# Do Tax Cuts Generate Twin Deficits? A Multi-Country Analysis

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**Abstract**

We study the effects of tax shocks on the budget and external deficits for 16 industrialized countries over the post-1975 period. Our structural approach is based on a tractable small open-economy model where a tax cut generates a budget deficit. In turn, the budget deficit affects the external deficit by two distinct channels. The demographic channel works through the overlapping-generation structure of the model. The forecasting channel works through the dynamic structure of the model. Our empirical analysis documents that tax shocks generate significant positive comovements between the budget and external deficits. We also find that both the demographic and forecasting channels are important to explain the comovements.

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## 1. Introduction

The last few years have seen renewed interests on the impact of government budget deficits on the economy, and in particular on external deficits (e.g. Bartolini and Lahiri 2006; Beetsma, Klaassen, and Giuliodori 2008; Bussiere, Fratzcher, and Muller 2005; Chinn 2005; Corsetti and Muller 2006 and 2008). One view is that large budget deficits reduce aggregate savings and generate external deficits. The empirical support for this view in international data, however, is slim. As shown in Figure 1, the budget and external deficits series do not display a homogenous pattern of positive comovements among industrialized countries. In part, the lack of homogenous evidence occurs because the raw data jointly captures the effects of several shocks. These shocks may simultaneously push the budget and external deficits in different directions.

To circumvent this difficulty, our analysis relies on a structural approach to isolate solely the effects of tax shocks on the budget and external deficits. This exercise is in the spirit of the classical literature seeking to discriminate between the twin deficit hypothesis and the Ricardian equivalence hypothesis. The twin deficit hypothesis stipulates that a tax cut raises both the budget and external deficits. In contrast, the Ricardian equivalence hypothesis stipulates that a tax cut raises the budget deficit, but leaves the external deficit unchanged.

Our structural approach employs a tractable small-open economy model with overlapping generations. The model offers the advantage of nesting both the twin deficit and Ricardian equivalence hypotheses. In the model, a tax cut always raises the budget deficit, but not necessarily the external deficit. An increase in the external deficit can happen via two distinct channels: the demographic and forecasting channels. The demographic channel is standard in overlapping-generation models. In these models, consumers can shift a portion of their future tax burden to unborn generations. As a result, a tax cut raises consumer's wealth and aggregate consumption, lowers aggregate saving, and raises the external deficit.

The forecasting channel is less standard, but occurs in most dynamic models. In such models, agents require forecasts of future variables to make optimal choices. As long as the budget deficit contains information useful to forecast the future, it will affect optimal choices and thus the external deficit. As an example, consider the starve-the-beast hypothesis (Bartlett 2007, Romer and Romer 2008). If this hypothesis holds, a current tax cut starves the beasts (by reducing government income) and eventually forces future reductions in government expenditures. As a result, a tax cut raises consumer's wealth and aggregate consumption, lowers aggregate saving, and raises the external deficit.

Our analysis improves on the existing literature in several ways. First, because of its tractability, our approach permits a comprehensive study. Our empirical work uses data for 16 industrialized countries over the post-1975 period. The sample includes an Asian country (Japan), an Australian country (Australia), 12 European countries (Austria, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and United Kingdom), and 2 North American countries (Canada and United States). Although we make international comparisons, we mainly focus our analysis on the Scandinavian countries (Denmark, Norway, and Sweden) plus Finland. This emphasis simplifies the exposition without loss of generalities, because these countries exemplify the disparity found across all the 16 countries. For example, Norway and Sweden display positive comovements between the budget and external deficits, while Denmark and Finland do not (see Figure 1).

Second, our approach allows us to isolate tax shocks. The ability to eliminate the effects of other shocks is crucial to verify whether tax shocks generate positive comovements between the budget and external deficits. To highlight the importance of this exercise, we report the correlation between the deficits for two cases. For the first case, we simply compute the correlation from the raw data. For our countries, these unconditional correlations do not display a specific pattern. For example, we document a large positive and statistically significant unconditional correlation between the budget and external deficits for Norway and Sweden, but only a small and insignificant unconditional correlation for Denmark and Finland. For the second case, we compute the correlations as if the economy was hit only by tax shocks. The resulting conditional correlations display an obvious pattern consistent with twin deficits. The conditional correlations are large, positive, and significant for all countries. For example, the conditional correlations are 0.967 for Denmark, 0.977 for Finland, 0.812 for Norway, and 0.968 for Sweden.

Third, our approach allows us to study the propagation of tax shocks on both budget and external deficits of the different economies. We find that the large conditional correlations are attributable to the positive responses of both deficits to a tax cut over most horizons. A tax cut generates a positive impact response of the budget deficit for all countries, and a positive impact response of the external deficit for most countries. For the countries that do not display the positive impact response, the external deficit rises sharply soon after impact. Over time, the positive responses of the budget and external deficits are persistent. In addition, we document that the tax cut has important effects on the public and external debts for all countries. For example, after a decade, a tax cut that creates a contemporaneous currency unit budget deficit generates an external debt of roughly 61 currency units in Denmark, 35 currency units in Finland, 60 currency units in Norway, and 44 currency units in Sweden.

Finally, our structural approach allows us to disentangle the effects of tax shocks. Our tractable small open-economy model embodies demographic and forecasting channels by which tax shocks affect the economy. Importantly, our approach allows us to study each channel separately, because the model nests versions with and without each channel. Our analysis reveals that both channels are important to understand the mechanisms by which a tax cut generates positive comovements between the budget and external deficits. Both channels work to produce positive conditional correlations between the deficits, and to propagate the tax shocks through time. We document that the forecasting channel explains the shape of the responses of the external deficit, while the demographic channel explains the amplitude of the responses.

The paper is organized as follows. Section 2 presents the structural model and discusses the different channels by which a tax cut affects the external deficit. Section 3 presents our empirical approach. Section 4 discusses our empirical results. Section 5 concludes.

## 2. A Small Open Economy

Our small open-economy model is based on the overlapping-generation model of Blanchard (1985). The model yields solutions where the budget deficit affects the external deficit via two distinct channels.

*2.1 The Model*

The demographic structure of the small open economy is as follows. We define the birth rate to be $p$ and the survival probability to be $(1-p)$. Thus, the period $t$ size of a cohort that was born at any time $s \leq t$ is $P_{s,t} = p(1-p)^{t-s}$, where $P_{s,s} = p$ and total population is $P = \sum_{s=-\infty}^{t} P_{s,t} = 1$. As a result, the economy is populated by overlapping generations of consumers when $0 < p < 1$, but populated by a representative infinitely-lived consumer when $p = 0$. Also, note that as a convention variables indexed by $s$ and $t$ refer to cohort-specific variables, while variables indexed only by $t$ refer to aggregate variables.

At time $t$, a consumer from the cohort that was born at time $s$ chooses a stream of consumption to solve

$$\max_{\{C_{s,t+j}\}} E_t \left[ \sum_{j=0}^{\infty} \left( \frac{1}{1+\rho} \right)^j U(C_{s,t+j}) \right] \tag{1}$$

subject to

$$A_{s,t+1} = (1+\rho)(A_{s,t} + L_{s,t} - T_{s,t} - C_{s,t}). \tag{2}$$

The term $E_t$ is the expectation operator conditional on period $t$ information, $C_{s,t}$ is consumption, $A_{s,t} = (B_{s,t} + F_{s,t})$ is (non-human) wealth where $B_{s,t}$ and $F_{s,t}$ are the quantities purchased of one-period home government and foreign bonds, $T_{s,t}$ is lump-sum taxes, and $L_{s,t}$ is a non-insurable stochastic (labor plus dividend) income. Note that each consumer inelastically supplies a unit of labor, such that labor supply equals total population. As is standard, we assume the existence of insurance firms that make annuity payments to consumers holding wealth during their lives. In exchange, the insurance firms inherit the wealth at the consumer's death. This implies that the gross return on wealth is $(1+\rho) = (1+r)/(1-p)$, where $(1+r)$ is the gross return on one-period bonds.

