Using revenue from an energy tax to finance social security: A dynamic general equilibrium model for Switzerland

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Abstract: A substantial increase in the dependency ratio due to both population aging and low economic growth will put pressure on social security systems. This paper investigates on an ecological tax reform that uses revenues from an energy tax to finance reductions in either the wage or the value added tax. The simulation results based on a dynamic general equilibrium model for Switzerland show that increasing energy prices by 50 or 100% will substantially lower energy use, while decreasing the efficiency of the fiscal system only slightly. Furthermore, it turns out that the effects do not differ when an increase in the VAT substitutes part of the social security payroll tax.

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1. Introduction

The sustainability of social security and the environment are two of the most important issues on the political agenda in Western industrialized countries. Social security reform is urgent since aging of the population and low economic growth question the long run feasibility of the current finance structure in social security systems. Increasing the payroll tax to finance future deficits has adverse intergenerational effects as social security already heavily burdens the young and future generations. Moreover, a rise in the payroll tax may increase labor cost of firms, and have negative effects on the international position of domestic industry. For these reasons, politicians look for alternative sources for financing social security such as VAT and environmental taxes.

The interests of future generations are also at stake with the current environmental policy. Sustainability of the environment is not achievable with the measures taken so far for the protection of the environment. Several international conferences, including the UN conference in Kyoto in 1997, demanded for substantial reduction in global greenhouse gas emission levels. Most industrialized countries have committed themselves to lower domestic emissions or to support emission reduction projects in developing countries. The Swiss government follows a policy that brings CO$_2$ emission levels down to 90% from current levels by the year 2010.

This paper analyses the consequences of a policy that tackles both the social security and the environmental problem. It estimates the welfare effect of an ecological tax reform that uses the revenue of an energy tax to finance a part of the future deficits in social security. This is done by using a dynamic general equilibrium model for Switzerland. The model includes 38 production sectors, a private household, social security and the government. The time span extends from 1995, the base year, to 2100, the final year. While firms are assumed to maximize profits in every period, the private household plans consumption and leisure demand over the entire time horizon. The model incorporates existing taxes, including social security taxes as well as the social security payments (exogenously set). The additional tax rate needed to finance social security is determined endogenously by the budget constraint.

We investigate three tax cases in which the government and social expenditures remain unchanged. The base case resembles the status quo, i.e. social security is financed by a payroll tax and government contributions. In the two sets of reform scenarios, revenues from a 50 and a 100 percent increase in energy prices, respectively, partly pay for the social security bill. The first reform uses the payroll tax to finance the remaining gap. The second reform scenario combines the energy price increase with the VAT, while holding the payroll tax at its current level. We then compare the two reform scenarios with the base case in terms of CO$_2$ emissions, GDP and overall welfare.

The paper is organized as follows. Section 2 presents the financing structure of social security in Switzerland and gives figures on the expected rise in the contributions rates due to the aging of the population. Section 3 sketches the model. Section 4 presents the scenarios for financing the future deficits in social security and discusses the scope for a double dividend in environmental policy. Section 5 reports on the simulation results of social security reform, and section 6 concludes.

2. The Swiss social security system and the demographic transition

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1 See IMF (1996) for an overview of generational accounts in the industrialized world, and Felder (1997) for Switzerland.
Social security covers a variety of risks which citizens are exposed to. Old age insurance makes up for the biggest share in Swiss social security. Its first tier (AHV) is financed by a pay-as-you-go system. In 1995, the employees’ contributions towards AHV amounts to 8.4% of their wages (see Table 1). The government pays 20% of the AHV bill and provides income from certain excise taxes (3.5% of wages in total). The first tier also includes disability benefits which amounts to 3.0% of labor income. The second tier of old age benefits, called the occupational old age benefit plan, is capital funded. The contribution rate on average is 5.2%.

