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Fiscal Externalities and Optimal Taxation in an Economic Community

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1. Introduction

The Stability and Growth Pact is a continuing source of economic controversy within Europe. The pact is aimed at enforcing fiscal discipline on the member states of Europe, with the twin objectives of (1) maintaining the conditions for sustainable real growth in output and employment; and (2) providing the foundations for price stability. The pact recognizes that individual member states experience divergent business cycle conditions which may lead them to run deficits at certain points in time. However, the pact is designed to encourage member states to adopt fiscal policies which imply zero deficits on average and to limit their deficits to *3 percent of GDP* at any point in time.

The Stability and Growth Pact (SGP) involves two key ideas. First, it is based on the view that the fiscal policies of one member state are important to the other member states. Second, it is based on the view that the fiscal policy of the member states—particularly the national indebtedness—is important for the monetary policy of the European Central Bank and the behavior of the price level.

Our objective in this paper is to explore the first of these ideas in the context of a small and entirely real dynamic general equilibrium model of a multi-country economic union. We think that this is a logical starting point for two reasons. First, we believe that there are underlying real forces operating within economies that are highly important for the fiscal policies of member states. Therefore, it is important to understand the effects of these forces both on the individual member state and on the other members of the economic community. Second, modern models that give a central bank leverage over real economic activity frequently do so effectively by allowing the central bank to affect distortions arising from imperfect competition. These distortions have an alternative interpretation as tax rates, so that the consequences of alternative monetary policies and the design of optimal monetary policies are closely related to fiscal policy issues. Thus, monetary policy can frequently be given a fiscal policy interpretation. Further, desirable monetary policies depend heavily on the nature of fiscal policy.[1]

The model that we construct is parsimonious, designed to permit sharp focus on two key issues. First, we study the nature of fiscal externalities within an economic community such as the EU which lacks explicit rules for fiscal policy coordination. Second, to the extent that these externalities exist, we ask whether public sector deficits are a useful indicator of the extent of these fiscal externalities, as seems to have been believed by policymakers who framed the fiscal policy rules codified in the SGP. Our model abstracts from investment and capital formation and assumes that individual governments can commit to following dynamically optimal fiscal policies. Further, government expenditure is taken to be exogenous as is traditional in standard models of optimal taxation and optimal monetary policy.

There are two key observations about current fiscal policy in the EMU that we build into our model. First, all countries in the EMU employ national sales taxes (VAT) as well as income taxes, but there is considerable heterogeneity in terms of the relative use of these taxes. Second, in all countries, government expenditure contains four major components—purchases of goods and services; public employment; investment in government capital; and transfer payments. However, there is considerable heterogeneity across countries in the relative importance of these components.

The SGP is cast in terms of government deficits. However, our model highlights the international transmission of fiscal policy between countries not via the government deficit, but via the country's net exports, which we define as

$$x_{jt} \equiv y_{jt} - g^{c}_{jt} - c_{jt} \tag{1}$$

where y_{jt} is private output of country j at date t; c_{jt} is the amount of private consumption by country j at date t; and g^{c}_{jt} is the amount of government consumption in country j at date t. A higher level of net exports by an individual country in a given period has effects on other members of the economic community. If, for example, a country plans to run a surplus in net exports in a future period, that will have the effect of reducing the interest rate applicable to that period, with the strength of this effect depending on the relative size of the country running the surplus. The government surplus in our model is

$$s_{jt} = \tau^n_{jt} w_{jt} n_{jt} + \tau^c_{jt} c_{jt} - w_{jt} g^n_{jt} - g^c_{jt} \tag{2}$$

where w_{jt} is the wage rate; g^n_{jt} is government labor input, n_{jt} is total labor input; τ^n_{jt} is the tax on labor income; and τ^c_{jt} is the consumption tax. There are well-known economic mechanisms that make the trade deficit and the government deficit tend to move together. For example, holding other variables fixed, a rise in government consumption will increase both the fiscal deficit and the trade deficit. Through the trade channel, an individual country's fiscal policy can have effects on other countries which are transmitted via prices (here, the only price is the intertemporal price, i.e., the interest rate). However, the comovement of the fiscal and trade deficits clearly depends on the tax system, i.e., on the tax rates τ^n_{jt} and τ^c_{jt}. To learn about the character of "fiscal externalities" of national policies, we determine the behavior of optimal tax rates within several alternative settings. Our model also incorporates exogenous, time-varying levels of productivity, government purchases, and government labor input.

Our results can be briefly summarized as follows. For a small country within our basic model, which knows that its policies have no effect on community-wide interest rates, it is optimal to set tax rates constant over time. However, the model is silent on whether the necessary tax is applied to labor income, consumption, or both. Although the real equilibrium is invariant to the choice between τ^n and τ^c, the behavior of the public sector deficit obviously is not. Deficits can be highly variable if they involve mainly labor taxation, but relatively smooth if they involve mainly consumption taxation. Trade deficits, on the contrary, are invariant to the structure of taxation. Countries wishing to satisfy the SGP and avoid volatility in government deficits may wish to use the tax instrument that leads to smooth tax revenues. A closed economy will also choose to maintain a measure of tax rates constant over time, just as in the small open economy.

The character of the solution changes when we consider a community of several countries, each of which is "large" in the sense that it can affect community-wide prices via its fiscal policies. In this setting, which we propose as a model of the EMU, each country faces an intertemporal constraint on its net exports of the form:

$$\sum_{t=0}^{\infty} \beta^t \delta_t [y_{jt} - g^c_{jt} - c_{jt}] \geq 0 \tag{3}$$

where $\beta^t\delta_t$ is a discount factor applicable to date t. For a large open economy within an economic community, the effect of this constraint is quite different from the comparable effect for a single (closed) country or a small open economy. The government of a closed country knows that its fiscal policies affect the discount factors $\{\beta^t\delta_t\}_{t=0}^{\infty}$. However, in this closed economy, macroeconomic equilibrium requires that $[y_t - g_t^c - c_t] = 0$ so that the constraint is always satisfied in equilibrium and has no bearing on tax policy. By contrast, the government of a small country takes $\{\beta^t\delta_t\}_{t=0}^{\infty}$ as given and concentrates on the effects of its policies on net exports, $[y_{jt} - g_{jt}^c - c_{jt}]$, so as to assure that the constraint is satisfied. With an intermediate size country, tax policy takes into account effects on both intertemporal prices and net exports.

In community of "large" economies, a distinction emerges between coordinated and uncoordinated national policies. A coordinated community policy emphasizes the requirement that at each date

$$\sum_{j=1}^{J}\theta_j[y_{jt} - g_{jt}^c - c_{jt}] = 0 \tag{4}$$

where θ_j is the relative size of country j. Essentially, equation (4) specifies that effects of tax policies on intertemporal prices do not create wealth at the community level. In Nash equilibrium, by contrast, governments have an incentive to choose tax rates that are high when the economy would otherwise run positive net exports, so as to make the "net wealth" on the left-hand side of (3), by reducing the world intertemporal price. That is, governments would tend to choose labor income tax policies that would stabilize their net exports relative to the constant-tax-rate-case. Lack of coordination in fiscal policy thus tends to stabilize net exports, relative to the coordinated fiscal policy regime.

2. Fiscal Policy in the European Monetary Union

This section presents information on the key fiscal policy variables in the European Monetary Union (EMU). For comparison, we will also include evidence for (1) countries that are part of the European Union (EU) but not in the EMU, and (2) countries that are not in the EU.

2.1 *A Current Snapshot*

This sub-section describes the current situation in the EMU. Table 1 presents information on government expenditure, receipts, and the

Table 1
EMU fiscal policy in 2004

A. Government Expenditure: % of GDP

Country	(i) Government non-wage consumption	(ii) Government wage consumption	(iii) Government investment	(iv) Government total current disbursements
Austria	8.9%	18.8%	1.0%	50.6%%
Belgium	10.3%	22.1%	1.5%	50.0%
Finland	8.3%	22.1%	2.7%	52.1%
France	10.5%	24.3%	2.9%	55.5%
Germany	11.3%	19.0%	1.5%	48.8%
Greece	3.2%	N/A	N/A	N/A
Ireland	6.8%	15.3%	4.9%	34.1%
Italy	7.8%	18.6%	2.5%	46.5%
Netherlands	13.9%	24.4%	3.3%	49.2%
Portugal	5.6%	20.5%	3.4%	46.3%
Spain	7.3%	17.8%	3.3%	39.5%
Median value	8.3%	19.7%	2.8%	49.0%

B. Government Receipts: % of GDP

Country	(i) Total direct taxes	(ii) Total indirect taxes	(iii) Total receipts	(iv) Government surplus
Austria	13.8%	14.6%	50.7%	1.5%
Belgium	17.4%	12.8%	49.7%	5.1%
Finland	18.9%	12.9%	52.8%	2.9%
France	11.8%	15.2%	50.9%	–0.1%
Germany	10.8%	12.2%	45.5%	–0.2%
Greece	N/A	14.2%	44.7%	4.3%
Ireland	11.1%	12.5%	33.3%	–1.1%
Italy	13.3%	14.5%	43.9%	1.5%
Netherlands	10.6%	12.8%	45.0%	0.3%
Portugal	9.5%	15.1%	42.7%	0.3%
Spain	10.5%	11.3%	39.6%	2.2%
Median value	11.4%	12.9%	45.0%	1.5%

Table 1 *(continued)*
EMU fiscal policy in 2004

C. Employment: % of Working-age Population		
Country	(i) Government employment	(ii) Business sector employment
Austria	9.3%	63.5%
Belgium	11.1%	50.0%
Finland	16.7%	50.4%
France	14.8%	48.8%
Germany	7.5%	61.9%
Greece	7.3%	50.3%
Ireland	7.7%	58.8%
Italy	8.9%	54.2%
Netherlands	7.1%	52.5%
Portugal	12.7%	59.7%
Spain	9.2%	50.1%
Median value	9.2%	52.5%

sectoral structure of employment. Panel A contains details of some specific categories of government expenditures as a percentage of GDP. The median share of government total current disbursements (column (iv)) is 49 percent of GDP, ranging from a low of 34.1 percent (Ireland) to a high of 55.5 percent (France). Columns (i)–(iii) show government expenditures in three main categories: (1) non-wage consumption; (2) wage consumption; and (3) investment. (The remaining components of government disbursements are largely transfers, especially social security transfers.) Of the groups that we present, government wage consumption is substantially larger than either non-wage consumption or investment. Typically, wage consumption is about twice as large as non-wage consumption, and is an order of magnitude larger than government investment. In light of these facts, we develop a model with an important role for government wage consumption, i.e., government hiring of labor.

Panel B contains information on government receipts. Direct taxes and indirect taxes are about equally important in the EMU, each comprising about 12 percent of GDP. The difference between direct+indirect taxes and total receipts is again due largely to social security contributions by employers, employees, and the self-employed.

Column (iv) of Panel B shows the government primary surplus for 2005. According to these official OECD figures, only three EMU countries had deficits in 2004: France, Germany, and Ireland. The official figures show these deficits much smaller than those that would violate the SGP.

Panel C of Table 1 shows a breakdown of employment between the government sector and the business sector (this table does not include the self-employed), expressed as a fraction of the working-age population. Government employment is about one-sixth of the employment of the business sector, with some variation across countries.