At time $t$, the firm chooses employment and investment to solve

$$\max_{\{N_t, I_t\}} E_t \left[ \sum_{j=0}^{\infty} \left( \frac{1}{1+r} \right)^t \mathcal{D}_{t+j} \right] \tag{3}$$

subject to

$$\mathcal{D}_t = Y_t - \mathrm{w}_t N_t - I_t, \tag{4}$$

$$Y_t = Z_t K_t^{\alpha} N_t^{1-\alpha}, \tag{5}$$

$$K_{t+1} = I_t + (1-\delta) K_t, \tag{6}$$

where $\mathcal{D}_t$ is dividends, $\mathrm{w}_t$ is the wage rate, $N_t$ is employment, $Z_t$ is a stochastic productivity shock, and $K_t$ is the capital stock. Aggregate income is defined as $L_t \equiv \mathrm{w}_t N_t + \mathcal{D}_t = Y_t - I_t$. In the competitive equilibrium, $N_t = P = 1$.

The home government faces the budget constraint

$$B_{t+1} + B_{t+1}^* = (1+r)(B_t + B_t^* + G_t - T_t), \tag{7}$$

where $B_t^*$ is the quantity purchased of one-period home government bonds by foreign consumers, and $G_t$ is the home government stochastic expenditures on goods and services. The budget deficit is defined as

$$D_t = \left( \frac{r}{1+r} \right) (B_t + B_t^*) + G_t - T_t. \tag{8}$$

The term $[r/(1+r)]\,(B_t + B_t^*)$ denotes debt servicing and $(G_t - T_t)$ is the primary deficit.

The external deficit is defined as the negative of the current account. The current account is measured as the sum of net income from foreign assets and the trade balance:

$$CA_t = \left( \frac{r}{1+r} \right) (F_t - B_t^*) + Q_t - C_t. \tag{9}$$

The term $[r/(1+r)]\,(F_t - B_t^*)$ denotes net income from foreign assets and $Q_t - C_t$ is the trade balance, where $Q_t \equiv Y_t - I_t - G_t$ is net output (output net of investment and government expenditures).

*2.2 The Rules*

We solve the model as follows (see Technical Appendix). First, assuming quadratic preferences, we solve the consumer's problem to obtain cohort-specific consumption functions. Second, we aggregate across consumers to get the aggregate consumption function. Third, we use the aggregate consumption function to substitute out consumption from the current account equation (9). This yields the optimal rule for the current account:

$$CA_t = -\left(\frac{p}{1+r}\right) A_t - \left(\frac{\rho - r}{\rho}\right) D_t + x_t, \tag{10}$$

where

$$x_t = -\sum_{j=1}^{\infty} \left(\frac{1}{1+\rho}\right)^j E_t \left[\Delta Q_{t+j} + \left(\frac{\rho - r}{\rho}\right) \Delta D_{t+j}\right]. \tag{11}$$

Equation (10) relates the current account to wealth, the budget deficit, and the adjusted current account $x_t$. Equation (11) states that the adjusted current account represents the purely forward-looking component of the rule. Note that the forward-looking component depends exclusively on two forcing variables: the change in net output $\Delta Q_t \equiv Q_t - Q_{t-1}$ and the change in the budget deficit $\Delta D_t \equiv D_t - D_{t-1}$. Empirically, expressing the purely forward-looking component of the rule as a function of $\Delta Q_t$ and $\Delta D_t$ ensures stationarity. In addition, note that the current change in net output is unaffected by tax policies (see Technical Appendix).

Fourth, the optimal rule for aggregate wealth is derived from the aggregate consumer's budget constraint and the aggregate consumption function. The result is

$$A_{t+1} = (1-p)A_t + (1+r)\left(\frac{r}{\rho}\right) D_t + w_{t+1}, \tag{12}$$

where

$$w_{t+1} = -(1+r)\sum_{j=1}^{\infty} \left(\frac{1}{1+\rho}\right)^j E_t \left[\Delta Q_{t+j} + \left(\frac{\rho - r}{\rho}\right) \Delta D_{t+j}\right], \tag{13}$$

where $w_{t+1}$ denotes adjusted wealth.

For completeness, the rules are coupled with a law of motion for forcing variables. For now, we model the law of motion that drives these variables as

$$\begin{pmatrix} \Delta Q_{t+1} \\ \Delta D_{t+1} \end{pmatrix} = \begin{pmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{pmatrix} \begin{pmatrix} \Delta Q_t \\ \Delta D_t \end{pmatrix} + \begin{pmatrix} v_{Q,t+1} \\ v_{D,t+1} \end{pmatrix}$$

or

$$H_{t+1} = \Pi H_t + V_{t+1}. \tag{14}$$

We use the process (14) to construct the forecasts of future forcing variables in the forward-looking rules (11) and (13). The adjusted current account reduces to

$$x_t = \theta' H_t \tag{15}$$

or $x_t = \theta_1 \Delta Q_t + \theta_2 \Delta D_t$ where $\theta' = (\theta_1 \quad \theta_2)$ and $\theta' = -\left(e_1' + [(\rho - r)/\rho] e_2'\right) [\Pi/(1+\rho)] [I - \Pi/(1+\rho)]^{-1}$ for $e_1 = (1 \quad 0)'$, $e_2 = (0 \quad 1)'$, and $I$ is the identity matrix. Also, adjusted wealth reduces to

$$w_{t+1} = (1+r)\theta' H_t. \tag{16}$$

*2.3 Tax Cuts and Twin Deficits*

For a given contemporaneous government expenditure, a tax cut innovation clearly results in a budget deficit. To engineer a twin deficit, the budget deficit must generate an external deficit. The relation between the budget and external deficits are summarized by equations (10) and (11), as well as the solution (15). These expressions embed two different channels by which the budget deficit affects the external deficit. The demographic channel operates via the demographic structure of the model, and is controlled by the birth rate $p$. The forecasting channel operates via the dynamic structure of the law of motion, and is controlled by the parameter $\pi_{12}$.

As a benchmark, consider a case where both channels are closed ($p = 0$ and $\pi_{12} = 0$). In this case, $\rho = r$ and equations (10) and (11) reduce to $CA_t = x_t$ and $x_t = -\sum_{j=1}^{\infty} (1+r)^{-j} E_t [\Delta Q_{t+j}]$. Clearly, the budget deficit does not appear in these equations. In addition, the solution (15) becomes $x_t = \theta_1 \Delta Q_t$, given that $\theta_2 = 0$. Again, the budget deficit does not appear in the solution. As a result, there is no relation between the budget and external deficit. From this benchmark, we can sequentially study the effect of opening only one channel.

The effects of the demographic channel depend on the birth rate $p$. When $0 < p < 1$, the economy is populated by overlapping generations, and consumers can shift a fraction

$(0 < [(\rho - r)/\rho] < 1)$ of their tax burden to unborn generations. This ensures that changes in the budget deficit affect the current account. To see this, note that keeping $\pi_{12} = 0$ implies that equations (10) and (11) remain $CA_t = -[p/(1+r)]\, A_t - [(\rho - r)/\rho]\, D_t + x_t$ and $x_t = -\sum_{j=1}^{\infty} (1+\rho)^{-j} E_t [\Delta Q_{t+j} + ((\rho - r)/\rho)\, \Delta D_{t+j}]$. Clearly, the budget deficit appears in these equations: the current level of the budget deficit directly affects the current account and future changes in the budget deficit directly affect the adjusted current account. The latter effect is summarized by solution (15) where $x_t = \theta_1 \Delta Q_t + \theta_2 \Delta D_t$ with $\theta_2 = -[(\rho - r)/\rho]\pi_{22}/[1 + \rho - \pi_{22}]$. The effects on the current account and the adjusted current account both depend on the fraction, $[(\rho - r)/\rho]$, of the tax burden shifted to future generations.

The demographic channel promotes positive comovements between the budget and external deficits. To see this, note that the net effect is determined by the relative sizes of the effect of the budget deficit on the current account $(-[(\rho - r)/\rho])$ and the effect of changes in the budget deficit on the adjusted current account ( $\theta_2 = -[(\rho - r)/\rho]\pi_{22}/[1 + \rho - \pi_{22}]$). It can be shown that $\theta_2 < [(\rho - r)/\rho]$, regardless of the value of $\pi_{22}$. Accordingly, the net effect of an increase in the budget deficit is to reduce the current account on impact. This arises because an increase in the budget deficit leads to a positive wealth effect since consumers eschew a portion of their current tax burden. This wealth effect forces an impact increase in consumption and an impact deterioration of the current account. This impact response suggests a positive correlation between the budget and external deficits.