Social security also includes accident (2.7%), unemployment (2.4%), and health insurance (5.9%). Family allowances (1.8%), social aid (2%) and several small social insurance lines finally sum up to 35.3% of wages. We separate the sectors into two categories: taxes and transfers. Contributions are handled as transfers if a particular insurance mainly functions according to the equivalence principle, i.e. the individual contribution equals the expected benefits. If that is not the case, i.e. the relationship between contributions and benefits is loose, a contribution is regarded as a tax. In 1995, the estimated tax rate on labor supply due to social security amounts to 16.1%.2

Table 1: The finance structure of the Swiss social security system*

<table>
<thead>
<tr>
<th>section</th>
<th>share of labor 1995</th>
<th>expected share 2025</th>
<th>tax 1995 / 2025</th>
<th>transfer 1995 / 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>old age insurance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pay as you go</td>
<td>8.4</td>
<td>12.3</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>funded</td>
<td>5.2</td>
<td>5.3</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>government subsidy</td>
<td>3.5</td>
<td>4.1</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>disability insurance</td>
<td>3.0</td>
<td>4.2</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>accident insurance</td>
<td>2.7</td>
<td>2.7</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>unemployment</td>
<td>2.4</td>
<td>1.6</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>health insurance</td>
<td>5.9</td>
<td>9.8</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>family allowances</td>
<td>1.8</td>
<td>1.7</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>social aid</td>
<td>2.0</td>
<td>2.7</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>miscellaneous</td>
<td>0.4</td>
<td>0.7</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>35.3</td>
<td>45.1</td>
<td>16.1 / 21.5</td>
<td>19.2 / 23.6</td>
</tr>
</tbody>
</table>

* Source: Ecoplan and Felder (1998)

The Swiss government expects social security contributions to increase substantially over the next 30 years, the rational being the double aging of the population, on the one hand, and low economic growth on the other. The crude birth rate is currently at 1.68, i.e. well below the sustainable rate. At the same time, life expectancy increases. Productivity growth is very low at present, and the government expects long run growth not to exceed 1%. All these factors will result in a large increase in the dependency ratio over the next 30 years, which in turn asks for a substantial increase in contributions to social security. Table 1 gives the expected

2 Drawing the line between distortionary and non-distortionary social security contributions is somewhat arbitrary. As the figures show, we move on middle grounds. It should be clear that the larger the tax share in social security contributions, the more important is the financing structure of social security.
contribution rate in 2025. It is expected to raise to 45.1% of labor income by 2025. The tax share of social security contributions will increase which is mainly due to the expansion of the first tier in the public pension scheme.

3. The model

The investigation on the consequences of partly financing social security by an energy tax is based on a dynamic large-scale general equilibrium model of the Swiss economy. The model includes 38 production sectors, a private household, government and social security. It is calibrated on the 1990 input-output-table of Switzerland, extended by aggregated data on the evolution of the capital stock, allowing for an estimation of the (steady-state) depreciation rate. The production and consumer sectors as incorporated in the model are described in short.

Private household

The decision problem of the household refers to the entire time horizon. The household maximizes a utility stream, extending from the base year 1990 \((t=1)\) to the terminal year 2100 \((t=T)\):

\[
U = \frac{1}{1 - \frac{1}{\gamma}} \sum_{t=1}^{T} (1 + r)^{-(t-1)} u_t^{1-1/\gamma},
\]

where \(u_t\) is utility in period \(t\), \(\gamma\) (set equal to 0.5) indicates the household’s willingness to substitute consumption over periods, and \(r\) is the steady state interest rate (2%). Periodic utility aggregates a consumption aggregate and leisure:

\[
u_t = \left[ e_t^{1-1/\rho} + \alpha l_t^{1-1/\rho} \right]^{1/(1-1/\rho)}
\]

\(\rho\) is the instantaneous elasticity of substitution between consumption and leisure. \(\alpha\) indicates the household’s preference for leisure as compared to consumption. \(\alpha\) and the wage elasticity of labor supply determine \(\rho\). We go with a wage elasticity of 0.1, and calculate a \(\rho\) equal to 1.65.

