CHRISTOPHER L. HOUSE
University of Michigan

LINDA L. TESAR
University of Michigan

Greek Budget Realities: No Easy Option

ABSTRACT This paper uses a quantitative dynamic open economy macroeconomic model to examine alternative strategies that the Greek government could implement to increase its primary balance on a flow basis by 1 percent of GDP, representing roughly one quarter of Greece's total annual liability. We examine the impact of increases in distortionary taxes and reductions in government expenditures on the macroeconomy in both the short and long run. The necessary fiscal adjustments are large and entail substantial macroeconomic costs. These costs are even greater when one takes into account realistic elasticities of the tax base and the fact that Greece is a small open economy. Delaying fiscal adjustment could yield short-term benefits, but ultimately such delays come at a high price unless Greece's creditors are willing to provide additional finance at below-market rates. The basic framework holds the growth rate of the Greek economy fixed. Naturally, fiscal adjustments become less painful under a scenario in which the Greek economy returns to a positive growth path. Whether structural reforms or other policies can generate such growth remains an open question.

As of August 2015, Greece's loan repayments due to external creditors through 2057 summed to €319.5 billion, requiring an average debt payment on a flow basis of 4.1 percent of 2014 Greek GDP.[1] This paper examines the economic impact of alternative strategies that Greece could implement to generate a sizable primary surplus. To be specific, we consider increases in distortionary taxes on consumption, capital, and labor income, as well as reductions in government expenditures sufficient to increase Greece's primary balance by 1 percent of 2014 GDP—roughly

1. This sum reflects a variety of interest rates, revolving credit agreements, and bond maturities. The International Monetary Fund's Dissemination Standards Bulletin Board reports budgetary central government debt of €312.8 billion for the second quarter of 2015.

a quarter of Greece's total debt obligations. By studying each policy in isolation, we illustrate the costs and benefits associated with each. In the discussion in section IV, we also consider combinations of policies that could yield the necessary 4.1 percent.[2]

Our analysis yields the following conclusions:

—In the baseline case calibrated to the Greek economy, all of the tax and expenditure policies that we consider produce declines in output in both the short and the long run. The model projection for the near term involves output declines on the order of 1 to 2 percent of 2014 GDP.

—Projections of the primary surplus based on static revenue scoring grossly overestimate the actual amount of revenue that Greece would raise from tax increases. The overestimate is because the static projections ignore endogenous adjustments of capital and labor.

—Meeting the debt repayment schedule is substantially more costly because Greece is a small economy that is integrated with the larger European economy. Failure to incorporate the impact of capital and labor mobility results in a significant overestimate of future revenue.

—Delaying the implementation of tax increases or government expenditure cuts can help mitigate the short-run fall in output, but such delays require greater economic hardship in the long run.

I. Framework for Analysis

The basic model for our analysis includes features of dynamic stochastic general equilibrium models commonly used by central banks and macroeconomists to study both short-run business cycle dynamics and long-run adjustment to permanent changes in fiscal policy. At its core, the model closely resembles the framework used by Jonathan Heathcote and Fabrizio Perri (2002), in which foreign and domestic intermediate goods are combined to create a "final good" that is ultimately used for domestic consumption, investment, and government purchases.[3] Greece, the home country, is treated as a small part of a larger European aggregate. Greece faces a downward sloping demand curve for its country-specific export good, but the share of Greece in the European economy is so small that events in Greece have no meaningful effect on economic activity in the European aggregate.

2. The Memorandum of Understanding between the European Commission, the Greek government, and the National Bank of Greece, agreed to in August 2015, included a commitment on the part of the Greek government to run primary surpluses from 2018 forward of 3.5 percent of (current) GDP (European Commission 2015).

3. Given space constraints, we do not provide a detailed discussion of the model in this paper. We refer the interested reader to House, Proebsting, and Tesar (2015).

Tradable intermediate goods are produced with capital and labor inputs. Bond markets, asset markets, and currency markets in the euro area are fully integrated, and as a member state, Greece takes the nominal interest rate set by the European Central Bank (ECB) as given. In the baseline model, labor cannot move across international borders, but that assumption of labor immobility is belied by the outflow of labor, particularly skilled workers, from Greece since the onset of the crisis. To capture the effect of labor mobility, we consider high labor supply elasticity as a special case. Not surprisingly, when labor responds more elastically to increases in tax distortions it is much harder to raise revenue, and the excess burden of the tax on the labor that remains in Greece is larger.

The Greek government is assumed to raise revenue through distortionary taxes on capital and labor income and on consumption spending. Part of the revenue is transferred back to households, part is used to finance government spending on final goods, and some is transferred to foreign creditors as debt repayment. We assume that government purchases do not affect the marginal utility of consumption, the marginal disutility of labor, or production. The model includes sluggish adjustment in prices and wages and allows for adjustment costs in investment.

We examine the impact on macroeconomic aggregates in response to once-and-for-all changes in policy over different time intervals and under different specifications of model parameters. Our analysis can be thought of as an extension of the tax experiments considered by Greg Mankiw and Matthew Weinzierl (2006), where here we include integrated capital markets and a richer set of adjustment mechanisms, and examine changes in macroeconomic variables along the transition to the post-policy steady state.