Table 2 provides more detailed information on aspects of taxation in the EMU. For comparison, we also provide information for several non-EMU members of the EU. The first three columns of the table show the top marginal personal income tax rates for employees, with and without social security contributions. For comparison, column 3 lists the statutory income tax rate that would apply at the threshold for the highest tax bracket. When the effect of social security contributions is taken into effect, the median of the top marginal personal income tax rate is higher than the median of the statutory income tax rate. For some countries, the difference can be very large. For example, in Germany the statutory tax rate is 47.5 percent for an individual with the highest marginal tax rate (this corresponds to the actual tax rate, barring social security), but when social security is taken into account, the marginal tax rate is 13 percent higher than the statutory rate. Large discrepancies are also observed for Belgium, Greece, Ireland, Italy, Luxembourg, and Portugal. Only for France and Austria is the actual marginal tax rate (including social security) lower than the statutory rate. The non-EMU countries listed in the bottom panel of the table contain one very low-tax economy (the Slovak Republic), as well as two of the highest-tax-rate countries in Europe: Denmark and Sweden. The discrepancy between the statutory tax rate and the true marginal rate including social security is very large for Hungary in particular, where the statutory rate is 38 percent and the true rate is 69.5 percent. The corresponding rates for non-EU countries are listed at the bottom of the table. The median rates are in line with the EMU countries. The notable difference is that, among the non-EU countries, there is little difference between the true rates and the statutory rates.

In contrast to the high variation among countries in marginal personal income tax rates, there is little cross-country variation in the VAT. The median value is 19.3 percent. The highest VAT rate is in Finland (22 percent), while Luxembourg and Germany have relatively low VAT

Table 2
Taxation in the EMU and the EU (OECD members)

Country	Top Marginal Personal Income Tax Rates for Employees (2004): Combined central plus sub-central rates	Including Social Security contributions	Statutory income tax rate (2004) τ^n	VAT standard rate (2003) (%) τ^c	Corporate income tax (2005): Combined central plus sub-central rates	"Extent of taxation" $\frac{1-\tau^n}{1+\tau^c}$
Austria	42.9%	42.9%	50.0%	20.0	25.0	0.42
Belgium	45.1%	59.3%	53.5%	21.0	34.0	0.38
Finland	50.3%	56.7%	52.1%	22.0	26.0	0.39
France	37.0%	47.2%	55.7%	19.6	35.0	0.37
Germany	47.5%	60.5%	47.5%	16.0	38.9	0.45
Greece	33.6%	49.6%	40.0%	18.0	N/A	0.51
Ireland	42.0%	48.0%	42.0%	21.0	12.5	0.48
Italy	41.4%	51.6%	46.1%	20.0	33.0	0.45
Luxembourg	33.9%	47.8%	38.9%	15.0	30.4	0.53
Netherlands	52.0%	52.0%	52.0%	19.0	31.5	0.40
Portugal	35.6%	46.6%	40.0%	19.0	27.5	0.50
Spain	45.0%	45.0%	45.0%	16.0	35.0	0.47
Median	42.4%	48.8%	46.8%	19.3	31.5	0.45

EU, non-EMU						
Czech Republic	28.0%	40.5%	32.0%	22.0	26.0	0.56
Denmark	54.9%	62.9%	59.7%	25.0	30.0	0.32
Hungary	56.0%	69.5%	38.0%	25.0	16.0	0.50
Poland	26.2%	51.6%	40.0%	22.0	n.a.	0.49
Slovak Republic	8.4%	21.8%	19.0%	20.0	19.0	0.68
Sweden	56.5%	56.5%	56.5%	25.0	28.0	0.35
United Kingdom	40.0%	41.0%	40.0%	17.5	30.0	0.51
Median	41.5%	54.1%	39.0%	23.5	26.0	0.49
Non-EU						
Australia	48.5%	48.5%	48.5%	10.0	30.0	0.47
Canada	46.4%	46.4%	46.4%	7.0	36.1	0.50
Iceland	42.0%	42.0%	43.6%	24.5	18.0	0.45
Japan	47.1%	47.8%	50.0%	5.0	n.a.	0.48
Korea	36.6%	39.2%	39.6%	10.0	27.5	0.55
Mexico	26.6%	28.9%	33.0%	15.0	30.0	0.58
United States	41.4%	42.9%	41.6%	n/a	39.3	n/a
Median	42.0%	42.9%	43.6%	10.0	30.0	0.51

rates at 15 percent and 16 percent, respectively. As a group, the non-EMU countries have higher VAT rates than the EMU countries. Notably, Denmark, Hungary, and Sweden have VAT rates of 25 percent—higher than any of the EMU countries. The non-EU countries rely much less heavily on the VAT, with the exception of Iceland.

The next-to-last column of Table 2 contains data on the corporate income tax rates. There is wide variation across countries in this tax rate, although the median in each group of countries is about 30 percent. Each group of countries has some members with low corporate taxes. In the EMU, Ireland has the lowest corporate tax rate, of only 12.5 percent. Hungary has the lowest rate (16 percent) of the non-EMU members of the EU, and Iceland (18 percent) has the lowest corporate tax rate in the non-EU group.

Finally, the last column of Table 2 contains a measure of what is commonly called the "wedge"

$$\frac{1-\tau_{jt}^{n}}{1+\tau_{jt}^{c}} \tag{5}$$

since it indicates the combined effect of labor and consumption taxation on the relative price of leisure and consumption. To compute this measure, we have used the statutory highest marginal personal income tax rate as our measure of τ^n and have used the VAT tax rate as our measure of τ^c. Given its prominence in public discussions of fiscal policy in Europe, we examine the behavior of the "wedge" under optimal fiscal policy in our analysis below.

2.2 *A Longer View*

This sub-section presents some evidence on the evolution of the key fiscal variables over the past 45 years. Figure 1 shows total government receipts and disbursements, expressed as shares of GDP. For most of the EMU countries, the government share of GDP has exhibited a rising trend since the early part of the sample. Ireland shows the opposite trend. Although government expenditure and receipts has been rising in Ireland, GDP has been rising faster still. Figure 2 shows the government "primary balance" as a share of GDP. Figure 3 graphs employment by the government and by the business sector as a fraction of the working age population. The self-employed are not included in the business-sector total. Employment in the government sector has been a gently rising fraction of the working-age population, and is smoother

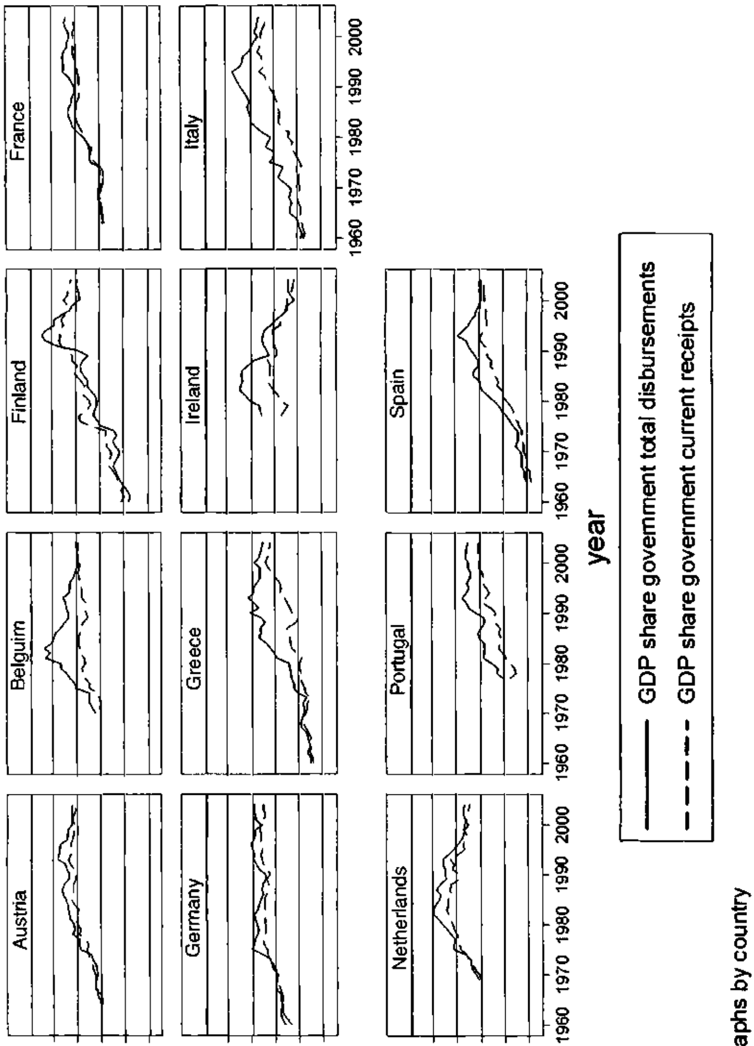

Figure 1
Government receipts and disbursements

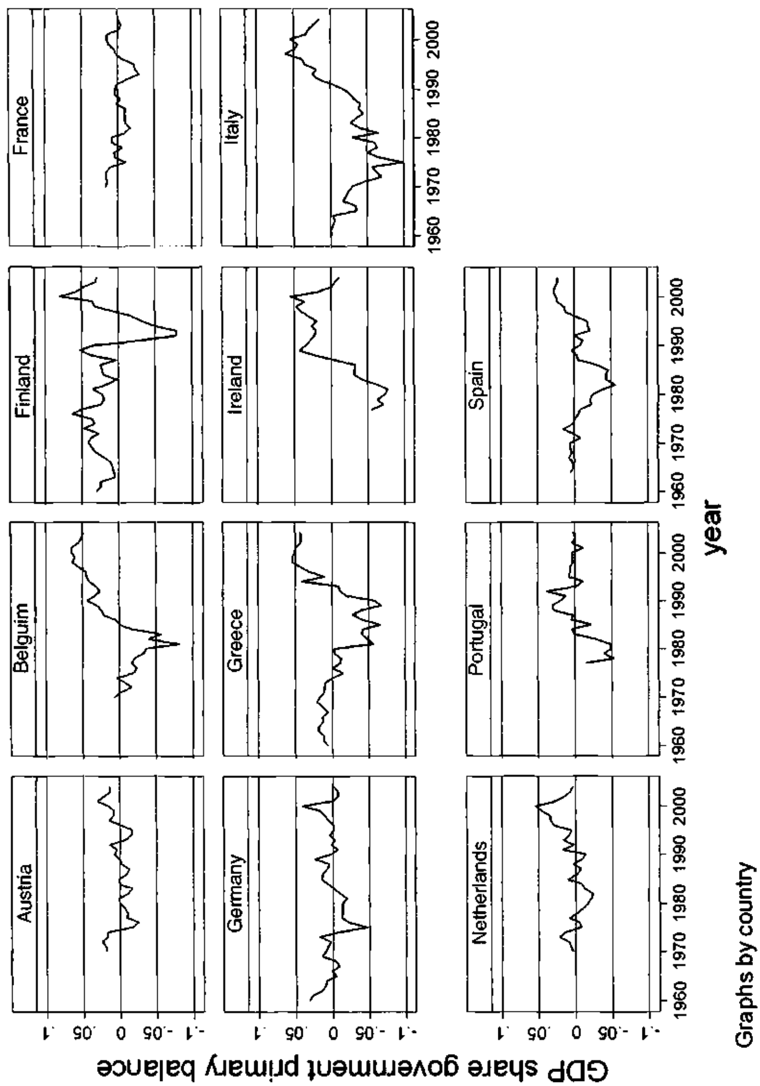

Figure 2
Government surplus (primary balance)