The household’s budget can be written as:

\[
\sum_{i=1}^{T} p^c t c_t (1 + r)^{-(t-1)} + \sum_{i=1}^{T} l_t p^l_t (1 + r)^{-(t-1)} + p^K_T (1 + r)^{-(T-1)} K_T^h
\]

\(= p^T_T K^h_T + \sum_{i=1}^{T} \left[ p^T_i (1 + n_t + m_t) \right]^{1 + \frac{\lambda}{1 + r}}
\]

where \(p^c_i\) denotes the consumer price index, the price of leisure and the price of capital, respectively, and \(K^h_i\) is the private capital stock. While the l.h.s of (3) sums up the expenditure, the r.h.s denotes aggregated endowments. The latter is the value of both the capital stock in the base year (1995) and the value of time endowment. The period length is set equal to one. We assumed labor augmenting technical progress at rate \(\lambda\) (=0.5%) which also applies to the new labor force entering at period \(t\) through population growth \((n_t)\) and net-immigration \((m_t)\).

\(\text{Note that the bulk of the demographic burden will occur later, around 2035, when the baby boomers reach retirement age.}\)
Expenditures consist of consumption and leisure demand and the value of the capital stock at the final period (2100). The capital stock in the final period fulfills a transversality condition for a steady state with a 1% overall growth, a 4% depreciation and a 2% interest rate.

The household’s consumption bundle incorporates 37 commodities, which are aggregated according to a logarithmic CES-function (Cobb-Douglas). The consumption and leisure decisions together with the initial and terminal capital stock determine savings in each period and the evolution of the capital stock. Formally, savings in period $t$ can be described as:

$$s_t = w_t \left[ 1 + n_t + m_t - l_t \right] + m^K_t K_t^h - c_t.$$  

The period savings determine gross investments. The capital stock in period $t$ finally equals the capital stock in period $t-1$ minus depreciation plus gross investments.

**The government and social security**

Government and social security are subject to an intertemporal budget constraint. For simplicity, we assume that the present value of accounts in the final year (2100), corrected for growth, equals the value in 1995 (at present, the government runs a deficit, while social security has a substantial surplus). The expenditure of the government increase with the overall growth rate, hence the government share of GDP remains constant. The government finances its budget by an income tax, a VAT, excise taxes and tariffs. The marginal income tax rate equals 20%\(^4\), while the VAT is at 6.3%. The expenses of social security are exogenous. While their growth exceeds by far the overall growth rate in the first 50 years, it converges in the second half of the century to the long run economic growth rate of 1%.

**Producers**

The submodel of producer behavior is disaggregated into 38 industrial sectors. Each sector produces one single commodity, except for the petroleum refining sector which produces a joint product of oil derivatives including crude oil, light and heavy fuel-oil, gasoline, diesel and kerosene. This level of industrial detail allows us to trace the effects of changes in tax policy on relatively narrow segments of the economy.

Producers are assumed to maximize periodic profits subject to the production technology represented by a nested CES function (for details, see Felder and van Nieuwkoop, 1996). The efficiency parameters of the technology as well as the share parameters of input costs are calibrated using the 1990 input-output table for Switzerland, which includes interindustry flows and value added inputs in the 38 sectors.

**Foreign trade**

In modeling foreign trade, we follow the well known Armington approach by assuming that imports are imperfect substitutes for similar domestic commodities. Each commodity is assigned an elasticity of substitution between domestic and imported products. With respect to exports, we proceed in an analogous way: Exports and domestic supply are a joint product, the

\(^4\) The overall marginal income tax rates is the sum of the income tax and the social security contribution rate. With the current contribution rate of 18.3% the overall marginal tax rate is 38.3%. Note, however, that the actual rate in the simulations will be higher as the calculated contribution rate covers social security expenses over the entire time horizon.
elasticity of transformation indicating the degree of substitution imperfectness between the two commodities. Switzerland runs a permanent trade surplus which is traded off with capital exports. Moreover, there are social security transfers, for instance, to foreigners who are retired and live abroad. All activities over the frontier are captured by a single currency market, the price on which indicates the terms of trade.

4. Financing the future social security deficit by an ecological tax reform

As we have seen in section 2, the current contribution rate of roughly 15% will not allow to finance future expenses of social security, because the demographic transition will increase the social security payments. A federal commission has estimated future expenses of social security (Social Security Office, 1997). We take these estimates as exogenous. The simulation model then determines the contribution rate via the social security budget constraint. We consider three cases. The base case mimics the status quo, i.e. besides the government subsidies, social security is exclusively financed by a wage tax. The reform scenarios keep the contribution rate at its current level and impose an energy tax, a 50% and 100% increase in the energy prices, respectively. The revenue from the energy tax are used to finance social security expenses. The remaining gap is closed by either an increase in the wage tax (the payroll case) or in the value added tax (the VAT case).