For illustrative purposes, we verify this intuition from some simulation exercises that account for the dynamics of the budget and external deficits relative to net output (similar transformations will be used in our empirical application). Table 1 shows that the correlation between the budget deficit ratio and the external deficit ratio is positive, regardless of the value of $\pi_{22}$. For these computations, we construct simulated series for the current account from equations (10) and (15), and for the budget deficit and net output from the process (14). To do so, we parametrize $\Pi$ to various values and focus on the innovation $v_{d,t}$ because it directly affects the budget deficit. Formally, we fix $v_{Q,t} = 0$, and assume that $v_{D,t}$ is drawn from a standard normal distribution.

Next, the effects of the forecasting channel depend on the parameter $\pi_{12}$. When

$\pi_{12} \neq 0$, changes in the budget deficit Granger-cause changes in net output. This ensures that changes in the budget deficit affect the current account. To see this, note that keeping $p = 0$ ($\rho = r$) implies that equations (10) and (11) reduce to $CA_t = x_t$ and $x_t = -\sum_{j=1}^{\infty} (1+r)^{-j} E_t [\Delta Q_{t+j}]$. Clearly, the budget deficit does not appear in these equations, so that changes in the budget deficit do not directly affect the current account. However, changes in the budget deficit indirectly affect the current account. That is, equation (15) becomes $x_t = \theta_1 \Delta Q_t + \theta_2 \Delta D_t$ with $\theta_2 = -\pi_{12} / [(1+r-\pi_{11})(1+r-\pi_{22}) - \pi_{12}\pi_{21}]$. Clearly, changes in the budget deficit appear in the solution, because changes in the budget deficit indirectly affect the current account via their effect on expected future net output. The indirect effect occurs because changes in the budget deficit contain information useful to forecast future changes in net output.

Importantly, the forecasting channel can promote either positive or negative comovements between the budget and external deficits. This occurs because the direction of the indirect effect is determined by the sign of $\theta_2$, which is related to the sign of $\pi_{12}$. For example, $\theta_2 < 0$ when $\pi_{12} > 0$ and $\pi_{11} = \pi_{22} = \pi_{21} = 0$. In this case, a rise in the budget deficit signals future increases in net output that generate a positive wealth effect, an increase in consumption, and a deterioration of the current account. This mechanism suggests a positive correlation between the budget and external deficits. In contrast, $\theta_2 > 0$ when $\pi_{12} < 0$ and $\pi_{11} = \pi_{22} = \pi_{21} = 0$. In this case, a rise in the budget deficit signals future reductions in net output that generate a negative wealth effect, a decrease in consumption, and an improvement of the current account. This mechanism suggests a negative correlation between the budget and external deficits.

Table 1 confirms this intuition. Namely, the correlation between the budget deficit ratio and the external deficit ratio is negative for negative values of $\pi_{12}$. Conversely, the correlation is positive for positive values of $\pi_{12}$.

## 3. The Empirical Approach

We wish to study the effects of a tax cut on the budget and external deficits of several countries. To do so, we first generalize the solutions. We then test the main restrictions imposed by the model and provide estimates for the birth rate.

### *3.1 The Augmented Rules*

The solutions (15) and (16) show that the adjusted current account and adjusted wealth are functions of the whole vector of exogenous variables. The solutions embed the effects of both demographic and forecasting channels. Importantly, the forecasting channel operates through the forecast of future forcing variables. However, there may be omitted variables that help forecast future forcing variables, so that the law of motion (14) is misspecified. To ensure that the law of motion is well specified, we follow Boileau and Normandin (2002). That is, we assume that the law of motion for forcing variables is

$$\mathbf{H}_{t+1} = \Pi \mathbf{H}_t + \mathbf{V}_{t+1}, \tag{17}$$

where $\mathbf{H}_t = (\,\Delta Q_t \quad \Delta D_t \quad h_t\,)'$ and $\mathbf{V}_t = (\,v_{Q,t} \quad v_{D,t} \quad v_{h,t}\,)'$. The variable $h_t$ summarizes all variables that contain information useful to forecast future forcing variables. We then use (17) to construct the forecasts in the forward-looking rules (11) and (13). This yields $x_t = \theta' \mathbf{H}_t$ and $w_{t+1} = (1+r)\theta' \mathbf{H}_t$ where $\theta \equiv (\,\theta_1 \quad \theta_2 \quad \theta_3\,)'$ and $\theta' = -\left(\mathbf{e}_1' + [(\rho - r)/\rho]\mathbf{e}_2'\right)[\Pi/(1+\rho)]\left[\mathbf{I} - \Pi/(1+\rho)\right]^{-1}$ for $\mathbf{e}_1 = (\,1 \quad 0 \quad 0\,)'$, $\mathbf{e}_2 = (\,0 \quad 1 \quad 0\,)'$, and $\mathbf{I}$ is the identity matrix.

Unfortunately, we have no detailed knowledge about the additional variable $h_t$. The new solution however suggests that the measurable adjusted current account $x_t$ summarizes all the relevant information required to forecast future forcing variables. That is, we can rewrite the solution in vector form as

$$\mathbf{X}_t = \Theta \mathbf{H}_t, \tag{18}$$

where $\mathbf{X}_t = (\,\Delta Q_t \quad \Delta D_t \quad x_t\,)'$ and $\Theta = (\,\mathbf{e}_1 \quad \mathbf{e}_2 \quad \theta\,)'$. Equation (18) is used to rewrite the law of motion (17) as

$$\mathbf{X}_{t+1} = \Gamma \mathbf{X}_t + \mathbf{U}_{x,t+1}, \tag{19}$$

where $\Gamma = \Theta \Pi \Theta^{-1}$ and $\mathbf{U}_{x,t} = \Theta \mathbf{V}_t$. This suggests that an unrestricted version of the VAR (19) can be used to make adequate forecasts of future forcing variables.

Applying this insight to construct the forecasts in the forward-looking rule (11) results in

$$\widehat{x}_t = \upsilon' \mathbf{X}_t, \tag{20}$$

where $\widehat{x}_t$ is the predicted value of the adjusted current account, and the vector of parameter is $\upsilon' = -\left[\mathbf{e}_1' + ((\rho - r)/\rho)\mathbf{e}_2'\right](\Gamma/(1+\rho))\left[\mathbf{I} - \Gamma/(1+\rho)\right]^{-1}$. This yields the predicted VAR:

$$\widehat{\mathbf{X}}_{t+1} = \Gamma_x \widehat{\mathbf{X}}_t + \widehat{\mathbf{U}}_{x,t+1}, \tag{21}$$

where $\widehat{\mathbf{X}}_t = \begin{pmatrix} \Delta Q_t & \Delta D_t & \widehat{x}_t \end{pmatrix}'$, $\Gamma_x = \Upsilon\Gamma\Upsilon^{-1}$, $\widehat{\mathbf{U}}_{x,t} = \Upsilon\mathbf{U}_{x,t}$ for $\Upsilon = \begin{pmatrix} \mathbf{e}_1 & \mathbf{e}_2 & \upsilon \end{pmatrix}'$.

For completeness, we specify the unrestricted VAR for adjusted wealth as

$$\mathbf{W}_{t+1} = \Psi \mathbf{W}_t + \mathbf{U}_{w,t+1}, \tag{22}$$

where $\mathbf{W}_t = \begin{pmatrix} \Delta Q_t & \Delta D_t & w_{t+1} \end{pmatrix}'$. Using the VAR (22) to forecast the future forcing variables in rule (13) yields the predicted VAR:

$$\widehat{\mathbf{W}}_{t+1} = \Psi_w \widehat{\mathbf{W}}_t + \widehat{\mathbf{U}}_{w,t+1}, \tag{23}$$

where $\widehat{\mathbf{W}}_t = \begin{pmatrix} \Delta Q_t & \Delta D_t & \widehat{w}_{t+1} \end{pmatrix}'$, $\Psi_w = \Phi\Psi\Phi^{-1}$, $\widehat{\mathbf{U}}_{w,t} = \Phi\mathbf{U}_{w,t}$, $\Phi = \begin{pmatrix} \mathbf{e}_1 & \mathbf{e}_2 & \phi \end{pmatrix}'$, $\phi = -(1+r)\left[\mathbf{e}_1' + ((\rho - r)/\rho)\mathbf{e}_2'\right](\Psi/(1+\rho))\left[\mathbf{I} - \Psi/(1+\rho)\right]^{-1}$, and $\widehat{w}_t$ is the predicted adjusted wealth.