I.A. Distortionary Labor and Consumption Taxation

Labor and consumption taxation jointly reduce the incentive to work, depress the supply of labor, and reduce consumption. In the absence of wage rigidity, these distortions would enter through the labor supply condition

$$v'(N_t) = \frac{W_t(1-\tau_t^N)}{P_t(1+\tau_t^C)}u'(C_t). \tag{1}$$

N_t denotes total hours of labor supply and $v'(N_t)$ is the marginal disutility of labor; C_t is real consumption and $u'(C_t)$ is the marginal utility of consumption. The term $W_t(1 - \tau_t^N)/P_t(1 + \tau_t^C)$ is the after-tax real wage. Increases in the tax rate on labor income τ_t^N or the tax rate on consumption spending τ_t^C reduce labor supply by reducing the real after-tax

compensation for work. For the numerical model, we assume the flow utility function takes the form

$$u(C_t) - v(N_t) = C_t^{1-\frac{1}{\sigma}} - \phi N_t^{1+\frac{1}{\eta}}.$$

The parameter η is the Frisch labor supply elasticity; higher values of η imply that workers are more responsive to changes in the after-tax real wage. The parameter σ is the intertemporal elasticity of substitution. While the consumption-labor supply choice is distorted by the wedge that jointly reflects the labor and consumption tax, the taxes are not equivalent in their revenue implications, and therefore we consider each tax separately.

The labor supply condition (equation 1) embodies a second channel through which changes in government finance influence labor supply. A reduction in consumption, for example one triggered by an increase in government spending, results in an increase in labor supply through a wealth effect. Events or policies that reduce wealth and thus reduce consumption are also predicted to ultimately raise employment by giving workers a greater incentive to work. (This is sometimes referred to as an "impoverishment effect" on labor supply.)

The model we analyze includes both wage and price rigidity, and as a consequence the simple labor supply condition described in equation 1 does not hold at every moment, though the basic economic intuition discussed above remains intact. To capture the slow adjustment of nominal prices and wages, the model includes Calvo price- and wage-setting mechanisms, following Lawrence Christiano, Martin Eichenbaum, and Charles Evans (2005). The rates at which prices and wages adjust are governed by two Calvo parameters. The Calvo mechanism allows for fully flexible prices and wages as a special case.

I.B. Distortionary Capital Taxation

Capital taxes reduce the after-tax payoff to capital accumulation and thereby reduce the incentive to expand business activity. This effect typically takes some time to materialize. In the short run, the capital stock is already in place, and thus the supply of capital is relatively inelastic. In the model, this distortion enters through the investment demand schedule, which itself is a combination of the two equations

$$Q_t = \beta E_t\left[\sum_{j=1}^{\infty}\beta^j(1-\delta)^j \frac{u'(C_{t+j})}{u'(C_t)}\frac{R_{t+j}(1-\tau_{t+j}^K)}{P_{t+j}}\right] \tag{2}$$

and

$$\Delta \ln I_t = \frac{1}{\kappa} \ln Q_t + \beta E_t [\Delta \ln I_{t+1}]. \tag{3}$$

Equation 2 gives the relative value of capital (Tobin's Q) in terms of the discounted stream of real capital payoffs. In equation 2, $R_t(1 - \tau_t^K)/P_t$ is the real after-tax flow payoff to a unit of capital. Equation 3 provides a connection between the relative value of capital (Q_t) and investment. We adopt the approach in Christiano, Eichenbaum, and Evans (2005), who use "higher order adjustment costs" to generate additional persistence in investment. The degree of adjustment costs is then governed by a single parameter $\kappa \geq 0$. Expected increases in future capital taxes reduce the relative value of capital through equation 2, and that in turn depresses current investment.

In a closed economy, an increase in the capital tax rate would reduce capital investment, but some of the negative impact of the tax increase would be offset by a change in the domestic interest rate. Because Greece is part of a global financial system, Greek savers have the option of substituting away from investing in domestic capital to investing in international bonds. This channel of substitution will increase the long-run elasticity of capital with respect to the tax rate.[4]

I.C. Government Solvency Constraint

In all of the model simulations, we assume that Greece chooses a policy combination that enables it to repay a given amount of money to its foreign creditors. This requires that the policy options satisfy the government's budget constraint

$$\sum_{j=1}^{\infty} \left(\frac{1}{1+i} \right)^j [P_t G_t + T_t + X_t - \tau_t^K R_t K_t - \tau_t^N W_t N_t - \tau_t^C P_t C_t] = 0, \tag{4}$$

where X_t is a nominal repayment commitment, T_t is a nominal lump sum transfer (or tax), and $i_t = i$ is the nominal interest rate.

4. Because the final investment good is country-specific, physical capital is immobile in the sense that a unit of capital cannot be unbolted from the home factory and put into operation abroad. However, the capital stock does gradually adjust to changes in the tax rate through the substitution between investment in new domestic capital and international bonds.