This simulation exercise basically performs an ecological tax reform. At the center of current debate on ecological tax reform is the double-dividend hypothesis. The double-dividend hypothesis claims that using tax revenues to finance cuts in existing distortionary taxes produces an efficiency gain in the fiscal system (Terkla, 1984). It is uncontroversial that the so-called weak form of the double dividend holds. The weak form states that by using revenues from the environmental tax to lower existing taxes rather than to finance lump-sum transfers to households, one achieves efficiency gains (Goulder, 1995).

The conditions for the strong form of the double-dividend hypothesis are stronger and more controversial. The strong form claims that the cost of the environmental tax is lower than the efficiency gains of an equal revenue change of the distortionary tax. The theoretical as well as the empirical literature cast doubt on the validity of the double-dividend hypothesis. A crucial finding which dates back to Diamond and Mirrlees (1971) and which has been recently reiterated by Bovenberg and de Mooij (1994) is that environmental taxes aggravate rather than alleviate the distortion of existing taxes. The intuition behind this result is that the tax base narrows as taxation is shifted from the broader based labor income tax to selective environmental taxes. This shift reduces the tax base by inducing households to substitute “cleaner” commodities, and if the government wishes to keep revenues unchanged, it will therefore be unable to cut labor taxes so much as to fully compensate workers for the erosion of their after-tax real wages stemming from higher environmental taxes.

Bovenberg and van der Ploeg (1994) and Bovenberg and de Mooij (1996) point to cases where the double-dividend claim holds. For instance, environmental tax reforms always prove to be welfare-enhancing when the environmental tax is efficient from a purely fiscal point of view (abstracting from the consequences for the environment). In this case, the introduction of an environmental tax raises environmental quality, while reducing the inefficiency of the existing tax system.
5. Results

5.1 Base case

Table 2 reports on the characteristics of the base case, in which social security is financed by a wage tax and no energy tax applies. Since the absolute values for the variables are not as important, we concentrate on relative figures (indices). Over the first 15 years, GDP is raised by 19%. This is due to technological change, on the one hand, and to a change in labor endowment (low birth rate, a decrease in immigration) and in labor supply, on the other. Energy demand is very closely linked with the evolution of GDP.

In later periods, labor supply decreases below the 1995 level. This is partly due to an increase in real wages, which leads the representative household to work less and enjoy more leisure time. In the period 2025-2040, we observe a lower increase in total energy use, as compared to GDP growth. The tax rate needed to finance the financial gap in social security amounts to 11.2% of labor income.

Table 2: The evolution of aggregate figures in the base line

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP</th>
<th>Employment</th>
<th>Energy (GJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2010</td>
<td>119</td>
<td>105</td>
<td>119</td>
</tr>
<tr>
<td>2025</td>
<td>135</td>
<td>97</td>
<td>136</td>
</tr>
<tr>
<td>2040</td>
<td>158</td>
<td>93</td>
<td>149</td>
</tr>
</tbody>
</table>

The base case resembling the status quo finance structure of social security provides us with a benchmark against which the equilibrium paths under alternative tax rules can be compared with. We will first look at the welfare effects, before turning to the consequences of an ecological tax reform for GDP, employment and the environment.

5.2 The welfare effects of an ecological tax reform

The additional revenues needed to finance the status quo benefits of the social security system are too big to be exclusively financed by an increase in the energy prices. The necessary additional payroll tax rate with a 50% increase in energy prices is 10.0% (see Table 3). It means that the energy tax saves an 1.1% increase in the wage tax. The welfare effects of the reforms are as expected, i.e. the efficiency of the tax system decreases with the ecological tax reform. This result is in line with several other numerical studies on the double-dividend issue. Bovenberg and Goulder (1996), in an intertemporal general equilibrium model of the US-economy, conclude that an equal-yield environmental tax reform results in a decrease in welfare.\(^5\)