Finally, we obtain augmented rules for the current account and wealth by coupling these new solutions for the adjusted current account and adjusted wealth to the optimal rules (10) and (12).

### *3.2 Tax Shocks*

In our analysis, we seek to study the effects of orthogonal tax shocks on both the budget and external deficits. For this, we transform the statistical innovations of the unrestricted laws of motion to recover the structural shocks, and in particular the tax shock. The transformation involves applying a Cholesky decomposition. For example, consider the decomposition $\Xi_{x,t} = \Lambda_x^{-1}\mathbf{U}_{x,t}$ where $\Xi_{x,t}$ is the vector of structural shocks, $\mathbf{U}_{x,t}$ is the vector of statistical innovations, $\Lambda_x$ is a lower triangular matrix, $E(\mathbf{U}_{x,t}\mathbf{U}'_{x,t}) = \Lambda_x\Lambda'_x$, and $E(\Xi_{x,t}\Xi'_{x,t}) = \mathbf{I}$. The decomposition imposes the following relations

$$\lambda^*_{11}u_{Q,t} = \xi_{Q,t}, \tag{24}$$

$$\lambda^*_{22}u_{D,t} = -\lambda^*_{21}u_{Q,t} + \xi_{T,t}, \tag{25}$$

$$\lambda^*_{33}u_{x,t} = -\lambda^*_{31}u_{Q,t} - \lambda^*_{32}u_{D,t} + \xi_{x,t}, \tag{26}$$

where $\mathbf{U}_{x,t} = \begin{pmatrix} u_{Q,t} & u_{D,t} & u_{x,t} \end{pmatrix}'$, $\Xi_{x,t} = \begin{pmatrix} \xi_{Q,t} & \xi_{T,t} & \xi_{x,t} \end{pmatrix}'$, and $\lambda^*_{ij}$ is the $(i,j)$ element of $\Lambda_x^{-1}$.

Equation (24) implies that the statistical innovation to net output $u_{Q,t}$ depends only on the orthogonal structural shock $\xi_{Q,t}$ and thus is orthogonal to all other shocks. This is consistent with our model where net output is unaffected at impact by tax policies and current account movements (see technical appendix).

Equation (25) implies that the statistical innovation to the budget deficit $u_{D,t}$ is affected by the statistical innovation to net output $u_{Q,t}$ and an orthogonal structural shock $\xi_{T,t}$. The dependence of $u_{D,t}$ with respect to $u_{Q,t}$ reflects changes in the budget deficit that are related to changes in the economic condition. Also, this dependence accords with our model, since, by definition, the budget deficit and net output are both affected at impact by government expenditures. As a result, the portion of $u_{D,t}$ that is orthogonal to $u_{Q,t}$ is unaffected by government expenditures. Thus, $\xi_{T,t}$ captures a current change of the budget deficit that is unrelated to government expenditures, and as such represents a tax shock.

Equation (26) implies that the statistical innovation to the adjusted current account $u_{x,t}$ is affected by the statistical innovation to net output $u_{Q,t}$, the statistical innovation to the budget deficit $u_{D,t}$, and an orthogonal structural shock $\xi_{x,t}$. The dependence of $u_{x,t}$ with respect to $u_{Q,t}$ and $u_{D,t}$ is consistent with our model, as depicted by the solution for the adjusted current account (20).

*3.3 Birth Rates and Model Restrictions*

Finally, the empirical approach relies on the adjusted current account and adjusted wealth, which are measured from observables and the parameters $r$ and $p$. We calibrate the value of the real interest rate to $r = 0.01$ per quarter. We estimate the value of the birth rate $p$ by exploiting the orthogonality restrictions implied by the null hypothesis that the model is valid. Under the null, the predicted and actual adjusted current accounts are the same: $\widehat{x}_t = x_t$. This implies that $\varepsilon_t = x_t - (1+\rho)x_{t-1} - \Delta Q_t - ((\rho - r)/\rho)\,\Delta D_t$ must be orthogonal to all lagged variables (see Technical Appendix).

Table 1 presents the actual birth rate $\wp$ as well as different estimates of the birth rate based on the orthogonality restrictions. Our estimates use post-1975 quarterly data for 16 industrialized countries, including Denmark, Finland, Norway, and Sweden (see Data Appendix). The estimate $\underline{p}$ and $\overline{p}$ are the smallest and largest values for which the orthogonality conditions are not rejected at the 1, 5, and 10 percent levels of significance. These bounds are obtained by performing a grid search for the values of the birth rate and selecting those for which all the coefficients associated with the regression of $\varepsilon_t$ on $x_{t-1}$, $\Delta Q_{t-1}$, and $\Delta D_{t-1}$ are jointly insignificant. The estimate $\widehat{p}$ is a generalized method of moments (GMM) estimate. For this, we exploit the orthogonality between $\varepsilon_t$ and a vector that includes a constant, $\Delta Q_{t-1}$, and $\Delta D_{t-1}$.

First, the numerical values of the lower bound $\underline{p}$ are strictly positive and the higher bound $\overline{p}$ is strictly smaller than unity at the 1 percent level for all countries. The 1 percent level bound $\underline{p}$ is 0.1 percent for most countries, with the exception of 0.3 percent for the Netherlands. The 1 percent level bound $\overline{p}$ ranges from a low of 1.3 percent in Germany to a high of 7.7 percent in Italy. At other levels, the bounds are not always defined. For those that are defined, the lower bound $\underline{p}$ is strictly positive and the higher bound $\overline{p}$ is strictly smaller than unity.

Second, the GMM estimates $\widehat{p}$ are not statistically different from the lower bound $\underline{p}$ for all countries. The estimates $\widehat{p}$ fall inside the 1 percent bounds for all countries, but Germany and Norway. Although the birth rate estimates $\widehat{p}$ are imprecise, the overidentifying restrictions related to the GMM estimates are never rejected. The implication is that the orthogonality restrictions statistically hold for all countries.

Third, the actual birth rates $\wp$ range from a low of 1 percent per quarters in Germany to a high of 1.5 percent in Australia, Canada, and the United States. The actual birth rates $\wp$ fall inside the 1 percent level bounds $\underline{p}$ and $\overline{p}$ for all countries. Importantly, the restrictions of the model hold for the actual birth rate $\wp$ at the 1 percent level for all countries, including the Scandinavian countries.

## 4. Results

We first describe the data. We then use the our structural approach to construct the responses of the budget deficit and the external deficit to a tax cut.

### *4.1 Data Description*

Figure 1 plots the ratio of the external deficit to output and the ratio of the budget deficit to output for all the countries in our sample. A visual inspection suggests that the two deficits are positively correlated in some countries (e.g. Italy and Norway), but negatively correlated for others (e.g. Canada, Spain, and United Kingdom). For example, the budget deficit of Canada, France, Italy, and Spain show a similar pattern. The budget deficit was relatively high in the mid-70s, high in the mid-80s, and high again in the mid 90s. In contrast, for the same time periods, the external deficit was relatively low in Canada and Spain, high in Italy, and somewhere in between in France. For other countries, there are no sizeable correlations between the two deficits. For example, starting from the early 90s, the budget deficit started to climb rapidly in Japan, without any sizeable movements in the external deficit. During the same period, the external deficit plummeted in Switzerland without any sizeable movements in the budget deficit. As for the whole group of countries, the Scandinavian economies do not display a specific pattern. There are strong positive comovements between the budget and external deficits for Norway and Sweden, but not for Denmark and Finland.

Table 2 provides estimates of the unconditional contemporaneous correlation between the external deficit ratio and the budget deficit ratio. The two deficits are positively correlated in some countries and negatively correlated for others. The unconditional correlation ranges from a low of -0.468 for Canada to a high of 0.643 in Norway. It is negative for 9 countries and positive for 7 countries. As expected, the Scandinavian countries do not display a specific pattern. There is a large positive and statistically significant unconditional correlation between the two deficits for Norway and Sweden, but a small and insignificant unconditional correlation for Denmark and Finland.

So far, the data show little evidence of a general pattern of twin deficits. Importantly, the unconditional correlations jointly capture the effects of several shocks, and do not provide enough information to isolate the effects of specific shocks such as tax cuts.