We take 2014 as the point of departure and consider once-and-for-all changes to economic policy starting in 2015. Our baseline analysis assumes that the debt repayment commitment is not anticipated prior to 2014—that is, we assume that the indebtedness comes as a surprise to the Greek population.[5] Later, we relax this assumption and consider the case where the fiscal policy changes occur with a lag so that households anticipate future changes in policy. In all cases, we assume that Greece maintains access to financial markets (that is, it has sufficient credibility with its creditors) to borrow in years when debt payments exceed the fiscal surplus, and saves when the surplus exceeds its scheduled debt payment.[6]

To facilitate comparison across policy experiments, we consider spending reductions or tax increases sufficient to generate an average flow increase in the primary balance of 1 percent of 2014 GDP. For ease of exposition, we will refer to the permanent 1 percent increase in the primary balance as the *target* primary balance. The target we consider is only a quarter of the amount required to fully meet the scheduled stream of debt payments. Nonetheless, the magnitudes of the tax and expenditure changes needed to generate the target primary balance are already quite large. We do not push the model to generate the full 4 percent increase in the primary balance as a share of 2014 GDP for three reasons. First, to solve the model we use standard linearization techniques, which are appropriate for "small" perturbations in the neighborhood of a stable-trend growth path but are increasingly inaccurate for large policy changes that push the economy away from the initial steady state. In principle, a tax policy change that would satisfy (or attempt to satisfy) the full 4.1 percent increase could push capital and labor taxes into the downward-sloping portion of the Laffer curve (Trabandt and Uhlig 2006; Mendoza, Tesar, and Zhang 2014). Second, our baseline revenue forecasts are based on a model with zero economic growth. This calibration is in line with both recent experience in Greece as well as forecasts of long-run growth absent significant structural reform (McQuinn and Whelen 2015). Were the Greek economy to return to a positive rate of growth, the policy changes needed to meet the target would be smaller. We

5. To be precise, we assume that the Greek economy begins in an initial steady state. Then, in 2014, Greek taxpayers simultaneously learn that their debt obligations X_t are larger than previously believed and learn about the new policies aimed at reducing the debt.

6. In reality Greece faces a lumpy stream of payments, with large payments due in some years and smaller payments in others. An interesting question we leave for future study is the case when Greece faces binding credit constraints and must either accumulate balances in advance of large payments or adjust fiscal policy on a year-by-year basis.

return to the issue of economic growth later in the paper. Finally, the actual policy response is likely to be a combination of tax increases and spending cuts, rather than an increase in a single policy instrument.

II. Calibration

Table 1 lists the parameters used to solve the model along with their economic interpretation. The rate of time discount $\beta = 0.99$, and the intertemporal elasticity of substitution $\sigma = 0.50$. In the baseline case, the elasticity of substitution between home and foreign goods $\psi = 1.50$ (constant elasticity of substitution preferences over home and foreign goods). We also consider the case in which home and foreign goods are perfect substitutes (the neoclassical model in table 2). A key parameter in the model is the Frisch labor supply elasticity η, which we set at $\eta = 0.5$ in the baseline model (Chetty and others 2011). To proxy for international labor mobility, we assume a very high Frisch elasticity of $\eta = 10$ in one of the model specifications.

Turning to the production side of the model, we assume that the production function is Cobb-Douglas with a labor share $\alpha = 0.64$. We set adjustment costs on investment at roughly $\kappa = 2.5$, implying that a 1 percent increase in Tobin's Q causes a 0.4 percent increase in investment growth, all else equal. We set the Calvo parameters so that wages adjust on average once every 12 months (Barattieri, Basu, and Gottschalk 2014) and prices adjust on average once every 8 months (Nakamura and Steinsson 2008; Klenow and Kryvtsov 2008). Greece's share of total GDP in the system is 2 percent, consistent with Greece's GDP share of Europe. The share of imports relative to GDP is 0.21, consistent with the average observed import share from 2000 to 2013.

The initial stance of fiscal policy reflects the level of taxes and government expenditures observed in Greece in 2014 (or the latest year for which data are available). Estimates of average effective tax rates τ on labor, capital, and consumption are calculated using the methodology developed by Enrique Mendoza, Assaf Razin, and Linda Tesar (1994); they are 43, 18, and 16 percent, respectively. The bottom section of table 1 shows macro aggregates as shares of 2014 GDP. The consumption and investment shares are determined by the model while the other ratios are preset. We start from a benchmark trade-balance-to-GDP ratio of balanced trade, ignoring Greece's large initial current account deficit. We also set the primary-balance-to-GDP ratio equal to zero, consistent with the data from 2014. Government spending as a share of goods and services is set at 20 percent, slightly higher than the rate observed in 2014 (18 percent). The

Table 1. Parameters and Calibration

Preferences		
Subjective time discount factor, β		0.99
Trade elasticity, ψ		1.50
Intertemporal elasticity of substitution, σ		0.50
Frisch elasticity, η		0.5, 10
Technology		
Labor share, α		0.64
Inverse Q elasticity, κ		2.48
Duration of price rigidity		8 months
Duration of wage rigidity		12 months
Desired price and wage markup		0.10
Greek share of EU GDP		0.02
Greek import share		0.21
Initial effective tax rates	**Data**	**Model**
Labor income tax rate, τ^N	0.43	0.43
Capital income tax rate, τ^K	0.18	0.18
Consumption tax rate, τ^C	0.16	0.16
Ratios to GDP in 2014[a]		
Consumption	0.74	0.61
Investment	0.13	0.19
Government expenditures	0.18	0.20
Trade balance	–0.08	0.00
Primary balance	0.00	0.00

a. Empirical ratios based on 2014 (or most recent year available) data from Eurostat and the Organization for Economic Cooperation and Development.

model generates a consumption share that is lower than that in the data and an investment share that is too high, largely because it ignores the current account imbalance that supports higher Greek consumption.