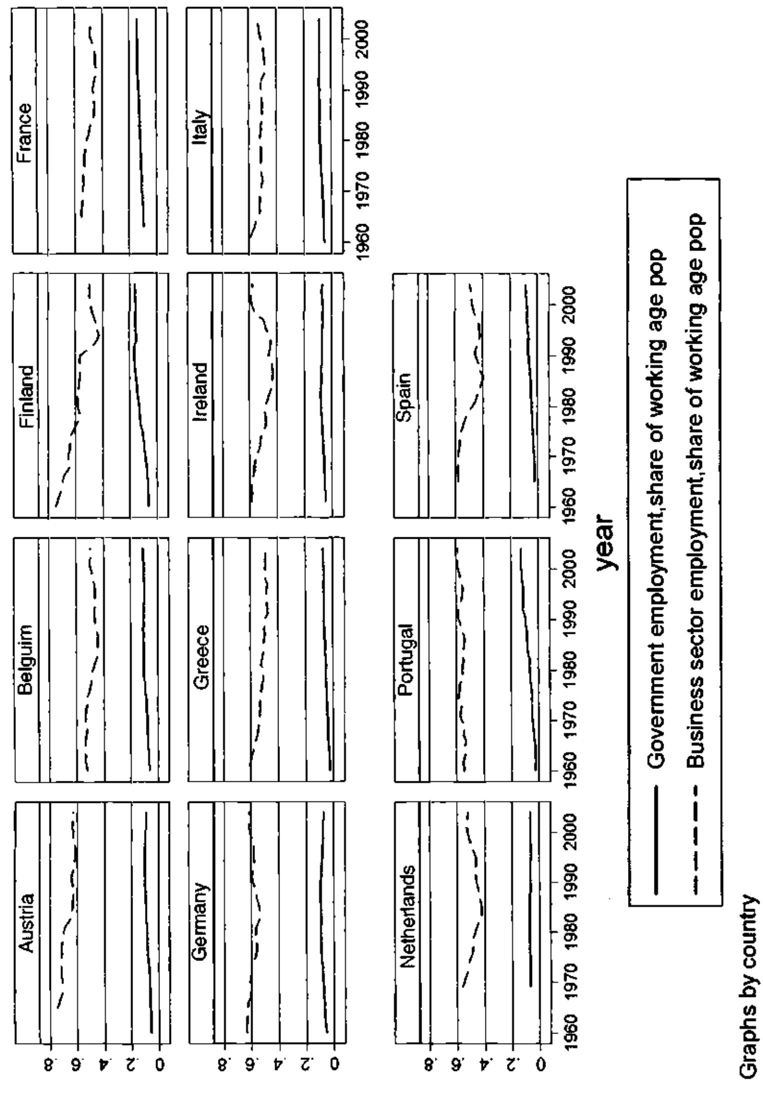

Figure 3
Employment

than employment in the business sector. Figure 4 plots the government primary balance (the government surplus) against net exports. It may seem odd to graph these two variables together. However, our theoretical model highlights the relationship (actually, the potential lack thereof) between these two economic variables and we will refer back to this figure later on. Table 3 presents summary volatility and correlation statistics for the fiscal and trade deficits. The volatility measure is the standard deviation of annual growth rates. In most countries, the trade deficit is somewhat more volatile than the fiscal deficit. There is no clear pattern at all to the correlation between the fiscal deficit and the trade deficit: the correlations range from –0.32 (Spain) to 0.83 (Ireland). Our theory illustrates why, in an optimal tax setting, there need be no strong relationship between the trade and fiscal deficits.

Finally, Figure 5 plots three components of government expenditure, each measured as a fraction of GDP: (1) non-wage consumption (purchases of goods and services); (2) final wage consumption (purchases of labor), and (3) government fixed capital formation (investment). Government transfers are not included. Government wage expenditure is the largest of the three components of government expenditure, and shows a flat to slightly rising trend over the past 40 years. Government purchases of goods and services is one-half to two-thirds as large as government expenditure on labor, and exhibits a similar flat-to-slightly-rising trend over this period. Government investment represents the smallest GDP share of the three components, and has been falling as a fraction of GDP in several countries.

3. A Model of an Economic Community

We will study a community with J countries which are indexed by $j = 1, 2, \ldots J$. There will be several elements which distinguish a country. First, each country will have a unified labor market, with no labor mobility across countries. Second, countries will be subject to country-specific shocks to productivity and government purchases. Countries may differ in terms of size. We use θ_j to denote country j's fraction of community population, thus $\theta_j > 0$ and $\Sigma_{j=1}^{J} \theta_j = 1$.

3.1 *Structure of Basic Model*

In order to keep the analysis as simple as possible, all countries produce the same internationally traded final good, which can be used for public and private consumption.

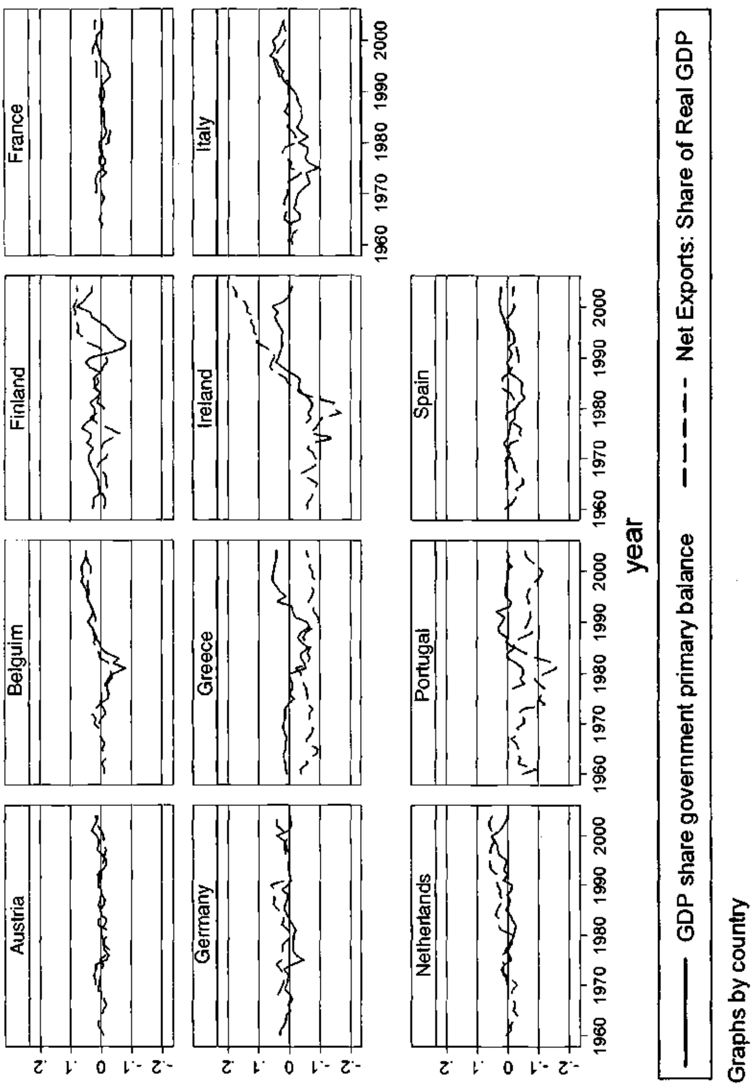

Figure 4
Government surplus and net exports

Table 3
Relationship between net exports and the fiscal deficit

Country	Volatility of Growth Rate: % Per Year		Correlation: net exports and fiscal deficit
	Net exports	Fiscal deficit	
Austria	1.1%	1.4%	0.25
Belgium	2.3%	3.9%	0.87
Finland	4.0%	3.2%	–0.09
France	1.4%	1.2%	0.00
Germany	1.7%	1.5%	0.13
Greece	1.6%	3.4%	–0.14
Ireland	10.2%	4.2%	0.83
Italy	1.9%	3.9%	0.55
Netherlands	2.9%	1.8%	0.46
Portugal	3.5%	2.3%	0.50
Spain	1.8%	2.1%	–0.32
Median value	1.9%	2.3%	0.25

3.1.1 Production

We will assume that countries produce the single good according to constant-returns-to-scale production functions which depend only on labor input and have time-varying productivity levels. Private output is therefore of the form:

$$y_{jt} = a_{jt}(n_{jt} - g^{n}_{jt})$$

where a_{jt} is labor productivity. As above, y_{jt} is output in country j at time t, n_{jt} is total labor input, and g^{n}_{jt} is government use of labor input.

3.1.2 Labor Markets

We assume that there is a competitive labor market in each country. Competition ensures that the real wage—measured in units of the consumption good—in country j is given by

$$w_{jt} = a_{jt}$$

so we use these two symbols interchangeably below.

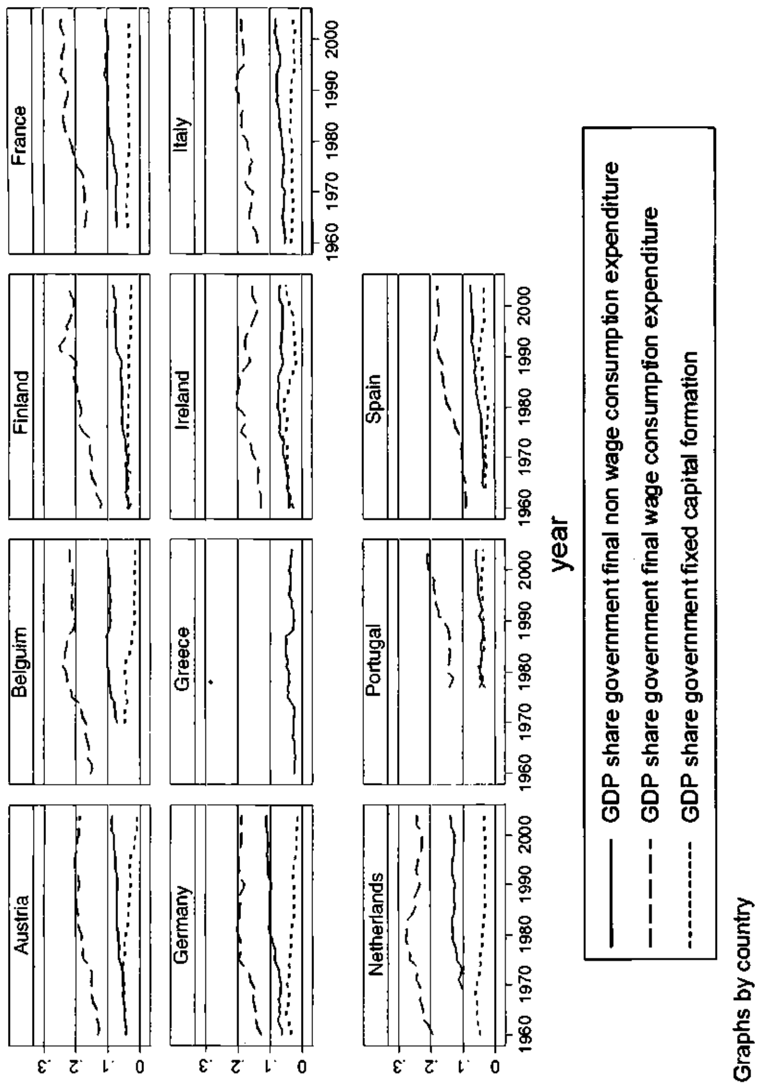

Figure 5
Components of government expenditure

3.1.3 Government

We assume that each country's government faces an exogenous requirement for two types of purchases: (1) purchases of labor for its own use, and (2) purchases of the consumption good. At date t, let g^c_{jt} be the amount of purchases of goods and g^n_{jt} be country j purchases of labor. Let τ^n_{jt} be the period t labor income tax rate in country j and let τ^c_{jt} be the consumption tax rate.

3.2 *Dynamic Elements*

We assume that there is a single, community-wide market in which all public and private financial instruments are traded. We assume that this market establishes a discount factor, $\beta^t\delta_t$, which is the price of a unit of the consumption good at t (β and δ_t will be discussed further below).