### *4.2 Tax Cuts and Twin Deficits*

Table 3 provides estimates of the conditional contemporaneous correlation between the budget deficit ratio and the external deficit ratio. To isolate the effects of taxes, the conditional correlations are computed from the predicted VARs (21) and (23), assuming that the economy is hit only by tax shocks (see Technical Appendix). For this exercise, the correlations are computed for a benchmark calibration that uses a quarterly real interest rate of $r = 0.01$ and the actual birth rate $\wp$. Recall that the actual birth rate falls well within the range of values for which the model's orthogonality restriction holds for all countries.

Importantly, the conditional correlations generated by our benchmark calibration display a systematic pattern of twin deficits for all the countries. The positive conditional correlations are all numerically large and significantly different from zero. The conditional correlations range from a low of 0.416 for Switzerland to a high of 0.993 for Austria. The conditional correlations are 0.967 for Denmark, 0.977 for Finland, 0.812 for Norway, and 0.968 for Sweden.

Intuitively, the positive conditional correlations between the budget and external deficits can be attributed to the positive responses of both deficits to a tax cut over most horizons. To see this, Figure 2 displays the dynamic responses of the budget and external deficits to a unit reduction of the tax shock. That is, the figure shows the dynamic responses to an unexpected unit increase of the budget deficit that is exclusively due to an unexpected tax cut. The dynamic responses are computed using the predicted VARs (21) and (23) (see Technical Appendix). Figure 3 shows the probability values of the test that the response of the external deficit is null for each period. The test relies on a $\chi^2(1)$ statistic and accounts for the uncertainty associated with the estimated parameters in the unrestricted VARs. To be concise, we do not present the probability values for the responses of the budget deficit, but those are statistically significant for all countries (these results can be obtained from the authors).

By design, the tax cut generates unit positive impact responses of the budget deficit for all countries. The positive responses of the budget deficit are highly persistent for most countries. Focusing on the Scandinavian countries, the responses appear extremely persistent for Norway, but less so for Denmark, Finland, and Sweden. As previously stated, these responses are statistically significant.

The tax cut also generates large positive impact responses of the external deficit for most countries. The impact responses of the external deficit are close to unity for several countries. That is, a one unit rise in the budget deficit due to a tax cut leads to a one unit rise in the external deficit. Exceptions include the negative impact responses for Australia, Japan, and Norway, as well as the very large positive impact responses of Finland and Sweden. For the countries that initially display negative responses, the external deficit rises sharply soon after impact. Finally, the responses of the external deficit appear very persistent for many countries, but much less so for Finland, Italy, Sweden, and the United States.

Figure 3 shows that the impact responses of the external deficit are significant for most countries. The impact responses are not statistically different from zero for Australia and Japan, two of the four countries that display impact reductions of the external deficit. The impact responses are also statistically null for Denmark and Germany. Over time, the responses are significant for most countries, but become insignificant for some (Finland, France, Italy, Sweden, and United States).

Finally, we evaluate the effects of a tax cut on the public and external debts at different horizons. The responses of the debts are obtained by cumulating the responses of the deficits. To be concise, we do not present the responses of the public debt, but they are positive and significant at all considered horizons. Table 4 provides the responses of the external debt at impact, after 5 years, and after a decade. After a decade, the responses are positive and significant for most countries. More importantly, the rises are economically meaningful. For example, a Danish Krone increase in the budget deficit of

Denmark raises their external debt by 0.825 Krone at impact, 36.897 Kroner after five years, and 61.036 Kroner after a decade. For the other Scandinavian countries, a tax cut that creates a current currency unit budget deficit generates an external debt of roughly 35 currency units in Finland, 60 currency units in Norway, and 44 currency units in Sweden after a decade.

Overall, these results provide ample evidence that a tax cut generates twin deficits. The positive conditional correlations between the budget and external deficits are large and significant. The positive and significant dynamic responses of the two deficits explains the conditional correlation and describe the mechanism by which the tax cut is propagated through time. Finally, the responses of the deficits have large economic repercussions on the public and external debts.

### *4.3 Demographic versus Forecasting Channels*

To disentangle the effects of the different channels on the propagation of the tax shock, we reproduce our empirical results while shutting down the different channels. In what follows, the conditional correlations and dynamic responses are computed as before. To do so, we reestimate the full structural model for the different parametrizations. This implies small differences in the responses of the budget deficit to the tax shock, but the responses remain significantly positive at all horizons.

The results under no demographic are computed for a version of our structural model that closes the demographic channel. These results appear in Figure 4, as well as Tables 3 and 4. For this, we set the birth rate to the lower bound $\underline{p}$ for which the restrictions of the model hold. Although these values are not strictly null, they are small enough that the demographic channel is virtually closed. With this parametrization, consumers find it very difficult to shift their tax burden to unborn generations.

The results under no forecasting are computed for a version of our structural model that closes the forecasting channel. The results appear in Figure 6, as well as Tables 3 and 4. For this, we employ a law of motion where the changes in the budget deficit and in net output follow univariate autoregressive (AR) processes. As such, the matrix $\Pi$ in VAR (17) is strictly diagonal, which forces $\Gamma_x$ to be lower triangular. In that sense, current budget deficits contain no information useful to forecast future changes in net output, and this closes the forecasting channel. With this parametrization, the starve-the-beast type mechanism is absent.

The conditional correlations suggest that both channels are important for the determination of twin deficits. For the no demographic channel, the model does not have a strong prediction concerning the sign of the conditional correlations (see Section 2.3). It is interesting to note that the estimated conditional correlations are all positive and statistically significant. The conditional correlations range from 0.253 for the Netherlands to 0.950 for France. The conditional correlations are 0.730 for Denmark, 0.788 for Finland, 0.505 for Norway, and 0.913 for Sweden. For the no forecasting channel, the model predicts non-negative conditional correlations. As expected, the estimated conditional correlations are positive, numerically large, and statistically significant. The conditional correlations range from 0.897 for Italy to 0.997 for France, the Netherlands, and Sweden. The conditional correlations are 0.985 for Denmark, 0.984 for Finland, 0.989 for Norway, and 0.997 for Sweden.

To understand the transmission of the tax shock, we compare the dynamic responses of the external deficit obtained under each channel to those obtained with the benchmark calibration of the model. The comparison suggests that the amplitude of the benchmark responses is attributable to the demographic channel, while the shape of the benchmark responses is attributable to the forecasting channel. For the no demographic channel, the dynamic responses of the external deficit have similar shapes, but smaller amplitudes than the responses generated by the benchmark calibration of the model. Exceptions include Finland and Italy. The responses are statistically different from zero in a number of countries (not reported for conciseness), but are fairly small. Accordingly, the cumulated responses of the external deficit are often small and insignificant. For the Scandinavian countries, the dynamic responses of the external deficit are small (and eventually significant) for Denmark and Norway, but are small (and always insignificant) for Finland and Sweden. Also, the cumulated responses of the external deficit are all insignificant.

For the no forecasting channel, the dynamic responses of the external deficit are large and persistent, but do not display the shapes generated by the benchmark calibration.

As a result, the cumulated responses of the external deficit are all large and significant. Note that the restrictions imposed by univariate AR processes ensure that the responses are precisely estimated. For the Scandinavian countries, the dynamic responses and the cumulated responses of the external deficit exhibit the features documented for the other countries.

These results suggest that the demographic and forecasting channels are important in understanding how a tax cut generates twin deficits. Both channels work to produce positive conditional correlations between the deficits. In particular, the forecasting channel explains the shape of the responses of the external deficit, while the demographic channel explains the amplitude of the responses.

## 5. Conclusion

We study the effects of tax shocks on the budget and external deficits of industrialized economies over the post-1975 period. To do so, we employ a tractable small open-economy model with overlapping generations. In the model, a tax cut raises the budget deficit. In turn, the increase in the budget deficit may affect the external deficit via two distinct channels. The demographic channel is standard and occurs when consumers can shift a portion of their future tax burden to unborn generations. The forecasting channel is less standard, and occurs when agents require forecasts of future variables to make optimal choices.

We find that tax shocks generate positive comovements between budget and external deficits for all the countries in our sample. Conditioning on tax shocks, the correlation between the budget and external deficits are large, positive, and significant. These conditional correlations are attributable to the positive responses of both deficits to a tax cut over most horizons. Finally, we find that both demographic and forecasting channels play a role in producing positive comovements. That is, the forecasting channel explains the shape of the responses of the external deficit, while the demographic channel explains the amplitude of the responses.