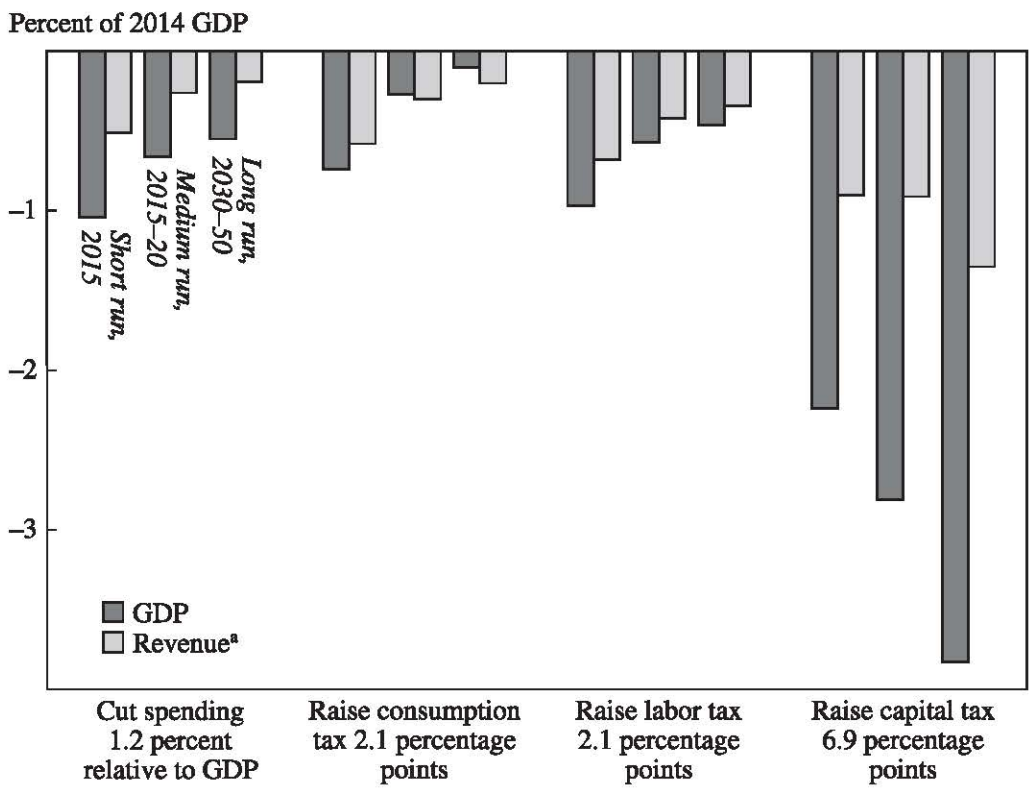
III. Results

Figure 1 illustrates the change in GDP (dark gray) and the difference between the actual and static revenue scores (light gray) associated with the various policy changes needed to reach the target primary balance in the baseline model. The figure shows the effect of the policy in the short run (2015), the medium run (2015–20), and the long run (2030–50). Table 2 reports results for output and employment for each policy change and compares results across different model specifications.

III.A. Decrease in Government Spending

In the baseline model, a decrease in government spending (the first set of bars) results in a roughly 1 percent decline in GDP in the short run,

Figure 1. Effects of Policies on GDP and Revenue Scores



a. Actual revenue score minus static revenue score.

with slightly smaller average declines over the medium and long runs. If the policymaker had relied on a static score to estimate the impact of the policy, he or she would have assumed that there was no effect of the expenditure cut on revenue, and would therefore have underestimated the size of the expenditure cut needed to meet the repayment target. In the dynamic model, however, the decrease in government expenditures reduces aggregate demand for the home good, resulting in declines in labor and capital income as well as consumption and therefore in a decline in tax revenue. The gap between the static score and the dynamic score is roughly 0.5 percent of 2014 GDP.

If the economy is truly neoclassical (see table 2, second panel), with flexible prices and wages and perfect substitutability between the home and the foreign good (essentially a one-good economy), the reduction in government spending has no impact on macroeconomic activity beyond the transfer of domestic resources to foreign creditors. In this case, the government reduces its purchases by exactly enough to repay its foreign creditors. Net exports rise by exactly the amount that government demand falls, leaving aggregate demand (and thus economic activity)

Table 2. Effects of Policies on GDP, Employment, and Revenue Scores

	Government spending cut			*Consumption tax increase*		
	Short run, 2015	*Medium run, 2015–20*	*Long run, 2030–50*	*Short run, 2015*	*Medium run, 2015–20*	*Long run, 2030–50*
Baseline model						
	Cut spending by 1.21 percent of GDP			Tax increase from 16 to 18.2 percent		
GDP	–1.04	–0.66	–0.55	–0.74	–0.27	–0.10
Employment	–1.05	–0.23	0.06	–0.60	0.34	0.62
Static revenue	0.00	0.00	0.00	1.22	1.22	1.22
Actual revenue	–0.51	–0.26	–0.19	0.64	0.92	1.02
Neoclassical model						
	Cut spending by 1 percent of GDP			Tax increase from 16 to 17.7 percent		
GDP	0.00	0.00	0.00	0.27	0.34	0.47
Employment	0.00	0.00	0.00	0.40	0.43	0.47
Static revenue	0.00	0.00	0.00	0.98	0.98	0.98
Actual revenue	0.00	0.00	0.00	0.95	0.97	1.01
Sticky prices and wages						
	Cut spending by 1 percent of GDP			Tax increase from 16 to 17.7 percent		
GDP	–0.01	0.00	0.00	0.21	0.33	0.47
Employment	–0.01	0.00	0.00	0.31	0.41	0.47
Static revenue	0.00	0.00	0.00	0.98	0.98	0.98
Actual revenue	0.00	0.00	0.00	0.93	0.97	1.01
International labor mobility						
	Cut spending by 1.3 percent of GDP			Tax increase from 16 to 18.7 percent		
GDP	–1.50	–1.08	–0.81	–1.45	–1.06	–0.80
Employment	–1.84	–0.84	–0.24	–1.75	–0.81	–0.23
Static revenue	0.00	0.00	0.00	1.51	1.51	1.51
Actual revenue	–0.63	–0.39	–0.28	0.70	0.92	1.02

unchanged. This is not to say that the Greek citizens do not care about this policy change; while GDP and employment are unaffected, welfare decreases to the extent that households value the government services that are no longer being provided.