3.2.1 Private and Public Intertemporal Budget Constraints

Private saving per capita in country j is

$$(1-\tau^n_{jt})w_{jt}n_{jt}-(1+\tau^c_{jt})c_{jt} \qquad (6)$$

where c_{jt} is the amount of country j's private consumption demand for the aggregate good. The representative household's budget constraint is therefore

$$0\leq\sum_{t=0}^{\infty}\beta^t\delta_t[(1-\tau^n_{jt})w_{jt}n_{jt}-(1+\tau^c_{jt})c_{jt}]. \qquad (7)$$

The country j government's primary surplus at date t is

$$s_{jt}=\tau^n_{jt}w_{jt}n_{jt}+\tau^c_{jt}c_{jt}-w_{jt}g^n_{jt}-g^c_{jt} \qquad (8)$$

and the government's intertemporal budget constraint is

$$0\leq\sum_{t=0}^{\infty}\beta^t\delta_t s_{jt}. \qquad (9)$$

These imply a country-wide constraint (3), as discussed in the introduction:

$$0\leq\sum_{t=0}^{\infty}\beta^t\delta_t[w_{jt}n_{jt}-g^c_{jt}-w_{jt}g^n_{jt}-c_{jt}]=\sum_{t=0}^{\infty}\beta^t\delta_t[y_{jt}-g^c_{jt}-c_{jt}]$$

which is the requirement that the discounted value of a country's net exports is zero.

3.2.2 Intertemporal Consumption and Labor Supply Choices

Agents in country j maximize

$$U_j = \sum_{t=0}^{\infty} \beta^t u(c_{jt}, n_{jt})$$

subject to the household budget constraint. We assume that the momentary utility function takes the form

$$u(c,n) = \frac{1}{1-\sigma} c^{1-\sigma} - \frac{\chi}{1+\gamma} n^{1+\gamma}. \tag{10}$$

Intertemporally efficient consumption and labor supply plans require that

$$0 = u_c(c_{jt}, n_{jt}) - \Lambda_j \delta_t (1+\tau^c_{jt}) \tag{11}$$

$$0 = u_n(c_{jt}, n_{jt}) + \Lambda_j \delta_t (1-\tau^n_{jt}) w_{jt} \tag{12}$$

where Λ_j is a country-specific Lagrange multiplier which assures that the household's budget constraint is satisfied. Generally, these conditions define a set of Frischian behavioral equations for consumption and labor, which are each functions of $\Lambda_j \delta_t (1 + \tau^c_{jt})$ and $\Lambda_j \delta_t (1 - \tau^n_{jt}) w_{jt}$. With the specified momentary utility function, we have a simpler, constant elasticity form of consumption demand,

$$c_{jt} = [\Lambda_j \delta_t (1+\tau^c_{jt})]^{-\frac{1}{\sigma}}.$$

Labor supply also takes on a constant elasticity form,

$$n_{jt} = [\Lambda_j * (1-\tau^n_{jt}) w_{jt} \delta_t / \chi]^{\frac{1}{\gamma}}.$$

These rules imply that individuals substitute away from consumption and leisure when the intertemporal relative price, δ_t, is high. Individuals also substitute toward work in periods in which the after-tax wage rate is high.

The multiplier Λ_j has a number of properties of importance to us below. We illustrate the first of these by noting that, with the specified preferences, the multiplier which satisfies the household's budget constraint is

$$\Lambda_j = \left[\chi^{\frac{1}{\gamma}} \frac{\sum_{t=0}^{\infty} \beta^t [\delta_t (1+\tau^c_{jt})]^{1-\frac{1}{\sigma}}}{\sum_{t=0}^{\infty} \beta^t [\delta_t (1-\tau^n_{jt}) w_{jt}]^{1+\frac{1}{\gamma}}} \right]^{\frac{\sigma\gamma}{\sigma+\gamma}}.$$

Hence, if all of the intertemporal prices are scaled up so that $\delta'_t = \phi\delta_t$, then the multiplier is scaled by $1/\phi$. This is just a consequence of the fact that real demands for goods and leisure are invariant to units in which prices are stated.

3.3 *Community General Equilibrium*

Our assumption is that the community is closed, which we think of as a workable approximation to the idea that the community is a large part of the world, as is Europe. We find it useful to think about the equilibrium in two steps. First, given aggregate demand and interest rates, the market for each country's goods and factors must clear. Second, aggregate demand and interest rates must be consistent with the overall equilibrium conditions of the community.

Community per-capita consumption demand is

$$C_t = \sum_{j=1}^{J} \theta_{jt} c_{jt}$$

and total government consumption is

$$G_t^c = \sum_{j=1}^{J} \theta_{jt} g_{jt}^c .$$

Aggregate world supply of the good, in per capita terms, is given by the weighted sum of all countries' outputs:

$$\sum_{j=1}^{J} \theta_{jt} y_{jt} .$$

Equating the aggregate supply and demand for goods implies an equilibrium sequence $\{\delta_t\}_{t=0}^{\infty}$.

Our interest is in studying settings in which each government must obey its budget constraint: there are no intergovernmental transfers. We explore two alternative assumptions about interactions across governments: (1) the community's governments cooperate to as to maximize the joint welfare of their citizens with the setting of their tax instruments; and (2) each government maximizes the welfare of its citizens, taking the policies of other governments as given. Before turning to this analysis, we discuss optimal taxation in simpler settings.

4. Background on Optimal Taxation

To establish some core ideas and benchmark results, this section studies three basic settings. First, following Ramsey, we consider a closed economy, as addressed in most analyses of fiscal policy. Second, we consider a small open economy, paralleling the Ramsey analysis of the closed economy. Third, we consider an alternative approach to the analysis of the small open economy, which is easier to extend to the analysis of interacting economies. In all of the settings that we study, an important element is the equilibrium form of the government budget constraint.

4.1 The Government Budget Constraint in Equilibrium

To study a formulation of the government's problem that does not involve taxes or market prices, we start by noting that the government budget constraint can be rewritten as

$$\begin{aligned} 0 &\leq \sum_{t=0}^{\infty} \beta^t \delta_t [-(1-\tau_{jt}^n) w_{jt} n_{jt} + (1+\tau_{jt}^c) c_{jt} - w_{jt} n_{jt} - g_{jt}^c - c_{jt} - w_{jt} g_{jt}^n] \\ &= \sum_{t=0}^{\infty} \beta^t \delta_t [-(1-\tau_{jt}^n) w_{jt} n_{jt} + (1+\tau_{jt}^c) c_{jt} + y_{jt} - g_{jt}^c - c_{jt}] \\ &= \sum_{t=0}^{\infty} \beta^t \delta_t [-(1-\tau_{jt}^n) w_{jt} n_{jt} + (1+\tau_{jt}^c) c_{jt}] \end{aligned} \tag{13}$$

where the first line simply involves adding and subtracting consumption and labor income; the second makes use of the equilibrium wage rate and the production function; and the third imposes the requirement that $\Sigma_{t=0}^{\infty} \beta^t \delta_t [y_{jt} - g_{jt} - c_{jt}] = 0$.

Multiplying by Λ_j and imposing the private sector first-order conditions, we arrive at the requirement that

$$\sum_{t=0}^{\infty} \beta^t [u_c(c_{jt}, n_{jt}) c_{jt} + u_n(c_{jt}, n_{jt}) n_t] \geq 0. \tag{14}$$

That is: the government budget constraint in equilibrium is the requirement that the private sector must be able to afford to purchase the quantities that the government chooses for it, when the prices are stated in marginal utility units.

Since this expression will appear repeatedly below, it is convenient for us to have a short-hand version of it. Defining $q(c_t, n_t) = [u_c(c_t, n_t)c_t + u_n(c_t, n_t)n_t]$, we can thus write the equilibrium government budget constraint as

$$\sum_{t=0}^{\infty} \beta^t [q(c_{jt}, n_{jt})] \geq 0 \tag{15}$$

for country j.

4.2 *Neutral Tax Changes*

A standard result in public finance is that consumption taxes and labor income taxes are equivalent instruments when switches between these involve no change in government revenue. In intertemporal frameworks, such as those which we study in this paper, this equivalence arises when tax changes are considered which take the form

$$(1+\tau_t^c)' = \varsigma(1+\tau_t^c)$$

$$(1-\tau_t^n)' = \varsigma(1-\tau_t^n)$$

for all dates t. In view of the government budget constraint in equilibrium (15), it is clear that this policy is *revenue* neutral for any positive ς. Further, the government budget constraint in equilibrium implies the private sector budget constraint: both are essentially $\Sigma_{t=0}^{\infty}\beta^t\delta_t[-(1 - \tau_{jt}^n)w_{jt}n_{jt} + (1+\tau_{jt}^c)c_{jt}] = 0$. In view of the first order conditions, this policy is *behaviorally* neutral when the multiplier adjusts according to

$$\Lambda' = \frac{\Lambda}{\varsigma}$$

which in turn is consistent with the original budget constraint. So, such a switch in tax policy is neutral on all accounts.

Hence, for exploration of behavior—including the analysis of optimal policy—a country's fiscal policy is better summarized by an effective consumption wedge and an effective labor wedge,

$$\xi_{jt}^c = \Lambda_j(1+\tau_{jt}^c)$$

$$\xi_{jt}^n = \Lambda_j(1-\tau_{jt}^n)$$

than by the statutory tax rates themselves.

4.3 *Single Country Benchmark*

Our model is structured so that it would be optimal to have constant tax rates over time if there were a single country. To display this result and provide the background for some aspects of our analysis of an economic community, we start by supposing that there is a single country (the country subscript, j, will not appear). In this setting, the appropriate Ramsey tax problem is to maximize

$$U = \sum_{t=0}^{\infty} \beta^t u(c_t, n_t)$$

subject to the sequence of resource constraints

$$y_t = a_t(n_t - g^n_t) = c_t + g^c_t$$

the government budget constraint

$$0 \leq \sum_{t=0}^{\infty} \beta^t \delta_t [\tau^n_t w_t n_t + \tau^c_t c_t - g^c_t - w_t g^n_t]$$

and the private sector first order conditions ((11) and (12) above), which take the form

$$0 = u_c(c_t, n_t) - \Lambda(1 + \tau^c_t)\delta_t$$

$$0 = u_n(c_t, n_t) + \Lambda(1 - \tau^n_t) w_t \delta_t$$

for the closed economy.

There are a series of conceptual and technical issues about this closed economy problem that bear on our analysis below. First, a crucial component of the closed-economy Ramsey problem is that the government understands that it can have effects on prices—specifically the intertemporal prices δ_t—and takes this effect on its own budget constraint into account. Second, the closed-economy Ramsey problem is most often analyzed in its "primal" form, with optimal (second-best) quantities derived and their implications for taxes and market prices then deduced.

Accordingly, the constrained optimization problem has a Lagrangian of the form

$$L = \sum_{t=0}^{\infty} \beta^t u(c_t, n_t) + \Phi \left\{ \sum_{t=0}^{\infty} \beta^t [q(c_t, n_t)] \right\} + \sum_{t=0}^{\infty} \beta^t \lambda_t [a_t n_t - c_t - g^c_t - a_t g^n_t]$$

where the multiplier Φ has the interpretation as the cost of satisfying the equilibrium government budget constraint (15) and the multiplier λ_t has the conventional interpretation as the shadow value of goods at t. The Ramsey planner's first order conditions are

$$u_c(c_t, n_t) + \Phi q_c(c_t, n_t) - \lambda_t = 0 \qquad (16)$$

$$u_n(c_t, n_t) + \Phi q_n(c_t, n_t) + \lambda_t a_t = 0$$

$$a_t n_t - c_t - g^c_t - a_t g^n_t = 0$$

at each date t. As Lucas and Stokey (1983) observe, these efficiency conditions look like those for a standard representative agent optimization problem, except that the preferences of the agent are modified from

$u(c_t, n_t)$ to $u(c_t, n_t) + \Phi q(c_t, n_t)$. In general, then, the second-best quantities can be determined by solving an optimization problem which includes the requirements that: consumption and work decisions satisfy the first-order conditions; the resource constraint and the equilibrium version of the government budget constraint.