## Technical Appendix

*The Forward-Looking Rules*

The forward-looking rules for the current account and wealth are derived from the consumer's problem. The consumer chooses consumption to maximize lifetime utility (1) subject to the budget constraint (2). Assuming that consumers have quadratic preferences, consumption is a martingale:

$$E_t\left[C_{s,t+1}\right] = C_{s,t}. \tag{A.1}$$

Using the budget constraint (2), the Euler equation (A.1) is solved to yield the individual consumption function

$$C_{s,t} = \left(\frac{\rho}{1+\rho}\right)\left(A_{s,t} + \sum_{j=0}^{\infty}\left(\frac{1}{1+\rho}\right)^j E_t\left[L_{s,t+j} - T_{s,t+j}\right]\right). \tag{A.2}$$

We aggregate cohort-specific consumption functions (A.2) and budget constraints (2) to obtain the aggregate consumption function and the aggregate budget constraint:

$$C_t = \left(\frac{\rho}{1+\rho}\right)\left(A_t + \sum_{j=0}^{\infty}\left(\frac{1}{1+\rho}\right)^j E_t\left[L_{t+j} - T_{t+j}\right]\right) \tag{A.3}$$

and

$$A_{t+1} = (1+r)\left(A_t + L_t - T_t - C_t\right), \tag{A.4}$$

where $C_t = \sum_{s=-\infty}^{t} P_{s,t}C_{s,t}$, $A_t = \sum_{s=-\infty}^{t} P_{s,t}A_{s,t} = \sum_{s=-\infty}^{t} P_{s,t}\left[B_{s,t} + F_{s,t}\right] = B_t + F_t$, and $A_{t+1} = \sum_{s=-\infty}^{t+1} P_{s,t+1}A_{s,t+1} = (1-p)\sum_{s=-\infty}^{t} P_{s,t}A_{s,t+1} = B_{t+1} + F_{t+1}$. Following Gali (1990), we assume that income and taxes are identical across consumers of different cohort, $L_{s,t} = L_t$ and $T_{s,t} = T_t$, such that aggregate labor income and taxes are $L_{t+j} = \sum_{s=-\infty}^{t} P_{s,t}L_{s,t+j}$ and $T_{t+j} = \sum_{s=-\infty}^{t} P_{s,t}T_{s,t+j}$.

To obtain the rule for the external deficit, we restate the consumption function in terms of the changes in net output $\Delta Q_t \equiv Q_t - Q_{t-1}$ and in budget deficit $\Delta D_t \equiv D_t - D_{t-1}$. Following Normandin (1999), we replace tax revenues with $T_{t+j} = \left[r/(1+r)\right](B_t + B_t^*) + (1+r)\sum_{k=0}^{j-1} D_{t+k} + G_{t+j} - D_{t+j}$ in the consumption function (A.3):

$$\begin{aligned} C_t = {} & \left[\left(\frac{\rho}{1+\rho}\right)(B_t + F_t) - \left(\frac{r}{1+r}\right)(B_t + B_t^*)\right] + \left[Q_t + \left(\frac{\rho - r}{\rho}\right) D_t\right] \\ & + \sum_{j=1}^{\infty}\left(\frac{1}{1+\rho}\right)^j E_t\left[\Delta Q_{t+j} + \left(\frac{\rho - r}{\rho}\right)\Delta D_{t+j}\right]. \end{aligned} \tag{A.5}$$

Substituting (A.5) in the current account equation (9) yields

$$
\begin{aligned}
CA_t = &-\left(\frac{p}{1+r}\right)A_t - \left(\frac{\rho-r}{\rho}\right)D_t \\
&- \sum_{j=1}^{\infty}\left(\frac{1}{1+\rho}\right)^j E_t\left[\Delta Q_{t+j} + \left(\frac{\rho-r}{\rho}\right)\Delta D_{t+j}\right]. \qquad (A.6)
\end{aligned}
$$

Using the aggregate budget constraint (A.4) and the consumption function (A.3), the rule for wealth is

$$
\begin{aligned}
A_{t+1} =&(1-p)A_t + (1+r)\left(\frac{r}{\rho}\right)D_t \\
&-(1+r)\sum_{j=1}^{\infty}\left(\frac{1}{1+\rho}\right)^j E_t\left[\Delta Q_{t+j} + \left(\frac{\rho-r}{\rho}\right)\Delta D_{t+j}\right]. \qquad (A.7)
\end{aligned}
$$

*Income, Investment, and Output*

In the model, current income, investment, output, and net output are unaffected by tax policies. To see this, consider the firm's problem. At time $t$, the firm chooses labor and investment to maximize the present value of dividends (3) subject to the definition of dividends (4), the production technology (5), and the accumulation equation (6). The optimality conditions are

$$\mathrm{w}_t = (1-\alpha)Y_t/N_t, \qquad (A.8)$$

$$1 + r = E_t\left[\alpha(Y_{t+1}/K_{t+1}) + 1 - \delta\right]. \qquad (A.9)$$

Note that, in equilibrium, $N_t = P = 1$, $Y_t = Z_t K_t^{\alpha}$, $L_t \equiv \mathrm{w}_t + \mathcal{D}_t = Y_t - I_t$, $K_{t+1}^{1-\alpha} = (\alpha/(r+\delta))\, E_t\left[Z_{t+1}\right]$, $I_t = K_{t+1} - (1-\delta)K_t$, and $Q_t = Y_t - I_t - G_t$. As a result, contemporaneous income $L_t$, investment $I_t$, output $Y_t$, and net output $Q_t$ are unaffected by tax policies.

*The Orthogonality Conditions*

The orthogonality conditions ensure that, under the null hypothesis that the model is valid, the actual and predicted adjusted current accounts are the same: $\widehat{x}_t = x_t$. Recall that $\widehat{x}_t = \upsilon'\mathbf{X}_t$ for $\upsilon' = -\left[\mathbf{e}_1' + ((\rho-r)/\rho)\mathbf{e}_2'\right](\Gamma/(1+\rho))\left[\mathbf{I} - \Gamma/(1+\rho)\right]^{-1}$, and that $x_t = \mathbf{e}_3'\mathbf{X}_t$. Thus, under the null,

$$-\left[\mathbf{e}_1' + ((\rho-r)/\rho)\mathbf{e}_2'\right](\Gamma/(1+\rho))\left[\mathbf{I} - \Gamma/(1+\rho)\right]^{-1} = \mathbf{e}_3'. \qquad (A.10)$$

Post-multiplying both sides of (A.10) by $(1+\rho)\left[\mathbf{I} - \Gamma/(1+\rho)\right]\mathbf{X}_{t-1}$ and rearranging yields

$$\left[\mathbf{e}_3' - \mathbf{e}_1' - ((\rho-r)/\rho)\mathbf{e}_2'\right]\mathbf{X}_t - (1+\rho)\mathbf{e}_3'\mathbf{X}_{t-1} = \left[\mathbf{e}_3' - \mathbf{e}_1' - ((\rho-r)/\rho)\mathbf{e}_2'\right]\mathbf{U}_{x,t}, \qquad (A.11)$$

where $\mathbf{X}_t = \mathbf{\Gamma X}_{t-1} + \mathbf{U}_{x,t}$. From (A.11), we define

$$\varepsilon_t \equiv \left[\mathbf{e}_3' - \mathbf{e}_1' - ((\rho - r)/\rho)\mathbf{e}_2'\right]\mathbf{X}_t - (1+\rho)\mathbf{e}_3'\mathbf{X}_{t-1}. \qquad (A.12)$$

Equation (A.12) states that $\varepsilon_t$ is a function of observables, as well as $r$ and $p$ (via $\rho$): $\varepsilon_t = x_t - \Delta Q_t - ((\rho - r)/\rho)\Delta D_t - (1+\rho)x_{t-1}$. Also from (A.11), note that

$$\varepsilon_t = \left[\mathbf{e}_3' - \mathbf{e}_1' - ((\rho - r)/\rho)\mathbf{e}_2'\right]\mathbf{U}_{x,t}. \qquad (A.13)$$

Equation (A.13) shows that $\varepsilon_t$ is an innovation. In our empirical work, we exploit the orthogonality between this innovation and lagged variables to estimate the birth rate.