III.B. Increases in Labor and Consumption Taxes

Consumption and labor tax rates jointly affect the wedge between the marginal rate of substitution and the marginal product of labor, as seen in equation 1. In the baseline model, the increase in the consumption and labor tax rates is about the same size, a 2.1 percentage point increase. The static score overstates the increase in revenue by roughly 0.3 percent of 2014 GDP.

Labor tax increase			*Capital tax increase*		
Short run, 2015	*Medium run, 2015–20*	*Long run, 2030–50*	*Short run, 2015*	*Medium run, 2015–20*	*Long run, 2030–50*
Tax increase from 43 to 45 percent			Tax increase from 18 to 25 percent		
–0.97	–0.57	0.46	–2.24	–2.81	–3.83
–0.96	–0.10	0.18	–1.74	–0.80	0.51
1.36	1.36	1.36	2.24	2.24	2.24
0.68	0.94	1.01	1.34	1.33	0.89
Tax increase from 43 to 44.8 percent			Tax increase from 18 to 26.6 percent		
0.06	0.07	0.10	0.73	–1.70	–6.13
0.09	0.09	0.10	1.98	1.17	–0.24
1.12	1.12	1.12	2.79	2.79	2.79
0.99	0.99	1.00	2.86	2.06	0.77
Tax increase from 43 to 44.8 percent			Tax increase from 18 to 26.6 percent		
0.04	0.07	0.11	0.37	–1.79	–6.14
0.06	0.09	0.11	1.44	1.05	–0.23
1.12	1.12	0.12	2.80	2.80	2.80
0.98	0.99	1.00	2.77	2.04	0.77
Tax increase from 43 to 47.3 percent			Tax increase from 18 to 31.1 percent		
–3.12	–3.77	–4.06	–5.26	–8.45	–9.64
–4.35	–4.79	–4.20	–5.82	–6.92	–2.32
2.78	2.78	2.78	4.24	4.24	4.24
1.28	1.13	0.97	2.64	1.71	0.81

The responses of labor and output to the increase in taxes depend on the relative strength of the income and substitution effects on labor supply and on the elasticity of substitution between domestic and foreign goods. For both the neoclassical model and the sticky price model, the income and substitution effects on labor supply nearly offset one another. The tax increase makes households poorer and increases their incentive to work. In our model, the income elasticity of labor supply is given by $-\eta/\sigma$, while the (Frisch) substitution elasticity is η. Since $\sigma = 0.5$ in our baseline calibration, the income effect dominates the substitution effect, so labor supply and output ultimately increase. The importance and realism of the wealth effect are somewhat controversial. Richard Blundell and Thomas MaCurdy

(1999) report empirical estimates of income elasticities of labor supply between 0 and –1, with typical estimates in the range of –0.1 to –0.2. Our calibration implies an income elasticity of –1, the top of the range reported by Blundell and MaCurdy (1999). Reducing the income elasticity would imply larger short-run output drops than those shown in figure 1.

In addition to the income and substitution effects on labor supply, the equilibrium also depends heavily on the trade elasticity. In both the neoclassical and the sticky price specifications, this elasticity is infinite. As a consequence, Greece can pay off its nominal obligations simply by working more and selling home goods to its foreign creditors at par. In the baseline specification, however, the trade elasticity is only 1.5. This implies that as the supply of Greek goods rises, the price of these goods falls, tempering the payoff to working more. In the baseline model, this trade effect causes employment and output to fall in equilibrium.

III.C. Increase in the Capital Tax

The capital tax is the most inefficient in terms of generating revenue per unit of output loss. It also generates the largest gap between actual revenue and the static projection. An increase in the capital tax leads directly (subject to adjustment costs) to a reduction in investment and an associated decline in output and employment. The erosion of the tax base is amplified by households' ability to substitute away from investment in the home capital good toward investment in the international bond. This erosion of the tax base explains why a much larger tax increase (6.9 percentage points) is needed to meet the revenue target. In the baseline model as well as the neoclassical model, an increase in the capital tax causes capital, labor, and output to fall in the long run.

III.D. Adding Sticky Prices to the Neoclassical Model

The third panel of table 2 reports results for a "sticky price" specification. This specification is identical to the neoclassical specification with the exception that prices and wages adjust slowly to changes in economic activity, as they do in our baseline model. Importantly, the sticky price specification maintains the assumption that there is an infinite elasticity of substitution between home and foreign goods, so this is effectively still a one-good model.

Price and wage rigidity have only modest effects relative to the predictions of the basic neoclassical model. Virtually all of the differences between the two model specifications are concentrated in the short-run responses, and even these differences are relatively small. In the long run, the two

models deliver essentially identical predictions. Prices and wages eventually adjust to the policy change, at which point the model has returned to the same trajectory as the one for an environment with fully flexible prices.