\(^5\) An exception is Felder and van Nieuwkoop (1996) who simulate an ecological tax reform in a model that differentiate between marginal and average labor tax rates. Reducing marginal income tax rates while adjusting the average tax rates produces a welfare gain.
Table 3: Additional tax rates, and the equivalent variation of an ecological tax reform

<table>
<thead>
<tr>
<th>50% increase in energy prices</th>
<th>100% increase in energy prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payroll</td>
<td>VAT</td>
</tr>
<tr>
<td>Additional Tax Rate</td>
<td>10.0%</td>
</tr>
<tr>
<td>Welfare</td>
<td>-0.35%</td>
</tr>
</tbody>
</table>

Interestingly enough the welfare effects do not differ between a payroll and a value added tax. This however comes at no surprise, since in a dynamic setting, abstracting from the saving issue, consumption and labor taxes in many respects.

5.3 The effects on GDP, Employment and Total Energy Use

GDP and employment is only slightly affected when a 50% increase in energy prices substitutes an increase in the wage tax (see Table 4). In particular, social security taxes do not harm labor supply as compared to VAT. Although net wages are lower with social security contributions, they are (partly) offset by lower consumer prices. According to our simulation results an increase in energy prices would have a substantial effect on energy demand. A 50% increase in energy prices decreases energy demand by 25%. This is a large reaction in view of the fact that the efficiency of energy employing technology is not assumed to change.

Table 4: The evolution of aggregate figures with a 50% increase in energy prices as compared with the base case

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP</th>
<th>Employment</th>
<th>Energy (GJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Payroll</td>
<td>VAT</td>
<td>Payroll</td>
</tr>
<tr>
<td>2010</td>
<td>118 (-1.2%)</td>
<td>110 (-7.3%)</td>
<td>105 (0.0%)</td>
</tr>
<tr>
<td>2025</td>
<td>134 (-1.1%)</td>
<td>126 (-7.0%)</td>
<td>97 (0.2%)</td>
</tr>
<tr>
<td>2040</td>
<td>157 (-0.9%)</td>
<td>147 (-6.8%)</td>
<td>93 (0.0%)</td>
</tr>
</tbody>
</table>

We do observe a difference in GDP between the payroll and the VAT (around 6%). The difference is not caused by labor supply. Rather the size of the capital stock differs between the two tax scenarios. With a VAT the capital stock is lower, which in turn leads to a lower GDP.

Table 4 presents the simulation results for a 100% increase in energy prices. The consequences for GDP and employment are comparable with the effect of a 50% increase. The effect on energy demand, however, are much stronger: the decrease in energy use is as high as 40%. The energy tax thus would induce a very substantial reduction in energy demand.

Table 5: The evolution of aggregate figures with a 100% increase in energy prices as compared with the base case

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP</th>
<th>Employment</th>
<th>Energy (GJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Payroll</td>
<td>VAT</td>
<td>Payroll</td>
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<td>2010</td>
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<td>2040</td>
<td>157 (-0.9%)</td>
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<td>93 (0.0%)</td>
</tr>
</tbody>
</table>
6. Conclusion

In this paper, a large scale dynamic general equilibrium model is employed to examine the scope for combining social security reform and environmental policy. The simulation results indicate that energy taxes have a substantial effect on energy demand. A 50 and 100% increase in energy prices results in a reduction of energy use of 25% and 40%, respectively. The welfare effects of the social security reform confirms the finding from the literature on the double dividend. An ecological tax reform compounds rather than alleviates the excess burden of taxation. The welfare effects, however, are relatively small, in the range of 0.3 to 0.7%.

The simulation results further indicate no significant difference in the welfare effects between a wage and a value added tax. In particular, the wage tax does not harm employment; a result which contradicts the position of many experts. The equivalence between a wage and a consumption based tax for employment, however, is strongly supported by both theoretical and numerical studies (OECD, 1994).

There is one issue not dealt with in the present paper, yet potentially important. The modeling of the energy sector may deserve more attention. The assumed substitution elasticities in the energy sector are rather high. The implied price-elasticities of supply and demand for these reason may be upwardly biased. However, we did not assume an exogenous increase in the efficiency of energy use as it is often done in energy studies.

References


IMF (1996), World Economic Outlook, Focus on Fiscal Policy, May.


