	+	+
$1 > \varepsilon_X > h(\varepsilon_w)$	+	-	-	-	-	+
$h(\varepsilon_w) > \varepsilon_X > 0$	-	+	+	+	+	-

Table 1 **Signs of variation of all variables in the three domains defined by the hypotheses about wage and trade sensitiveness.**

The general equilibrium mechanisms appear now more clearly.

Case 1: **a net activity and employment gain if $\boldsymbol{\varepsilon_X > 1}$**. For economies with high trade exposure, for which “price-competitiveness” is crucial, the marginal reform benefits all macroeconomic indicators (production, wages, domestic consumption and exports). The positive impact on production costs dominates the negative impact on domestic consumption. Consequently, the reform benefits external trade, and domestic agents more than compensate their higher energy bills by higher wage incomes and lower prices.

Case 2: **a net activity and employment loss if $\boldsymbol{h(\varepsilon_W) < \varepsilon_X < 1}$**. Economies with intermediary trade exposure, for which “price-competitiveness” is important, does not benefit from the marginal reform if the sensitivity of wage is “rather” low. The negative impact on domestic consumption dominates this time the positive impact on production costs. The reform benefits external trade, but this is not enough to compensate the higher energy bills of domestic agents. In this case, wage incomes do not maintain the purchasing power of households, and the drop in domestic demand exceeds the limited gain of trade.

Case 3: **a net activity and employment gain if $\varepsilon_X < h(\varepsilon_W)$**. Economies with an intermediate or low level of trade exposure and a certain level of wage autonomy benefit from the marginal reform. An increase in wage compensates the higher energy bills of domestic agents. The impact on consumption is positive, and this positive impact overcomes the negative impacts of higher wages on domestic costs and trade competitiveness.

6 Net impact on employment: A sensitivity to the state of the economy

What are the favourable and unfavourable conditions? We are now moving to an empirical discussion about the initial state of the economy. A simple way to undertake this problem is to look at the conditions for which the second domain (case 2 above) is narrowed. A narrow domain will limit the range of trade and wage elasticities (ε_X, ε_W) for which the marginal reform implies a loss of activity and employment. Of course, this analysis does not preclude practitioners from discussing the "true values" of these elasticities (those valid in the real world). And maybe, if the narrowed range includes the true elasticities the reform would actually cause a macroeconomic loss.

Having said this, we study the characteristics of the initial conditions for which the shape of function ***h*** is modified and the second domain is narrowed (see diagram II).

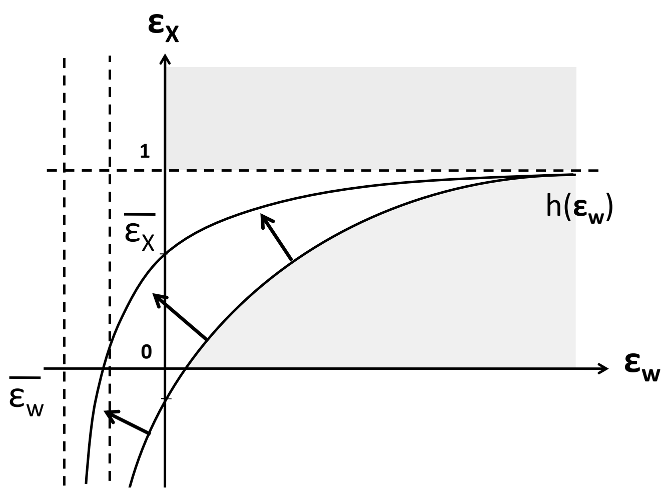

Diagram II Initial conditions for a narrow domain of macroeconomic loss

We see graphically that the second domain is narrowed when the value of $\overline{\varepsilon_X}$ is close to 1 and the negative value of $\overline{\varepsilon_w}$ is high. This is unequivocally the case for high values of μ_1 and μ_2 in the following expressions:

$$\overline{\varepsilon_w} = -\mu_1 . \frac{z_0}{1-z_0} \qquad (18)$$

$$\overline{\varepsilon_X} = -\frac{C_0}{X_0} + \left(\frac{C_0}{X_0} + 1\right) . \left[1 - \frac{1}{\mu_2}\right] \qquad (19)$$

with: $$\mu_1 = \frac{\tau_{E0}.E}{w_0.L.(1-z_0)}$$

$$\mu_2 = \frac{\tau_{E0}.E}{p_E^*.e.Y_0}$$

Those ratios μ_1 and μ_2 measure the magnitude of the tax transfer away from production costs and labour income. As seen above, given an economic behaviour (ε_X, ε_W), this tax reallocation effect and the sharing of its consequences between a gain of trade and a progression of wage determine the net impact of the reform on activity and employment.

This effect tends to be stronger when the following economic circumstances prevail:

- Households have an energy consumption important in absolute terms (E) and in relative terms as well compared to productive systems ($\frac{E}{e.Y_0}$)
- The level of unemployment is high (z_0);
- The level of wages is low (w_0);
- The import price of energy is low (p_E*)
- The relative taxation of energy compared to labour is high (τ_E)

Intuitively, the reallocation effect is stronger when the direction of tax reform is about taxing more final consumption than production costs. For an energy-dependent economy, this is the case when the energy consumption of households is high and the energy consumption of producers is low. Furthermore, the additional tax revenue raised on final energy consumption reduces even more productive costs (or increases wages) if labour costs (or labour incomes) are initially low (if unemployment is high and wage development low).

It is less straightforward to understand the role of the last two conditions: a low import price of energy and a high initial relative level of energy taxation. Looking back at the price and activity curves (equations 11 and 12)11 we can better understand the economic meaning of those conditions. We see them resulting from partial derivatives of the level of activity, expressing therefore two feedback consequences of any initial change in activity.

The role of the import price of energy $p_E{}^*$ results from the partial derivatives of unemployment $\boldsymbol{z}$ in the activity curve (Γ in matrix 14 with $\varepsilon_W = 0$). But the feedback mechanism involved appears more directly with the accounting identity of the balance of payments (equation 10). The production of an additional unit requires an additional quantity of energy that needs to be financed. A low import price limits this financial need and the additional energy cost (and thus the increase in production price). Therefore, with a low import price, the gain of activity resulting from the tax reallocation effect is less constrained.

The role of a high relative energy taxation τ_E results from the partial derivatives of unemployment $\boldsymbol{z}$ in the price curve (Ψ in matrix 14). The feedback mechanism involved here modifies the magnitude of the tax reallocation effect. It is easy to see this in the last term of the price curve (equation 11). A first increase in production reduces the amount of tax reduction available for all units produced. Therefore, the higher is the initial amount of tax raised on the energy consumption of households, the smaller is this "dilution" effect.

Nevertheless, those two general equilibrium mechanisms will be modified in a model with 1) trade balance deficit and/or current account deficit, and 2) flexibilities in energy consumptions. Applied models must take into account those realities both to evaluate the nets impacts at longer runs and actual imbalanced economies. Talking about longer periods of time, we finally have to underlying the fact that what matters more than the characteristics of the *initial* situation is the characteristics of the *future* situation (in a *no-reform*, or *business-as-usual*, scenario). In this respect, it is of utmost importance to convey a discussion about past and on-going trends, and to analyse how different expectations about the future may lead to different statements about the desirability of a tax reform.