The responses to the government spending cut are identical with and without sticky prices. Since there was no shift in aggregate demand in the flexible price specification, there was no pressure on prices or wages to begin with. Since aggregate demand is unchanged, adding price and wage rigidity has no effect on the outcome.

III.E. International Labor Mobility

To proxy for labor mobility, we adopt a high Frisch elasticity of 10 (relative to the baseline elasticity of 0.5) and keep all other parameters set at the values in the baseline case (see the fourth panel of table 2). With labor mobility, changes in the real after-tax wage produce much larger changes in labor supply. In effect, because some workers can leave Greece and work abroad, and we assume that emigrating workers do not remit their labor earnings, domestic income (gross national product) falls one-for-one with the reduction in labor income. Notice that there is no contradiction with the microeconomic estimates of relatively low Frisch labor supply elasticities in our specification. The workers could all have Frisch elasticities of zero but still be willing to move abroad to avoid enduring the domestic policies that Greece adopts. Relative to the baseline model, an economy with mobile labor requires much greater policy changes to meet the revenue target. To afford a flow payment to foreign creditors of 1 percent of GDP, government spending has to fall by 1.3 percent and output has to fall by 1.5 percent in the short run. In the long run, output remains below trend by roughly 0.81 percent. Tax policies are similarly contractionary; the labor tax policy causes a long-run reduction in output of 4.06 percent, while the capital tax approach causes a long-run reduction of more than 9 percent.

IV. Discussion and Caveats

The policy options considered above were each structured to be sufficient to increase the primary balance by 1 percent of GDP. Greece's actual obligations are closer to 4 percent of GDP on a flow basis. Given the linearity of our model, we can get a rough sense of one policy combination that would come close to fully "resolving" Greece's debt burden by simply summing across the rows of the four policy options. For instance, in the baseline model, a decrease in government spending of 1.21 percent of GDP together with a 2.2 percentage point increase in the consumption tax,

a 2 percentage point increase in the labor tax, and a 7 percentage point increase in the capital tax would raise enough revenue to afford a 4 percent flow payment to Greece's creditors. This would entail a short-run decrease in GDP of approximately 9 percent and a long-run (permanent) decrease of 5 percent. If labor were mobile, the decrease in long-run GDP would be *nearly 15 percent.*

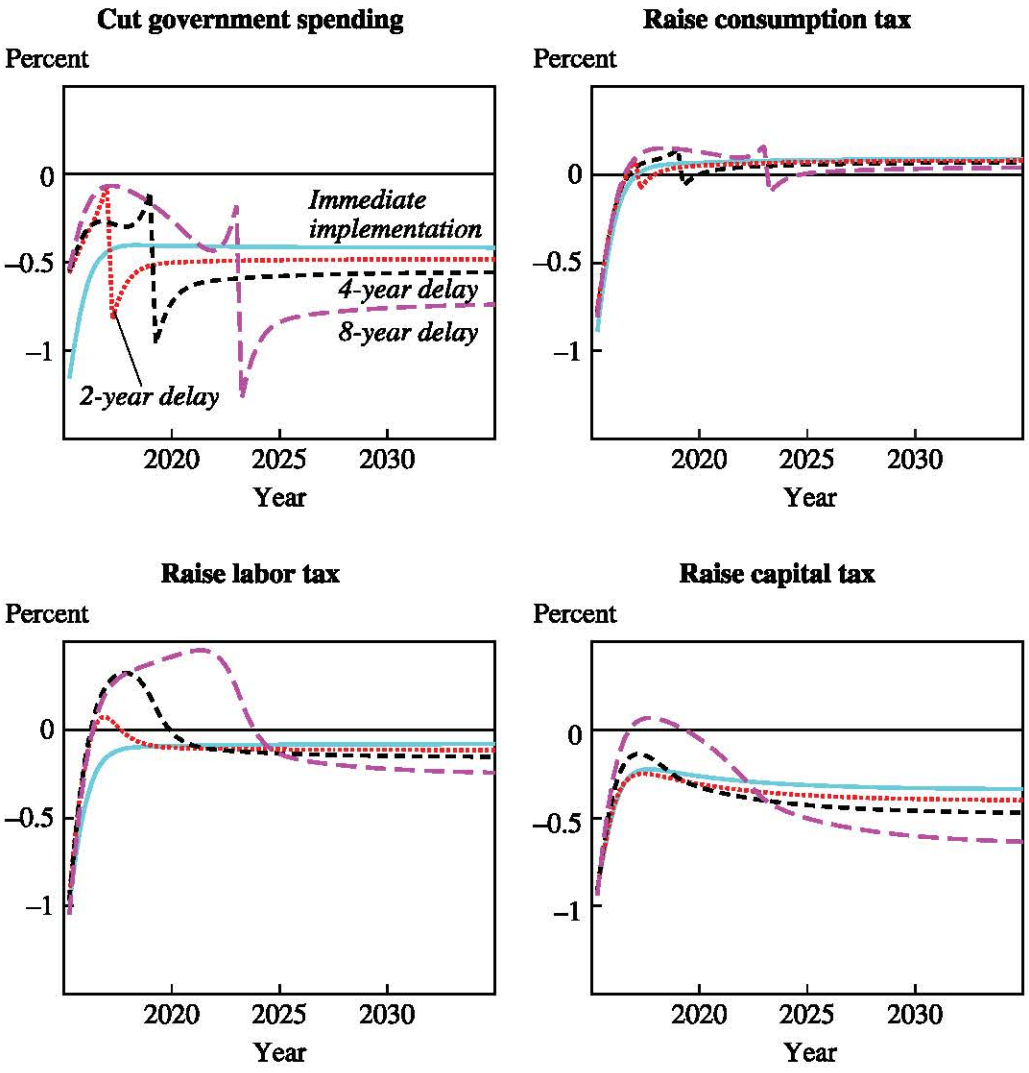
There are several important real-world issues that we have suppressed in our analysis. First is the credibility of the Greek government's carrying out future reforms. The policy simulations above illustrate the severity of the adjustments that Greece is facing, and it simply might be too much to expect that Greece will have the political willpower to follow through with such policy changes. Second is the issue of tax compliance in Greece. The tax changes we outlined above were changes in the effective tax rates, not increases in the statutory rates. To the extent that Greek firms and workers can avoid statutory tax increases, the required increase in the statutory rates will need to be even greater than the rate increases we analyzed. Finally, in the simulations we considered, Greek workers and firms are surprised by the revelation of the extent of government debt at the same instant that the Greek government sets out on a new policy path. In reality, labor and investment adjustments are already under way in Greece, influenced by the expectations of the policy choices that Greece might make.