We assume that the first order conditions are sufficient, as well as necessary, to determine optimal sequences of quantities, $\{c_t^*\}_{t=0}^{\infty}$ and $\{n_t^*\}_{t=0}^{\infty}$. The standard concavity assumptions on utility do not guarantee that this will be automatically satisfied in this "second best" setting, but we proceed under this assumption as in most other work in the optimal taxation literature.

4.3.1 Supporting Prices and Tax Rates

In order for optimal quantities to arise in competitive equilibrium, taxes and prices must satisfy

$$w_t = a_t \tag{17}$$

$$(1+\tau_t^c)\delta_t \propto u_c(c_t^*, n_t^*)$$

$$(1-\tau_t^n)a_t\delta_t \propto u_n(c_t^*, n_t^*).$$

These conditions highlight the following facts about supporting prices and tax rates. First, as in every real general equilibrium model, the prices δ_t are determined only up to a scale factor. Second, in terms of bringing about the optimal allocation, there are two alternative modes of taxation that are essentially perfect substitutes. Notice that the argument here is much stronger than the one discussed in section 4.2: the theory is silent on the composition of consumption and labor taxation at each date, simply specifying that a measure of the "wedge" is determined by

$$\frac{1-\tau_t^n}{1+\tau_t^c} = -\frac{1}{w_t}\frac{u_n(c_t^*, n_t^*)}{u_c(c_t^*, n_t^*)}.$$

Hence, the entire time path of consumption taxation may be viewed as arbitrary, with market discount prices responding to bring about a particular "full price" of consumption $(1 + \tau_t^c)\delta_t$.

4.3.2 Implications for Tax Rates

With our specified preferences, even though we cannot solve explicitly for optimal quantities, it is direct to show that (a) there is one sense in which the burden of tax rates must be constant over time; and (b) there is a wide range of policies for τ^c and τ^n that are potentially optimal.

The planner sets

$$-\frac{u_n(c_t^*,n_t^*)+\Phi q_n(c_t^*,n_t^*)}{u_c(c_t^*,n_t^*)+\Phi q_c(c_t^*,n_t^*)}=a_t,$$

while private agents set

$$-\frac{u_n(c_t^*,n_t^*)}{u_c(c_t^*,n_t^*)}=\frac{1-\tau_t^n}{1+\tau_t^c}a_t.$$

The ratio of these conditions implies that

$$\frac{1-\tau_t^n}{1+\tau_t^c}=\frac{u_c(c_t^*,n_t^*)+\Phi q_c(c_t^*,n_t^*)}{u_n(c_t^*,n_t^*)+\Phi q_n(c_t^*,n_t^*)}\frac{u_n(c_t^*,n_t^*)}{u_c(c_t^*,n_t^*)}.$$

Since $q(c_t, n_t) = [u_c(c_t, n_t)c_t + u_n(c_t, n_t)n_t] = c_t^{1-\sigma} - \chi n_t^{\gamma+1}$, it follows that the right-hand side is invariant to the date-t values of consumption and work,

$$\frac{1-\tau_t^n}{1+\tau_t^c}=\frac{1+(1-\sigma)\Phi}{1+\Phi(\gamma+1)}. \tag{18}$$

Thus, the "wedge" depends on the preference parameters that control the elasticities of consumption demand and labor supply, as well as the multiplier that insures that the government budget constraint is satisfied. As this condition makes clear, optimal quantities are consistent with either labor income taxation, consumption taxation or a mixture of the two. But the "wedge," $(1 - \tau_t^n)/(1 + \tau_t^c)$, must be constant over time.

4.3.3 Dynamic Responses

Following a general strategy in modern macroeconomics, we can study the response of the economy to perturbations in the exogenous variables of the closed economy model via linear approximation methods around a stationary point. In particular, we consider a stationary point with a specific tax wedge, which is set so that the government balances its flow budget constraint (since every period is identical in the stationary economy, this also balances the economy's intertemporal budget constraint). The stationary point is then values of c, n, $(1 - \tau^n)/(1 + \tau^c)$ which satisfy

$$\left(\frac{1-\tau^n}{1+\tau^c}\right)a=-\frac{u_n(c,n)}{u_c(c,n)}$$

$$c+g^c=a(n-g^n)$$

$$\left(\frac{1-\tau^n}{1+\tau^c}\right)an=c\,.$$

The first two of these expressions are readily interpretable as involving (1) the equating of labor demand and labor supply; and (2) the equating of goods demand and goods supply. The third is a stationary version of the government budget constraint in equilibrium (13), which is also the stationary household budget constraint. Given these stationary values, the multiplier Φ is also determined, since it must satisfy (18).

We can then explore the implications of small perturbations in the sequences $\{a_t\}$; $\{g_t^c\}$; $\{g_t^n\}$; around the stationary values a, g^c, g^n. In the process, we hold fixed the multiplier Φ, so that the analysis corresponds to the effects of shocks in the presence of complete financial markets, as in Lucas and Stokey (1983).

In fact, in this setting, it is feasible to study the dynamic responses analytically by differentiating the Ramsey planner's first order conditions (16) and the equations governing supporting prices and tax rates (17). Essentially, the absence of production-side connections across periods means that the economy's outcomes correspond to those of a static model. Derivations along these lines produce a solution for optimal work effort, which takes the form

$$\log(n_t/n)=\frac{\sigma}{\sigma\phi+\gamma s_c}s_g\log(g_t^c/g^c)$$
$$+\frac{\sigma}{\sigma\phi+\gamma s_c}(\phi-1)\log(g_t^n/g^n)+\frac{s_c-\sigma}{\sigma\phi+\gamma s_c}\log(a_t/a)$$

where $s_c=c/(c+g^c)$, $s_g=g^c/(c+g^c)$ and $\phi=an/(c+g^c)$.[2] That is, increases in government consumption of goods and labor services lead to higher work effort, while productivity exerts an ambiguous effect (due, essentially, to offsetting income and substitution effects).

Consumption is correspondingly governed by

$$\log(c_t/c)=-\frac{\gamma}{\sigma\phi+\gamma s_c}s_g\log(g_t^c/g^c)$$
$$-\frac{\gamma}{\sigma\phi+\gamma s_c}(\phi-1)\log(g_t^n/g^n)+\left(\frac{\sigma+\gamma}{\sigma\phi+\gamma s_c}\right)\log(a_t/a)$$

so that it declines with both types of government purchases and rises with productivity.

4.4 *Small Open Economy Benchmark*

In the case where the economy is asymptotically small, actions by private agents or the government have no effect on the intertemporal prices that are determined at the community level. Accordingly, the government selects quantities subject to its budget constraint ((13), which continues to imply (15) in the small open economy) and the requirement that the country have net exports that obey the intertemporal constraint (3).

A Ramsey planner's constrained optimization problem for quantities thus has a Lagrangian of the form

$$L_j = \sum_{t=0}^{\infty} \beta^t u(c_{jt}, n_{jt}) + \Phi_j \left\{ \sum_{t=0}^{\infty} \beta [q(c_{jt}, n_{jt})] \right\}$$

$$+ \Upsilon_j \sum_{t=0}^{\infty} \beta^t \delta_t [a_{jt} n_{jt} - c_{jt} - g_{jt}^c - a_{jt} g_{jt}^n]$$

where the multiplier Φ_j may be interpreted as the cost of satisfying the government budget constraint and Υ_j is the shadow value of relaxing the constraint that the intertemporal market value of net exports is zero. The first-order conditions are

$$u_c(c_{jt}, n_{jt}) + \Phi_j q_c(c_{jt}, n_{jt}) = \Upsilon_j \delta_t$$

$$u_n(c_{jt}, n_{jt}) + \Phi_j q_n(c_{jt}, n_{jt}) = \Upsilon_j \delta_t a_{jt}$$

plus the two constraints.

4.4.1 Supporting Prices and Taxes

The small open economy faces exogenous intertemporal prices, $\{\delta_t\}$, so that the conditions for supporting prices and tax rates are

$$w_t = a_t \tag{19}$$

$$(1+\tau_t^c) = \frac{1}{\Lambda \delta_t} u_c(c_t^*, n_t^*)$$

$$(1-\tau_t^n) = \frac{1}{\Lambda a_t \delta_t} u_n(c_t^*, n_t^*) .$$

4.4.2 Implications for Tax Rates

We can use these conditions to deduce three key results about optimal policy for the small open economy.

Result #1 Combining the foregoing with the private marginal rate of substitution implies that

$$\frac{1-\tau_{jt}^{n}}{1+\tau_{jt}^{c}}=\frac{1+(1-\sigma)\Phi_j}{1+\Phi_j(\gamma+1)}$$

should be constant over time, as we obtained in the prior closed economy case. Thus, the "wedge" is constant over time in the small open economy, just as it was in the closed economy.

Result #2 The ratio of the private to planner consumption first-order conditions for consumption requires that the consumption tax rate must be constant over time.

That is:

$$\frac{\Lambda_j(1+\tau_{jt}^{c})\delta_t}{\Upsilon_j\delta_t}=\frac{u_c(c_{jt},n_{jt})}{u_c(c_{jt},n_{jt})+\Phi_j q_c(c_{jt},n_{jt})}=\frac{1}{[1+(1-\sigma)\Phi_j]}$$

implies that

$$(1+\tau_{jt}^{c})=\frac{\Upsilon_j}{[1+(1-\sigma)\Phi_j]\Lambda_j}.$$

Since all three multipliers on the right-hand side of this expression are constant over time, the consumption tax rate is also constant over time. Hence, for the small open economy, optimal taxation implies no intertemporal distortions in consumption.

Result #3 The theory is silent on the determinants of the *levels* of the labor tax and the consumption tax. Either can be used to raise revenue efficiently—and yield precisely the same optimal quantities—when assumed constant over time. While the government of the small open economy cannot affect the intertemporal prices $\{\delta_t\}$, it can affect the relative price of consumption and work, which it can do either with a uniformly higher labor income tax or uniformly higher consumption tax.

This result for the small open economy is essentially the general neutral tax result discussed in section 4.2, operating at the level of a country rather than a representative individual. As discussed in the introduction, there are consequently a variety of efficient government deficit paths for the small open economy that are consistent with efficient taxation. For example, if the labor income tax rate is used alone, then the government surplus is

$$s_{jt} = \tau_j^n a_{jt} n_{jt} - g_{jt}^c - a_{jt} g_{jt}^n$$

where the constant tax rate is $\tau_j^n = \Sigma_{t=0}^{\infty} \beta^t \delta_t [g_{jt}^c + a_{jt} g_{jt}^n] / \Sigma_{t=0}^{\infty} \beta^t \delta_t [a_{jt} n_{jt}]$.[3] By contrast, if the consumption tax rate is used alone, then the surplus is

$$s_{jt} = \tau_j^c c_{jt} - g_{jt}^c - a_{jt} g_{jt}^n$$

where constant tax rate is by $\tau_j^c = \Sigma_{t=0}^{\infty} \beta^t \delta_t [g_{jt}^c + a_{jt} g_{jt}^n] / \Sigma_{t=0}^{\infty} \beta^t \delta_t [c_{jt}]$. Since consumption likely would be much smoother than income for this small open economy, the government deficit would be much more volatile with labor income taxation.