*The Conditional Measures*

We compute the conditional contemporaneous correlation between the budget deficit ratio and the external deficit ratio using the predicted VARs (21) and (23), but where we only retain the tax shocks. For this, we use Cholesky decompositions of the covariance matrices of the statistical innovations $\mathbf{U}_{x,t}$ and $\mathbf{U}_{w,t}$. As such, the vector of structural shocks are $\Xi_{x,t} = \Lambda_x^{-1}\mathbf{U}_{x,t}$ and $\Xi_{w,t} = \Lambda_w^{-1}\mathbf{U}_{w,t}$, where $\Lambda_x$ and $\Lambda_w$ are lower triangular matrices with positive elements on the diagonal such that $\Lambda_x\Lambda_x' = E(\mathbf{U}_{x,t}\mathbf{U}_{x,t}')$ and $\Lambda_w\Lambda_w' = E(\mathbf{U}_{w,t}\mathbf{U}_{w,t}')$. We then retain the structural tax shocks and discard all the other shocks. We feed these tax shocks in the predicted VARs to obtain simulated paths of the change in net output, the change in the budget deficit, the adjusted current account, and adjusted wealth. Finally, the simulated data are used to compute the budget deficit to net output ratio and the external deficit to net output ratio.

We also construct the dynamic responses of the budget and external deficits using predicted VARs. The $j^{th}$ response of the change in the budget deficit to the fiscal policy shock is $R_{\Delta D,j} = \mathbf{e}_2'\Gamma_x^j\Upsilon\Lambda_x\mathbf{e}_2$, where we normalize the shock to unity. Then, the $j^{th}$ response of the level of the budget deficit is constructed by summing the responses of the change in the budget deficit:

$$R_{D,j} = \sum_{i=0}^{j} R_{\Delta D,i}. \qquad (A.14)$$

Also, the $j^{th}$ response of the adjusted current account and adjusted wealth are $R_{x,j} = \mathbf{e}_3'\Gamma_x^j\Upsilon\Lambda_x\mathbf{e}_2$, and $R_{w,(j+1)} = \mathbf{e}_3'\Psi_w^j\Phi\Lambda_w\mathbf{e}_2$, where we normalize the shock to unity. Finally, the $j^{th}$ response of the current account is

$$R_{CA,j} = R_{x,j} - \left(\frac{p}{1+r}\right)R_{A,j} - \left(\frac{\rho - r}{\rho}\right)R_{D,j}, \qquad (A.15)$$

where $R_{A,j}$ is constructed from

$$R_{A,(j+1)} = R_{w,(j+1)} + (1-p)R_{A,j} + (1+r)\left(\frac{r}{\rho}\right)R_{D,j}, \qquad (A.16)$$

for $R_{A,0} = 0$ (since wealth is predetermined).

## Data Appendix

The quarterly seasonally adjusted measures are constructed for the post-1975 period, using raw data from the International Financial Statistics (IFS) released by the International Monetary Funds, the Economic Outlook (EO) published by the Organization for Economic Cooperation and Development, and the World Development Indicators (WDI) reported by the World Bank. In our analysis, we measure variables in local currencies.

The countries (samples) are Australia (1975-I to 2002-IV), Austria (1975-I to 1998-IV), Canada (1976-II to 1995-III), Denmark (1981-1 to 1999-IV), Finland (1975-I to 1998-IV), France (1975-I to 1998-IV), Germany (1975-I to 1998-IV), Italy (1975-I to 1998-IV), Japan (1977-I to 2004-IV), Netherlands (1977-I to 1998-IV), Norway (1975-I to 2003-IV), Spain (1975-I to 1998-IV), Sweden (1980-I to 2004-IV), Switzerland (1977-I to 2004-IV), the United Kingdom (1975-I to 1998-I), and the United States (1975-I to 2006-III). Germany refers to West Germany and Unified Germany for the pre- and post-1990 periods. Finally, the samples for the European countries end in 1998 to avoid convertibility issues related to the creation of the Euro.

*Current Account*

The current account is the product of the nominal current account in US dollars (source: IFS) and the nominal exchange rate of national currency units per US dollar (source: IFS), divided by a price index. For Norway and Switzerland, the nominal current account is interpolated from an annual to quarterly frequency by the algorithm Distrib (source: RATS) over the subsamples for which quarterly data are unavailable. Otherwise, the nominal current account is seasonally adjusted by the exponential smoothing algorithm Esmooth (source: RATS). Also, for Germany the price index is the Gross Domestic Product (GDP) deflator (source: IFS). For the other countries, the price index is the all-item consumer price index (CPI) (source: IFS).

*Budget Deficit*

The budget deficit is defined as the negative of the nominal budget surplus in national currency divided by the price index. For Japan, the nominal budget surplus is obtained by multiplying the sum of the primary surplus to GDP ratio (source: EO) and the net interest income to GDP ratio (source: EO) by the nominal GDP in national currency (source: IFS). For the other countries, the nominal budget surplus is directly collected (source: IFS). For Australia, Denmark, Germany, Norway, Sweden, and Switzerland the nominal budget surplus is interpolated over the subsamples for which quarterly data are unavailable. Otherwise, the seasonality in the nominal budget surplus is removed.

*Net Output*

Net output is measured as nominal GDP in national currency (source: IFS) minus the sum of nominal government expenditures in national currency (source: IFS) and nominal investment expenditures in national currency (source: IFS), normalized by the price index. For Austria, Denmark, Finland, Norway, and Sweden, nominal GDP as well as nominal investment and government expenditures are transformed to remove seasonal effects.

*Wealth*

Wealth is the sum of the nominal net foreign assets in US dollars (source: Lane and Milesi-Ferretti 2007) adjusted by the nominal exchange rate of national currency units per US dollar (source: IFS) and the nominal domestic government debt in national currency, deflated by the price index. For all countries, the nominal net foreign assets is interpolated from an annual to quarterly frequency.

For Japan, the nominal government debt is obtained by multiplying the nominal government debt to GDP ratio (source: EO) by the nominal GDP in national currency (source: IFS). For Australia and Denmark, the nominal government debt is measured as the product of the nominal debt service (source: IFS) and the reciprocal of the annuity factor $(1 + r)/r$, where the nominal debt service is interpolated and the interest rate $r$ is fixed to 4 percent per year. For the other countries, the nominal government debt is directly collected (source: IFS). For Austria, Canada, Norway, Spain, Sweden, Switzerland, and the United Kingdom, the nominal government debt is interpolated over some subsamples. For France, Netherlands, and Sweden, the nominal government debt is transformed to remove seasonal effects.

*Birth Rates*

Birth rate refers to the sample average of birth rates (source: WDI).

## References


Bartlett, B., 2007. Starve the beast. Origins and development of a budgetary metaphor. *The Independent Review* **12**, 5–26.

Bartolini, L. and Lahiri, A., 2006. Twin deficits, twenty years later. *Current Issues in Economics and Finance* **12**, 1–7.

Beetsma, R., Klaassen, F., and Giuliodori, M., 2008. The effects of public spending shocks on trade balances and budget deficits in the European Union. *Journal of the European Economic Association* **6**, 414–423.

Blanchard, O., 1985. Debt, deficits, and finite horizons. *Journal of Political Economy* **93**, 223–247.

Boileau, M., and Normandin, M., 2002. Aggregate employment, real business cycles, and superior information," *Journal of Monetary Economics* **49**, 495–520.

Bussiere, M., Fratzscher, M., and Muller, G., 2005. Productivity shocks, budget deficits, and the current account, *European Central Bank* Working Paper Series No. 509.

Chinn, M., 2005. Getting serious about the twin deficits. Council on Foreign Relations, Council Special Report no. 10.

Corsetti, G. and Muller, G., 2008. Twin deficits, openness, and the business cycle. *Journal of the European Economic Association*, **6**, 404–413.

Corsetti, G. and Muller, G., 2006. Twin deficits: Squaring theory, evidence and common sense. *Economic Policy*, 597638.

Gali, J., 1990. Finite horizons, life cycle savings, and time series evidence on consumption. *Journal of Monetary Economics* **26**, 433–452.

Lane, P., and Milesi-Ferretti, G.M., 2007. The external wealth of nations mark II: Revised and expanded estimates of foreign assets and liabilities, 1970-2004. *Journal of International Economics* **73**, 223–250.

Normandin, M., 1999. Budget deficit persistence and the twin deficit hypothesis. *Journal of International Economics* **49**, 171–193.

Romer, C., and Romer, D., 2008. Do tax cuts starve the beast? The effect of tax changes on government spending. Mimeo, University of California Berkeley.