V. Costs and Benefits of Delaying Austerity

Given the current weakness of the Greek economy, a natural question is whether the necessary fiscal adjustments should be delayed. Delay would allow prices and wages to adjust in anticipation of the policy changes, hopefully mitigating the disruptive effects of sluggish nominal adjustments. On the other hand, there is a cost to delay, because any interim deficits before the austerity policies are implemented must be financed. In the analysis up to this point, we have implicitly assumed that there is no risk of default and that temporary shortfalls in revenue relative to the target could be financed at the eurozone (real) interest rate of 2 percent. The interest rate in the event of a delay would likely include a risk premium. Here we assume that incremental debt due to delay carries an interest rate of 6 percent (a risk premium of 4 percent over the 2 percent baseline rate).

To illustrate the trade-offs that Greece faces, we use the model to simulate four delay scenarios for the four policy adjustment options discussed above. For each policy adjustment (cutting government spending,

Figure 2. Effects of Policies on GDP under Different Delay Scenarios[a]



a. Plots simulated GDP for different polices and different delay horizons. Each panel considers a different policy option, and each line in a given panel considers a different delay horizon.

raising consumption taxes, raising labor taxes, and raising capital taxes), we simulate the response to a policy that goes into effect immediately and compare it with responses to policies with a 2-year delay, a 4-year delay, and an 8-year delay. The 4-year delay is similar to the actual recommendation in the Memorandum of Understanding, which called for increases in the primary balance of –0.25 percent in 2015, 0.5 percent in 2016, 1.75 percent in 2017, and 3.5 percent thereafter (European Commission 2015, p. 6). Figure 2 shows the simulated trajectories for

Greek GDP under each of these scenarios. The top left panel shows the responses to cutting government spending.

In all cases, there are clear short-run benefits to delay. Looking at the 2015–20 period, the delayed policies feature GDP that is roughly 0.5 percent greater than policies that go into effect immediately. The exception seems to be the consumption tax, for which the benefits of delay are small in all cases. Unfortunately, there are also clear long-run costs to delay. In every case, output in the long run is lower than otherwise by as much as 0.25 percent. How the Greek government would weigh these costs and benefits is unclear. It is also unclear what Greece's options for delay really are. If Greece can roll over its debt at a low interest rate, then the case for delay becomes stronger. Indeed, if it can roll over debt at below-market rates, this would be a form of debt forgiveness.

VI. Other Considerations

Here we consider three additional factors that may influence the conclusions. Specifically, we analyze the role of long-run economic growth, the possible benefits of structural reforms, and the potential benefits of debt write-downs and sales of assets owned by the Greek government.

VI.A. Economic Growth

Our analysis so far has adopted a pessimistic view, namely that Greece will not grow at all in the coming decades. A zero percent growth rate is consistent with Greece's recent experience (since 2000, real growth has actually been negative) and also consistent with some long-term forecasts (McQuinn and Whelan 2015). However, if Greece *does* grow over time, this would allow the government to raise more revenue for any given change in tax rates. To a rough approximation, if the annual discount rate for Greek debt is r and the long-run annual growth rate is g, then raising an amount equivalent to a perpetual payment of roughly 1 percent of Greece's 2014 GDP would require an adjustment that is only $(r - g)/r$ times as large as the adjustments reported in table 2. Thus, if the delay rate were indeed 6 percent, as we considered in our analysis of the delay scenarios above, and the growth rate were roughly 2 percent, then the tax changes (and spending cuts) would need be only two-thirds as large as those considered in table 2. The International Monetary Fund (2015, p. 9) reports that its revised growth assessment for Greece going forward is approximately 1.5 percent, though it still describes this projection as "ambitious."