4.4.3 Dynamic Responses

There are quite different dynamic responses for the small open economy relative to the closed economy. Variations in productivity stimulate strong intertemporal substitutions, in the sense that n_t^* moves together with a_t according to

$$\log(n_t^* / n) = \frac{1}{\gamma} \log(a_t / a) + \frac{1}{\gamma} \log(\delta_t / \delta)$$

while consumption is not affected by productivity,

$$\log(c_t^* / c) = -\frac{1}{\sigma} \log(\delta_t / \delta).$$

Variations in government consumption and government employment have no effect on either of the optimal quantities $\{c_t^*\}$ and $\{n_t^*\}$. These patterns of dynamic responses are characteristic of a small open economy under complete markets (see, for example, the discussion in Baxter 1995). Each derives from the effect that the wealth effects of shocks is insured away in these markets, leaving only substitution effects.

Intertemporal relative prices, $\{\delta_t\}$, also exert substitution effects, encouraging work and discouraging consumption in periods with high

δ. However, both the private sector and government of a small open economy view these prices as exogenous to their decisions.

4.5 The Direct Approach

In studying the small open economy above, we followed the Ramsey approach of computing optimal quantities, with the benefit that we could then deduce the implications for tax rates just discussed. An alternative look at the nature of the optimal taxation problem is afforded by the direct choice of optimal tax rates, given the conditions of government budget balance and macroeconomic equilibrium. We employ this direct approach within our analysis of community general equilibrium, but we start by considering its application in the context of the small open economy.

To implement the approach, it would be natural to write a representative agent indirect utility function that depends on tax rates as follows:

$$V(\{\tau^c_{jt}\}^{\infty}_{t=0}, \{\tau^n_{jt}\}^{\infty}_{t=0}, \ldots)$$

and then optimize with respect to tax rates, given a set of constraints. However, we have seen in section 4.2 that there are combinations of tax rates on labor income and consumption that are behaviorally equivalent if government revenue neutrality is imposed. This latitude is not desirable from the standpoint of the direct approach.

However, in section 4.2, we also saw that equivalent sequences of labor and consumption taxes could be readily related using a rescaling of the multiplier on the household's budget constraint. Hence, we use the effective wedges $\xi^c_{jt} = \Lambda_j(1 + \tau^c_{jt})$ and $\xi^n_{jt} = \Lambda_j(1 - \tau^n_{jt})$ as representing each class of equivalent tax rates. Then, we view small open economy as maximizing

$$V(\{\xi^c_{jt}\}^{\infty}_{t=0}, \{\xi^n_{jt}\}^{\infty}_{t=0}, \{a_{jt}\}^{\infty}_{t=0}, \{\delta_t\}^{\infty}_{t=0})$$

subject to decision rules for consumption and work,

$$c_{jt} = (\xi^c_{jt}\delta_t)^{-(1/\sigma)}$$

$$n_{jt} = (\xi^n_{jt}a_t\delta_t)^{(1/\gamma)}$$

the equilibrium version of the government budget constraint

$$\sum_{t=0}^{\infty}\beta^t\delta_t[-\xi^n_{jt}a_{jt}n_{jt} + \xi^c_{jt}c_{jt}] = \sum_{t=0}^{\infty}\beta^t[q(c_{jt}, n_{jt})] \geq 0$$

and the intertemporal constraint on net exports

$$\sum_{t=0}^{\infty}\beta^t\delta_t[a_{jt}(n_{jt}-g^n_{jt})-g^c_{jt}-c_{jt}]\geq 0\,.$$

We think of the joint solution for optimal quantities and effective wedges as determining the fundamentals of fiscal policy. Once we have worked out this solution, we can construct any desired member of the class of equivalent fiscal policies, by calculating

$$(1+\tau^c_{jt})=\frac{1}{\Lambda_j}\xi^c_{jt}$$

$$(1-\tau^n_{jt})=\frac{1}{\Lambda_j}\xi^n_{jt}$$

for a specified value of Λ_j.

4.5.1 Efficiency Conditions for Taxation

The Lagrangian for the planner's problem is

$$L=\sum_{t=0}^{\infty}\beta^t u(c(\xi^c_t\delta_t),n(\xi^n_t a_t\delta_t))+\Phi_j\sum_{t=0}^{\infty}\beta^t q(c(\xi^c_t\delta_t),n(\xi^n_t a_t\delta_t))$$

$$+\Upsilon_j\sum_{t=0}^{\infty}\beta^t\delta_t[a_t n(\xi^n_t a_t\delta_t)-a_t g^n_t-g^c_t-c(\xi^c_t\delta_t)]\,.$$

The efficiency condition for consumption is as follows:

$$0=[u_{c_t}+\Phi_j q_{c_t}-\Upsilon_j\delta_t]\frac{\partial c_{jt}}{\partial\xi^n_t}\,.$$

The first three terms indicate that an efficient internal price of consumption ξ^c_{jt} takes into account: (1) the effect of the change in this price on utility; (2) the effect on the government budget constraint; and (3) the effect on the present discounted value of the country's net exports.

The efficiency condition for the internal price of labor ξ^n_{jt} takes a symmetric form

$$0=[u_{n_t}+\Phi_j q_{n_t}+\Upsilon\delta_t a_t]*\frac{\partial n_t}{\partial\xi^n_t}\,.$$

Note that the bracketed terms are exactly the first-order conditions of the Ramsey method with respect to quantities. Hence, the Ramsey method and the direct method each require that the bracketed terms be set to zero at an optimum: the results of the Ramsey and the direct method for quantities and values of the effective wedges are therefore identical.

5. Optimal Policy without Coordination

If the governments of the countries cannot coordinate their actions, they nevertheless recognize that these actions will have implications for the prices and quantities that will prevail in community-wide markets. We are interested in a Nash equilibrium of the game between the J different countries governments. That is, in posing the optimal tax policy for an individual-country's government—for concreteness, country 1—we assume that the tax policies for the other governments are taken as given. In addition, country 1's government assumes that local and world markets clear.

Following the discussion in the previous section, we assume that each government chooses sequence of effective consumption and labor wedges, i.e., selects a fundamental fiscal policy. Then, when we consider a Nash game between the country governments, the strategy of the government of country j is given by $\{\xi^c_{jt}\}_{t=0}^{\infty}$ and $\{\xi^n_{jt}\}_{t=0}^{\infty}$.

5.1 Community Equilibrium with Exogenous Policies

In the intermediate case that we now study, a government's fiscal actions may have effect both on intertemporal prices and net exports. Community goods market equilibrium requires that

$$\begin{aligned} 0 &= \sum_{j=1}^{J} \theta_j [a_{jt} n_{jt} - c_{jt} - g^c_{jt} - a_{jt} g^n_{jt}] \\ &= \sum_{j=1}^{J} \theta_j [a_{jt} n_{jt} - c_{jt}] - G_t \\ &= Y_t - C_t - G_t \end{aligned}$$

where $G^c_t = \Sigma^J_{j=1} \theta_j g^c_{jt}$, $G^n_t = \Sigma^J_{j=1} \theta_j a_{jt} g^n_{jt}$, $G_t = G^c_t + G^n_t$ and $C_t = \Sigma^J_{j=1} \theta_j c_{jt}$ as above. We also define a measure of community total output (the sum of private and public output),

$$Y_t \equiv \sum_{j=1}^{J} \theta_j [a_{jt} n_{jt}]. \tag{20}$$

The various supplies and demands are governed by

$$c_{jt} = (\xi^c_{jt}\delta_t)^{-(1/\sigma)}$$

$$n_{jt} = (\xi^n_{jt}a_{jt}\delta_t)^{(1/\gamma)}.$$

Accordingly, the market-clearing price is implicitly given by

$$0 = Y_t - C_t - G_t = \left[\delta_t^{\frac{1}{\gamma}} \sum_{j=1}^{J} \theta_j a_{jt}^{1+\frac{1}{\gamma}} (\xi^n_{jt})^{\frac{1}{\gamma}}\right] - \left[\delta_t^{-\frac{1}{\sigma}} \sum_{j=1}^{J} \theta_j (\xi^c_{jt})^{-\frac{1}{\sigma}}\right] - G_t \tag{21}$$

so that the equilibrium price depends on productivity; consumption and labor tax rates; and the aggregate government expenditure shock. We write this price function as

$$\delta(\{a_{jt}\}_{j=1}^J, \{\xi^c_{jt}\}_{j=1}^J, \{\xi^n_{jt}\}_{j=1}^J, G_t).$$

The effects on intertemporal prices take a natural form. For example, since $Y_t = C_t + G_t$, we know that the effect of government demand on the intertemporal price is simply given by

$$\frac{\partial \delta_t}{\partial G_t} = \frac{1}{\frac{\partial Y_t}{\partial \delta_t} - \frac{\partial C_t}{\partial \delta_t}} = \delta_t * \frac{1}{\frac{1}{\gamma}Y_t + \frac{1}{\sigma}C_t} \tag{22}$$

where the second line expresses the slope of the "excess supply of goods" using the relevant labor supply and consumption demand elasticities.

As an intermediate-size economy, the government in country 1 takes as given the fiscal policies in other countries, treating $\{\xi^c_{jt}\}_{t=0}^\infty$, $\{\xi^n_{jt}\}_{t=0}^\infty$ as parametric for all t and for $j = 2, \ldots, J$. It takes into account the effects of its own fiscal actions on intertemporal prices via the constraint above. The effect on the intertemporal prices due to country j fiscal policy decisions are:

$$\frac{\partial \delta_t}{\partial \xi^n_{jt}} = -\delta_t * \frac{\theta_j a_{jt}}{\frac{1}{\gamma}Y_t + \frac{1}{\sigma}C_t} * \frac{\partial n_{jt}}{\partial \xi^n_{jt}} \tag{23}$$

$$\frac{\partial \delta_t}{\partial \xi^c_{jt}} = \delta_t * \frac{\theta_j}{\frac{1}{\gamma}Y_t + \frac{1}{\sigma}C_t} * \frac{\partial c_{jt}}{\partial \xi^c_{jt}}. \tag{24}$$

Note that the effect of a country's fiscal actions on the intertemporal price involve the effect on its own labor supply or consumption and the effect of supply/demand shifts on the equilibrium price. More specifically, note that the magnitude of these intertemporal price effects of country j fiscal policy thus depends positively on the size of the country, θ_j.

5.2 *Optimal Taxation for Country j*

We now consider country j's optimal tax problem, using the "direct form" described above in the context of the small open economy:

$$L=\sum_{t=0}^{\infty}\beta^t u(c(\xi_{jt}^c\delta_t),n(\xi_{jt}^n a_{jt}\delta_t))+\Phi_j\sum_{t=0}^{\infty}\beta^t q(c(\xi_{jt}^c\delta_t),n(\xi_{jt}^n a_{jt}\delta_t))$$

$$+\Upsilon_j\sum_{t=0}^{\infty}\beta^t\delta_t[a_{jt}n(\xi_{jt}^n a_{jt}\delta_t)-a_{jt}g_{jt}^n-g_{jt}^c-c(\xi_{jt}^c\delta_t)]\,.$$

To make the first-order conditions as simple as possible, we view the government of country j as choosing the relevant tax wedge, $\xi^c_{jt}\delta_t$ or $\xi^n_{jt}\delta_t$. This simplifies the algebra somewhat and corresponds to the idea that the country j government (1) understands the effects of its tax actions on intertemporal prices and (2) understands that its tax actions affect intertemporal prices through their effects on quantities supplied to or demanded from the international market.