VI.B. Structural Reforms

Part of the August 2015 negotiations included specific requirements that Greece undertake a variety of structural reforms to modernize and liberalize labor markets, reform its pension system, reduce government regulation, and promote competition in product markets (European Commission 2015). Our analysis assumed that these structural reforms either would not be undertaken or would yield only a limited improvement in the functioning of the Greek economy. On the other hand, if the proposed structural reforms do result in substantial improvements to economic conditions, this would potentially reduce the fiscal pressure on the Greek economy. Quantifying the anticipated payoffs associated with the proposed structural reforms is extremely difficult. One recent attempt at doing so is that of Kieran McQuinn and Karl Whelan (2015), who use a neoclassical growth model similar to ours together with some plausible assumptions on the effects of major structural reforms to quantify the potential effects of the reforms. Most of the policies considered by McQuinn and Whelan (2015) focus on increasing labor supply, either by reducing labor market regulation or by reducing the generosity of state pension systems. Under the most optimistic scenarios, these reforms could push Greek labor market outcomes toward the labor market performance of the most productive countries in Europe. Were such an improvement to occur, it would raise Greek GDP substantially in the long run and raise long-run revenue.

VI.C. Debt Write-Downs and Asset Sales

One final consideration is the reduction of the debt burden by either debt forgiveness or through the sale of Greek assets. Both of these options would work directly to reduce the overall debt burden. Initially, the International Monetary Fund (2015) hoped that Greece could raise as much as €23 billion through the sale of various state holdings. While this sum is less than 10 percent of the overall total amount of debt payments, its effect on the present value of the debt would be substantial. For example, if we discounted future Greek debt payments at a 4 percent annual rate, asset sales of €23 billion would allow Greece to reduce its annual debt payment from 4.1 percent of GDP to roughly 3.5 percent of GDP.

VII. Conclusions

This paper provides a number of estimates of the impact of alternative fiscal adjustments that would enable Greece to increase its primary balance on a permanent basis by 1 percent of 2014 GDP. Under reasonable

assumptions, we show that (i) the required adjustments are very large and very painful, (ii) they are even larger when one takes into account realistic elasticities of the tax base, and (iii) they are larger still when one takes into account that Greece is a small open economy. There could be some short-term benefits from delaying fiscal adjustment, but delay would come at a relatively high price unless Greece's creditors were willing to provide additional finance at a relatively low interest rate. All of these adjustments become less painful under a scenario in which the Greek economy returns to a positive growth path. Whether proposed structural reforms can actually produce sustained growth remains to be seen.

References

Barattieri, Alessandro, Susanto Basu, and Peter Gottschalk. 2014. "Some Evidence on the Importance of Sticky Wages." *American Economic Journal: Macroeconomics* 6, no. 1: 70–101.

Blundell, Richard, and Thomas MaCurdy. 1999. "Labor Supply: A Review of Alternative Approaches." In *Handbook of Labor Economics* 3A, edited by Orley C. Ashenfelter and David Card. Amsterdam: North-Holland.

Chetty, Raj, Adam Guren, Day Manoli, and Andrea Weber. 2011. "Are Micro and Macro Labor Supply Elasticities Consistent? A Review of Evidence on the Intensive and Extensive Margins." *American Economic Review* 101, no. 3: 471–75.

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy* 113, no. 1: 1–45.

European Commission. 2015. "Memorandum of Understanding between the European Commission Acting on behalf of the European Stability Mechanism and the Hellenic Republic and the Bank of Greece." Brussels. http://ec.europa.eu/economy_finance/assistance_eu_ms/greek_loan_facility/pdf/01_mou_20150811_en.pdf

Heathcote, Jonathan, and Fabrizio Perri. 2002. "Financial Autarky and International Real Business Cycles." *Journal of Monetary Economics* 49, no. 3: 601–27.

House, Christopher L., Christian Proebsting, and Linda Tesar. 2015. "Austerity in the Aftermath of the Great Recession." Working Paper. http://www-personal.umich.edu/~ltesar/pdf/austerity.pdf

International Monetary Fund. 2015. "Greece: Debt Sustainability Analysis (Preliminary Draft)." IMF Country Report no. 15/165. Washington.

Klenow, Peter J., and Oleksiy Kryvtsov. 2008. "State-Dependent or Time-Dependent Pricing: Does It Matter for Recent U.S. Inflation?" *Quarterly Journal of Economics* 123, no. 3: 863–904.

Mankiw, N. Gregory, and Matthew Weinzierl. 2006. "Dynamic Scoring: A Back-of-the-Envelope Guide." *Journal of Public Economics* 90, nos. 8–9: 1415–33.

McQuinn, Kieran, and Karl Whelan. 2015. "Europe's Long-Term Growth Prospects: With and Without Structural Reforms." Working Paper no. 15/08. Dublin: Centre for Economic Research, University College Dublin.

Mendoza, Enrique G., Assaf Razin, and Linda L. Tesar. 1994. "Effective Tax Rates in Macroeconomics: Cross-Country Estimates of Tax Rates on Factor Incomes and Consumption." *Journal of Monetary Economics* 34, no. 3: 297–323.

Mendoza, Enrique G., Linda L. Tesar, and Jing Zhang. 2014. "Saving Europe? The Unpleasant Arithmetic of Fiscal Austerity in Integrated Economies." Working Paper no. 20200. Cambridge, Mass.: National Bureau of Economic Research.

Nakamura, Emi, and Jón Steinsson. 2008. "Five Facts about Prices: A Reevaulation of Menu Cost Models." *Quarterly Journal of Economics* 123, no. 4: 1415–64.

Trabandt, Mathias, and Harald Uhlig. 2011. "The Laffer Curve Revisited." *Journal of Monetary Economics* 58, no. 4: 305–27.