5.2.1 Efficiency Conditions for Country j

The efficiency condition for $\xi^c_{jt}\delta_t$ takes the form

$$0=\{u_{c_{jt}}+\Phi_j q_{c_{jt}}-\Upsilon_j\delta_t\}\frac{\partial c_{jt}}{\partial(\xi_{jt}^c\delta_t)}+\Upsilon_j[a_{jt}n_{jt}-a_{jt}g_{jt}^n-g_{jt}^c-c_{jt})]\frac{\partial\delta_t}{\partial(\xi_{jt}^c\delta_t)}\,.$$

As in the case of the small open economy exported in section 4, the first three terms indicate that an efficient effective wedge—represented by $\xi^c_{jt}\delta_t$—takes into account: (1) the effect of the change in this price on utility; (2) the effect on the government budget constraint; and (3) the effect on the present discounted value of the country's net exports. However, in the current case of an intermediate size economy, there are two components to this last term: the direct expenditure effect ($\Upsilon_j\delta_t$) also present in the small open economy case and a new indirect effect via the country's effect on the community discount factor ($\Upsilon_j x_{jt}$).

The efficiency condition for $\xi^n_{jt}\delta_t$ takes a symmetric form

$$0=\{u_{n_{jt}}+\Phi_j q_{n_{jt}}+\Upsilon_j\delta_t a_{jt}\}\frac{\partial n_{jt}}{\partial(\xi_{jt}^n\delta_t)}+\Upsilon_j[a_{jt}n_{jt}-a_{jt}g_{jt}^n-g_{jt}^c-c_{jt}]\frac{\partial\delta_t}{\partial(\xi_{jt}^n\delta_t)}\,.$$

As with the previous, there is an effect operating through the community discount factor,

$$\Upsilon_j x_{jt} \frac{\partial \delta_t}{\partial(\xi_{jt}^n \delta_t)}.$$

These expressions both contain effects of country j's fiscal actions on the world intertemporal price δ_t. These may be shown to be

$$\frac{\partial \delta_t}{\partial(\xi_{jt}^c \delta_t)} = \delta_t \frac{\theta_j}{\frac{1}{\gamma}(Y_t - \theta_j a_{jt} n_{jt}) + \frac{1}{\sigma}(C_t - \theta_j c_{jt})} \frac{\partial c_{jt}}{\partial \xi_{jt}^c}$$

$$\frac{\partial \delta_t}{\partial(\xi_{jt}^n \delta_t)} = -\delta_t \frac{\theta_j a_{jt}}{\frac{1}{\gamma}(Y_t - \theta_j a_{jt} n_{jt}) + \frac{1}{\sigma}(C_t - \theta_j c_{jt})} \frac{\partial n_{jt}}{\partial(\xi_{jt}^n \delta_t)}.$$

The preceding two first-order conditions imply basic restrictions that must be satisfied for a country that is following an optimal fiscal policy,

$$0 = u_{c_{jt}} + \Phi_j q_{c_{jt}} - \Upsilon_j \delta_t + \Upsilon_j \delta_t \theta_j \frac{x_{jt}}{z_{jt}} \tag{25}$$

$$0 = u_{n_{jt}} + \Phi_j q_{n_{jt}} + \Upsilon_j \delta_t a_{jt} - \Upsilon_j \delta_t a_{jt} \theta_j \frac{x_{jt}}{z_{jt}} \tag{26}$$

where z_{jt} is defined as

$$\left[\frac{1}{\gamma}(Y_t - \theta_j a_{jt} n_{jt}) + \frac{1}{\sigma}(C_t - \theta_j c_{jt})\right].$$

Note that these country j fiscal policy conditions are those of the small open economy problem, modified by the presence of terms involving x_{jt}/z_{jt}. Accordingly, if $x_{jt} = 0$, then the intermediate size country chooses the same tax rates as the small country.

5.2.2 Implications for Optimal Taxation

More generally, we can use the equilibrium conditions (25) and (26) to determine aspects of the optimal tax structure.

First, we consider constancy of the "wedge." Taking the ratios of these two conditions, we see that

$$\left(\frac{-u_n}{u_c}\right) \frac{1 + \Phi_j(1+\gamma)}{1 + \Phi_j(1-\gamma)} = a_{jt} \frac{1 - \theta_j x_{jt} / z_{jt}}{1 - \theta_j x_{jt} / z_{jt}} = a_{jt}$$

so that the optimal policy involves

$$\frac{1-\tau_{jt}^{n}}{1+\tau_{jt}^{c}}=\frac{\xi_{jt}^{n}}{\xi_{jt}^{c}}=\frac{1+(1-\sigma)\Phi_{j}}{1+\Phi_{j}(\gamma+1)}$$

so that the "wedge" is constant over time as in all of the other models above. However, as we shall see below, it is no longer the case that the tax rates are constant over time, so that constancy of the "wedge" now implies that the labor income tax and the consumption tax must move inversely.

Second, we consider variation in components of the "wedge." The labor condition (25) implies that

$$\chi n_{jt}^{\gamma}[1+\Phi_{j}(1+\gamma)]=a_{jt}[1-\theta_{j}x_{jt}/z_{jt}]\Upsilon_{j}\delta_{t}$$

so that optimal labor is higher in situations where the country is a net importer ($x_{jt}<0$) and lower when it is a net exporter ($x_{jt}>0$).[4] In order to bring about this higher labor, it is necessary that there be a labor tax rate when the country is a net importer. Further, given that there is a lower labor tax, there must be a higher consumption tax, given the inverse relationship which we determined above. Both taxes thus work to cut net imports, thus lowering the price that the country faces for being a net importer.

5.3 *Nash Equilibrium*

In a Nash equilibrium, each country chooses its optimal tax policy taking as given the actions of the others. From above, we can see that there are two main mechanisms by which countries interact. First, the community discount factor δ_t affects the supply and demand for goods in all countries. Second, the fiscal policy within a given country is affected by

$$\frac{x_{jt}}{z_{jt}}=\frac{a_{jt}n_{jt}-a_{jt}g_{jt}^{n}-g_{jt}^{c}-c_{jt}}{\frac{1}{\gamma}(Y_{t}-\theta_{j}a_{jt}n_{jt})+\frac{1}{\sigma}(C_{t}-\theta_{j}c_{jt})}$$

so that other country's tax actions—which affect the aggregate quantities produced Y_t and consumed C_t—are relevant to country j's fiscal policy and production.

A Nash equilibrium, then, requires that each country j's choices of effective wedges are consistent with the conditions (equilibrium conditions (25) and (26)). In addition, a Nash equilibrium requires the conditions of community general equilibrium discussed in sections 3.3 and 4.1.

To study the dynamic responses of economies within such a Nash equilibrium, we then can adopt the same approach as used for the closed economy and the small open economy. First, we consider a stationary equilibrium in which all of the countries are the same in terms of a, g^c, and g^n, so that each has a position of zero net exports. In such a setting, the discussion above leads to the conclusion that each country will choose the same constant levels of ξ^c and ξ^n. Second, we log-linearize the relevant equilibrium conditions—including (25) and (26)—around this stationary position and then consider the response to small perturbations in productivity and government purchases.

Before doing so, we briefly consider how the Nash equilibrium outcomes would differ from those in a setting with policy coordination.

6. Optimal Policy with Coordination

If tax policy is coordinated across countries, then a natural objective is to maximize a weighted average of welfare for community members (these utility weights are ϑ_j). However, in considering this coordinated situation, we continue to require that each country satisfy its present value budget constraint and its government budget constraint: there are no transfers between governments or economies other than through the price system. The appropriate Lagrangian for this problem is then

$$L = \sum_{j=1}^{J} \vartheta_j \left\{ \sum_{t=0}^{\infty} \beta^t u(c(\xi_{jt}^c \delta_t), n(\xi_{jt}^n a_{jt} \delta_t)) \right\} + \sum_{j=1}^{J} \left\{ \Phi_j \theta_j \sum_{t=0}^{\infty} \beta^t q(c(\xi_{jt}^c \delta_t), n(\xi_{jt}^n a_{jt} \delta_t)) \right\}$$

$$+ \sum_{j=1}^{J} \left\{ \Upsilon_j \theta_j \sum_{t=0}^{\infty} \beta^t \delta_t [a_{jt} * n(\xi_{jt}^n a_{jt} \delta_t) - a_{jt} g_{jt}^n - g_{jt}^c - c(\xi_{jt}^c \delta_t)] \right\}$$

where the first line is the weighted-average objective; the second line represents the requirement that coordinated policy respect each of the government budget constraints; and the third line represents the requirement that coordinated policy represent each of the country budget constraints.

For the single decision maker, the first-order conditions with respect to country j's "prices" are as follows.

$$0=\{\vartheta_j u_{c_{jt}}+\Phi_j\theta_j u_{c_{jt}}-\Upsilon_j\delta_t\theta_j\}\frac{\partial c_{jt}}{\partial(\xi^c_{jt}\delta_t)}$$

$$+\left\{\sum_{h=1}^{J}\Upsilon_h\theta_h[a_{ht}*n_{ht}-a_{ht}g^n_{ht}-g^c_{ht}-c_{ht})]\right\}\frac{\partial\delta_t}{\partial(\xi^c_{jt}\delta_t)}$$

$$0=\{\vartheta_j u_{n_{jt}}+\Phi_j\theta_j u_{n_{jt}}-\Upsilon_j\delta_t\theta_j\}\frac{\partial n_{jt}}{\partial(\xi^n_{jt}\delta_t)}$$

$$+\left\{\sum_{h=1}^{J}\Upsilon_h\theta_h[a_{ht}*n_{ht}-a_{ht}g^n_{ht}-g^c_{ht}-c_{ht})]\right\}\frac{\partial\delta_t}{\partial(\xi^n_{jt}\delta_t)}$$

In each of these expressions, notice that the community decision-maker takes into account the effect on *all* countries' budget constraints of changing the community-wide discount factor. In this sense, the community decision-maker can choose tax rates that are quite different from those of the single country decision-maker.

An important reference case comes about when the decision-maker attaches the same weight to all country budget constraints ($\Upsilon_h = \Upsilon$). Then, the community general equilibrium condition,

$$\sum_{h=1}^{J}\theta_h[a_{ht}*n_{ht}-a_{ht}g^n_{ht}-g^c_{ht}-c_{ht})]=0,$$

implies that the second line of both conditions above is zero. Accordingly, the community decision-maker will choose country tax rates on labor and consumption that are constant across time, resulting in the same deficit behavior in each country as if it were small.

7. Effects of Government Purchases

To study the nature of fiscal externalities within an economic community, we now consider a particular shock, an increase in government consumption in one country that is persistent but ultimately temporary. In particular, we suppose that

$$\log(g^c_{t+1}/g^c)=\rho\log(g^c_t/g^c)+e_t$$

where $0<\rho<1$ and e_t is a shock. Accordingly, the effect of a shock at date 0 is to cause a revision upward in the path of government purchases of goods, as shown in the first panel of Figure 6. We choose an e_0 =.05 as we assume that government purchases are 20 percent of total

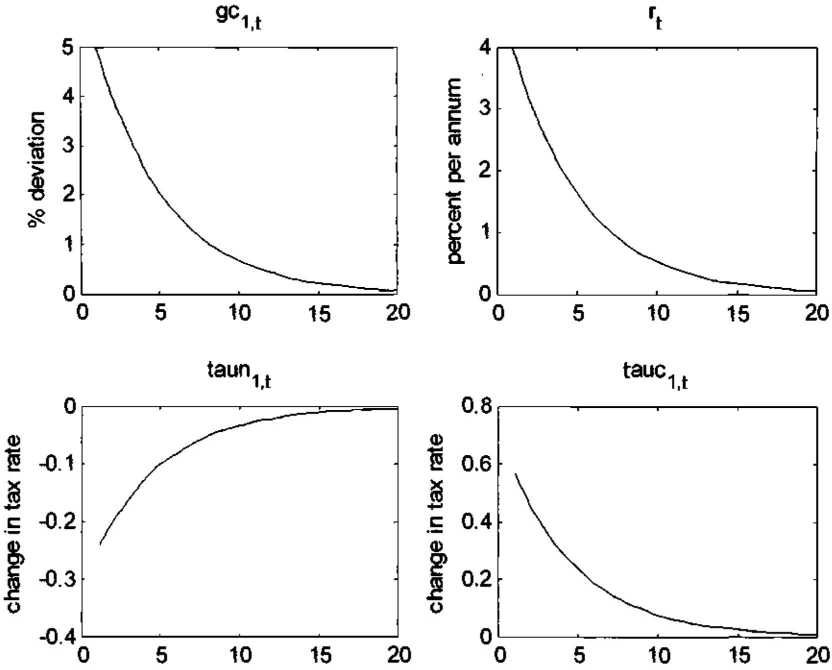

Figure 6
Effects of increase in country-1 government consumption

purchases $s_g = (g/(g + c) = .2$ and we want to consider a shock that is equal to 1 percent of private output $(c + g)$.

7.1 *Benchmarks*

Our analysis in section 4 above provides two benchmarks.

Small open economy: If there is a surprise in government purchases in the small open economy, then the public and private sectors have previously assured against this adverse outcome—essentially a negative net income shock for the country—in the complete financial markets of the community. Tax rates are held constant in the face of this disturbance. There are no effects on either work or consumption. In fact, the only manifestations are in the country's net exports, which decline by Δg and in the government's primary deficit, which rises by Δg.

Closed economy: The private and public sectors of the closed economy would like to insure against this shock, but it is impossible for them to do so since there is no international trade in securities. Accordingly, as discussed in section 4.3, there must be a rise in work and a decline in consumption: each of these is stimulated by the prices δ_t for those periods which are affected by the increase in government expenditure. In particular, if we consider the implications for the real one period return implied by these prices,

$$r_t = r + \frac{1}{\sigma} E_t[\log(c_{t+1}) - \log(c_t)]$$

$$= r - \frac{1}{\sigma} \pi E_t[\log(g^c_{t+1} / g^c) - \log(g^c_t / g^c)]$$

$$= r - \frac{1}{\sigma} \pi(\rho - 1)\log(g^c_t / g^c)$$

where $\pi = \gamma s_g / [\sigma\phi + \gamma s_c]$ with terms defined as shown in section 4.3.3. Hence, in the closed economy, the real rate of return rises if there is an increase in government consumption. The difference between these two responses lies in the fact that the small open economy can "export" the financing of higher government purchases to the world financial markets, while the closed economy cannot.

7.2 *An Intermediate Size Country*

We now consider the same disturbance in an intermediate size country, which is 40 percent of the economic community under two alternative assumptions.

7.2.1 Constant Tax Rates

If the country's fiscal decision-maker's ignored their influence on the prices $\{\delta_t\}_{t=0}^{\infty}$ in choosing their tax rates, then these would be constant over time. Further, under a coordinated fiscal policy, as discussed above, there are circumstances under which it is optimal for all countries to maintain constant tax rates. Accordingly, we begin by studying this case.

The economic community is assumed to be closed to the rest of the world. Therefore, the burden of higher government purchases must be borne by its citizens. Accordingly, all of the community's citizens work harder and consume less, with the market prices (interest rates) signaling that this is desirable. However, since the shock applies only to one of the community's economies, it has a smaller effect on prices and interest rates, scaled by the measure of θ_1 as in the discussions of general equilibrium above. In the simulations displayed in Figures 6 and 7, this fraction is .40, so that the interpretation is that the shock is equal to .40 percent of community private output (C + G).

Accordingly, the constant tax responses shown in Figure 6—indicated by the solid lines—show that consumption declines and labor supply increases, following the path of the shock. Net exports from country decline by about .5 percent of its GDP on impact. That is, although the shock is initially 1 percent, part of it is offset by consumption declines and labor supply increases.

7.2.2 Nash Equilibrium Taxes

When fiscal planners of country 1 take into account their influence on the market prices $\{\delta_t\}$, they choose to cut the path of the labor income tax rate and raise the path of the consumption tax rate, as shown in the bottom panels of Figure 6 (the dashed lines indicate responses under Nash taxation throughout all panels). Consequently, there are responses of greater magnitude in country 1 labor and consumption than arise

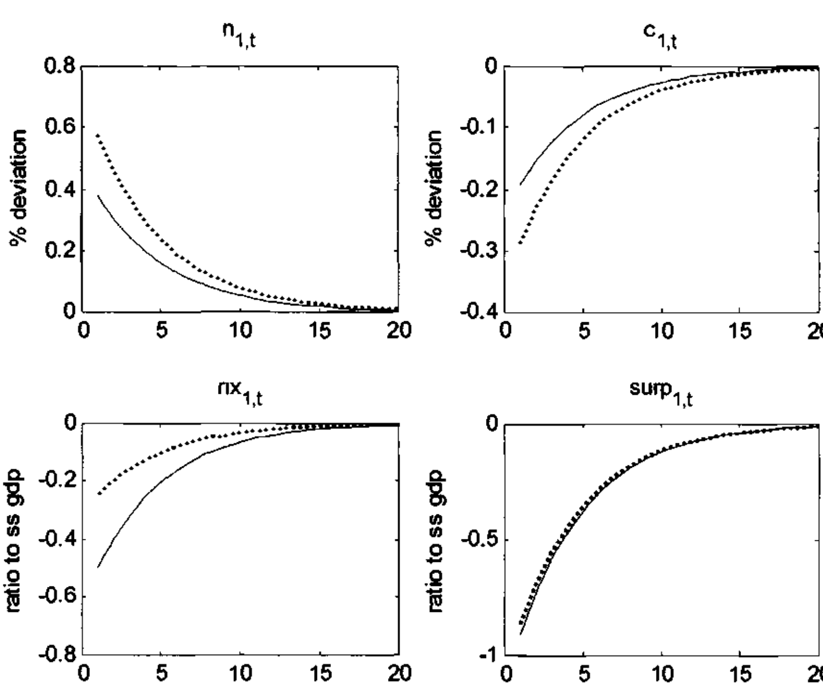

Figure 7
Effects on labor, consumption, net exports, and the fiscal surplus

under constant tax rates. Further, as discussed at the end of section 5, this policy has the effect of smoothing net exports: as shown in Figure 7, these become substantially less responsive to the government purchase shock in the home country. At the same time, declines in tax revenue mean that there is relatively little difference between the government's primary deficit under constant and optimal taxation. In each case, the deficit is dominated by the path of government purchases.

7.2.3 Fiscal Externalities

There are two types of externalities which we see as operating in this experiment and which bear further discussion.

First, treating the case of constant tax rates as proximately optimal under coordination, country 1 exerts a *pecuniary* externality on the economic community: the fact that it is using more goods leads to price variations that affect other members of the community. That is: there are gains to sharing the risk of variations in public purchases across members of the community. Markets handle these external effects efficiently.

Second, there are *policy externalities*—which can be interpreted as coordination failure or imperfect competition externalities—that arise because individual national fiscal policies take into account the effect of their policy actions on community prices. In the current setting of a government purchase (demand) shock, this lack of coordination means that the home country responds more and the community responds less to the shock, thus reducing the effectiveness of community risk-sharing.

8. Summary and Conclusions

Motivated by the Stability and Growth Pact, we have laid the groundwork for studying the external effects of national fiscal policies within an economic community, working within an entirely real dynamic general equilibrium model. While the model is simplistic and abstract, there are some conclusions from the analysis that seem likely to apply to other more complicated and realistic models in the future.

First, the SGP is cast in terms of government deficits. However, our model highlights the international transmission of fiscal policy between countries not via the government deficit, but via the country's net exports.

Second, there are some economic mechanisms that make the trade deficit and the government deficit tend to move together. For example, holding other variables fixed, a rise in government consumption will increase both deficits. In this way, an individual country's fiscal policy can have effects on other countries, which are transmitted via interest rates.

Third, the comovement of these deficit measures clearly depends as well on the tax system, i.e., on how the tax rates and are determined.

Further, to learn about whether there can be important fiscal externalities of national policies when there are optimizing governments, we determined the behavior of optimal tax rates within some alternative settings. Again, there are important lessons that seem to be general.

For a small country within our basic model, which assumes that its policies have no effect on community-wide interest rates, it is optimal to make tax rates constant over time, but the model is silent on whether the necessary tax is applied to labor income or consumption. While the result on tax rate constancy is dependent on the specification of preferences, the model's stress that there are a variety of consumption and income tax policies that are consistent with a given real equilibrium is more general. Further, while the real equilibrium is invariant to the choice between consumption and income taxes, the behavior of the public sector deficit is not. Deficits can be highly variable if they involve mainly labor taxation, but relatively smooth if they involve mainly consumption taxation. That is: countries wishing to satisfy the SGP and avoid volatility in government deficits may wish to use the tax instrument that leads to smooth tax revenues. Hence, community agreements like the SGP may be subject to manipulation via changes in the structure of taxation. Our model highlights this by showing that a very wide range of behavior of government deficits is consistent with optimal taxation, yet these alternative deficits all involve the country having the same effect on the economic community because its net exports are invariant to the structure of taxation.

When we turn to countries that are "large" in the economic community, we stress that the government of a single large country knows that its fiscal policies affect the intertemporal prices determined in community asset markets. In such a setting, a distinction emerges between coordinated and uncoordinated national fiscal policies.

Fiscal policies which are coordinated at the community level will, as our model stresses, recognize that the effects of national tax policies intertemporal prices do not create wealth at the community level, but rather redistribute between its members.

By contrast, with uncoordinated fiscal policies—which we model using a Nash equilibrium—governments have an incentive to choose tax rates that increase the price of exports when the country is a net exporter and reduce the price when the country is a net importer. In our model, these effects operate on financial markets, with fiscal policy aimed at lowering the cost of financing national net export deficits and increasing the value of having national net export surpluses. In our model, we show that these national fiscal policies will therefore work to stabilize net exports relative to the constant tax rate solution, which is approximately optimal under coordinated policies.

Notes

1. Our analysis of optimal taxation follows the Ramsey approach of Lucas and Stokey (1983) and Chamley (1986); some aspects of our results on tax rates in Nash equilibrium are similar to the tariff equilibrium described in Kennan and Riezman (1990). Other recent analyses of international monetary and fiscal policy coordination include Feldstein (1988), Chari and Kehoe (1990) and Lambertini (2005).

2. Given that we have seen that the tax rate is constant over time, this equation for work and that below for consumption are most easily derived by approximating the conditions $(1 - \tau^n)/(1 + \tau^c)a_t = -u_n(c_t,n_t)/u_c(c_t,n_t)$ and $c_t + g_t^c = a_t(n_t - g_t^n)$ around the stationary point.

3. Notice that it is not appropriate to say that "world discount factors do not affect the optimal tax rate" since the labor income tax rate depends on two present values. However, world discount factors do not affect the desirability of smoothing the tax rate over time.

4. This discussion is somewhat heuristic, as the surplus is a function of labor and consumption, but it describes the direction of tax effects appropriately.

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