**Table 1. Simulated Correlations**

Panel A: Demographic Channel ($\pi_{12} = 0$)

| | | $p$ | | | | |
|---|---|---|---|---|---|---|
| | | 0.00 | 0.01 | 0.03 | 0.05 | 0.10 |
| $\pi_{22}$ | −0.90 | 0.00 | 0.91 | 0.90 | 0.90 | 0.90 |
| | 0.00 | 0.00 | 0.99 | 0.98 | 0.98 | 0.98 |
| | 0.90 | 0.00 | 0.93 | 0.94 | 0.94 | 0.95 |

Panel B: Forecasting Channel ($p = 0$)

| | | $\pi_{12}$ | | | | |
|---|---|---|---|---|---|---|
| | | −0.70 | −0.30 | 0.00 | 0.30 | 0.70 |
| $\pi_{11} = \pi_{22}$ | −0.25 | −0.19 | −0.18 | 0.00 | 0.14 | 0.15 |
| | 0.00 | −0.18 | −0.21 | 0.00 | 0.21 | 0.80 |
| | 0.25 | −0.08 | −0.21 | 0.00 | 0.50 | 0.99 |

Note: Panel A: $\pi_{11} = \pi_{21} = 0$. Panel B: $\pi_{21} = 0$. Entries are the simulated correlations between the budget deficit ratio and the external deficit ratio. The correlations are constructed using only innovations to the budget deficit.

**Table 2. Birth Rates**

| Country | Level | $\underline{p}$ | $\overline{p}$ | $\widehat{p}$ | $\wp$ |
|---|---|---|---|---|---|
| Australia | 1 | 0.001 | 0.035 | 0.001 | 0.015 |
| | 5 | 0.001 | 0.027 | (0.002) | |
| | 10 | 0.001 | 0.022 | [0.741] | |
| Austria | 1 | 0.001 | 0.053 | 0.032 | 0.012 |
| | 5 | 0.001 | 0.027 | (0.035) | |
| | 10 | 0.001 | 0.008 | [0.410] | |
| Canada | 1 | 0.001 | 0.030 | 0.003 | 0.015 |
| | 5 | 0.006 | 0.021 | (0.004) | |
| | 10 | — | — | [0.220] | |
| Denmark | 1 | 0.001 | 0.015 | 0.010 | 0.012 |
| | 5 | 0.001 | 0.002 | (0.018) | |
| | 10 | — | — | [0.321] | |
| Finland | 1 | 0.001 | 0.045 | 0.006 | 0.013 |
| | 5 | 0.004 | 0.023 | (0.004) | |
| | 10 | — | — | [0.973] | |
| France | 1 | 0.001 | 0.075 | 0.023 | 0.014 |
| | 5 | 0.001 | 0.060 | (0.022) | |
| | 10 | 0.001 | 0.051 | [0.288] | |
| Germany | 1 | 0.001 | 0.013 | 0.021 | 0.010 |
| | 5 | — | — | (0.031) | |
| | 10 | — | — | [0.288] | |
| Italy | 1 | 0.001 | 0.077 | 0.027 | 0.011 |
| | 5 | 0.001 | 0.065 | (0.037) | |
| | 10 | 0.004 | 0.058 | [0.951] | |
| Japan | 1 | 0.001 | 0.048 | 0.003 | 0.011 |
| | 5 | 0.001 | 0.042 | (0.014) | |
| | 10 | 0.001 | 0.039 | [0.404] | |

**Table 2 (Continued). Birth Rates**

| Country | Level | $\underline{p}$ | $\overline{p}$ | $\widehat{p}$ | $\wp$ |
|---|---|---|---|---|---|
| Netherlands | 1 | 0.003 | 0.048 | 0.016 | 0.013 |
| | 5 | — | — | (0.025) | |
| | 10 | — | — | [0.259] | |
| Norway | 1 | 0.001 | 0.039 | 0.063 | 0.013 |
| | 5 | 0.001 | 0.008 | (0.034) | |
| | 10 | — | — | [0.162] | |
| Spain | 1 | 0.001 | 0.026 | 0.004 | 0.013 |
| | 5 | — | — | (0.012) | |
| | 10 | — | — | [0.232] | |
| Sweden | 1 | 0.001 | 0.034 | 0.016 | 0.012 |
| | 5 | 0.001 | 0.007 | (0.021) | |
| | 10 | 0.001 | 0.001 | [0.265] | |
| Switzerland | 1 | 0.001 | 0.033 | 0.005 | 0.011 |
| | 5 | 0.001 | 0.038 | (0.014) | |
| | 10 | 0.001 | 0.049 | [0.831] | |
| United Kingdom | 1 | 0.001 | 0.075 | 0.010 | 0.013 |
| | 5 | 0.001 | 0.055 | (0.014) | |
| | 10 | 0.001 | 0.044 | [0.525] | |
| United States | 1 | 0.001 | 0.051 | 0.005 | 0.015 |
| | 5 | 0.008 | 0.040 | (0.004) | |
| | 10 | — | — | [0.151] | |

Note: Entries are the estimated and actual values of the birth rate. $\underline{p}$ and $\overline{p}$ are the smallest and largest values of the birth rate for which the orthogonality restrictions are not rejected at the 1, 5, and 10 percent levels of significance. $\widehat{p}$ represents the GMM estimates of the birth rate. $\wp$ is the actual birth rate for the period. Numbers in parentheses are the standard errors of the GMM estimates. Entries in brackets are the probability values associated with the $J$-test of overidentification restrictions.

**Table 3. Correlations Between Budget and External Deficits**

| | | | Conditional | | | | | |
|---|---|---|---|---|---|---|---|---|
| Country | Unconditional | | Benchmark | | No Demographic | | No Forecasting | |
| Australia | −0.264 | [0.003] | 0.914 | [0.000] | 0.692 | [0.000] | 0.966 | [0.000] |
| Austria | 0.217 | [0.016] | 0.993 | [0.000] | 0.812 | [0.000] | 0.982 | [0.000] |
| Canada | −0.468 | [0.000] | 0.960 | [0.000] | 0.767 | [0.000] | 0.987 | [0.000] |
| Denmark | 0.167 | [0.180] | 0.967 | [0.000] | 0.730 | [0.000] | 0.985 | [0.000] |
| Finland | −0.099 | [0.333] | 0.977 | [0.000] | 0.788 | [0.000] | 0.984 | [0.000] |
| France | −0.140 | [0.126] | 0.968 | [0.000] | 0.950 | [0.000] | 0.997 | [0.000] |
| Germany | 0.433 | [0.000] | 0.720 | [0.000] | 0.339 | [0.000] | 0.983 | [0.000] |
| Italy | 0.423 | [0.000] | 0.881 | [0.000] | 0.461 | [0.000] | 0.897 | [0.000] |
| Japan | −0.025 | [0.690] | 0.605 | [0.000] | 0.853 | [0.000] | 0.978 | [0.000] |
| Netherlands | 0.165 | [0.069] | 0.492 | [0.000] | 0.253 | [0.004] | 0.997 | [0.000] |
| Norway | 0.643 | [0.000] | 0.812 | [0.000] | 0.505 | [0.000] | 0.989 | [0.000] |
| Spain | −0.430 | [0.000] | 0.965 | [0.000] | 0.338 | [0.000] | 0.971 | [0.000] |
| Sweden | 0.476 | [0.000] | 0.968 | [0.000] | 0.913 | [0.000] | 0.997 | [0.000] |
| Switzerland | −0.310 | [0.000] | 0.416 | [0.000] | 0.390 | [0.000] | 0.987 | [0.000] |
| | (0.099) | [0.000] | (0.002) | [0.000] | (0.011) | [0.000] | (0.001) | [0.000] |
| United States | −0.129 | [0.081] | 0.957 | [0.081] | 0.759 | [0.081] | 0.978 | [0.081] |

Note: Entries are the GMM estimates of the contemporaneous correlation between the ratios of external and budget deficits relative to output. Unconditional refers to the correlations computed from the raw data. Conditional refers to the correlations computed conditioning on only orthogonal budget deficit shocks. Benchmark refers to the version of the model with the actual birth rate and no restrictions on the law of motion for forcing variables. No Demographic refers to a variant of the benchmark that uses the lower bound of the birth rate. No Forecasting refers to a variant that restricts the law of motion to univariate AR processes. Numbers in brackets are the probability values associated with the test that the correlation is null.

**Table 4. Cumulative Responses of External Deficits**

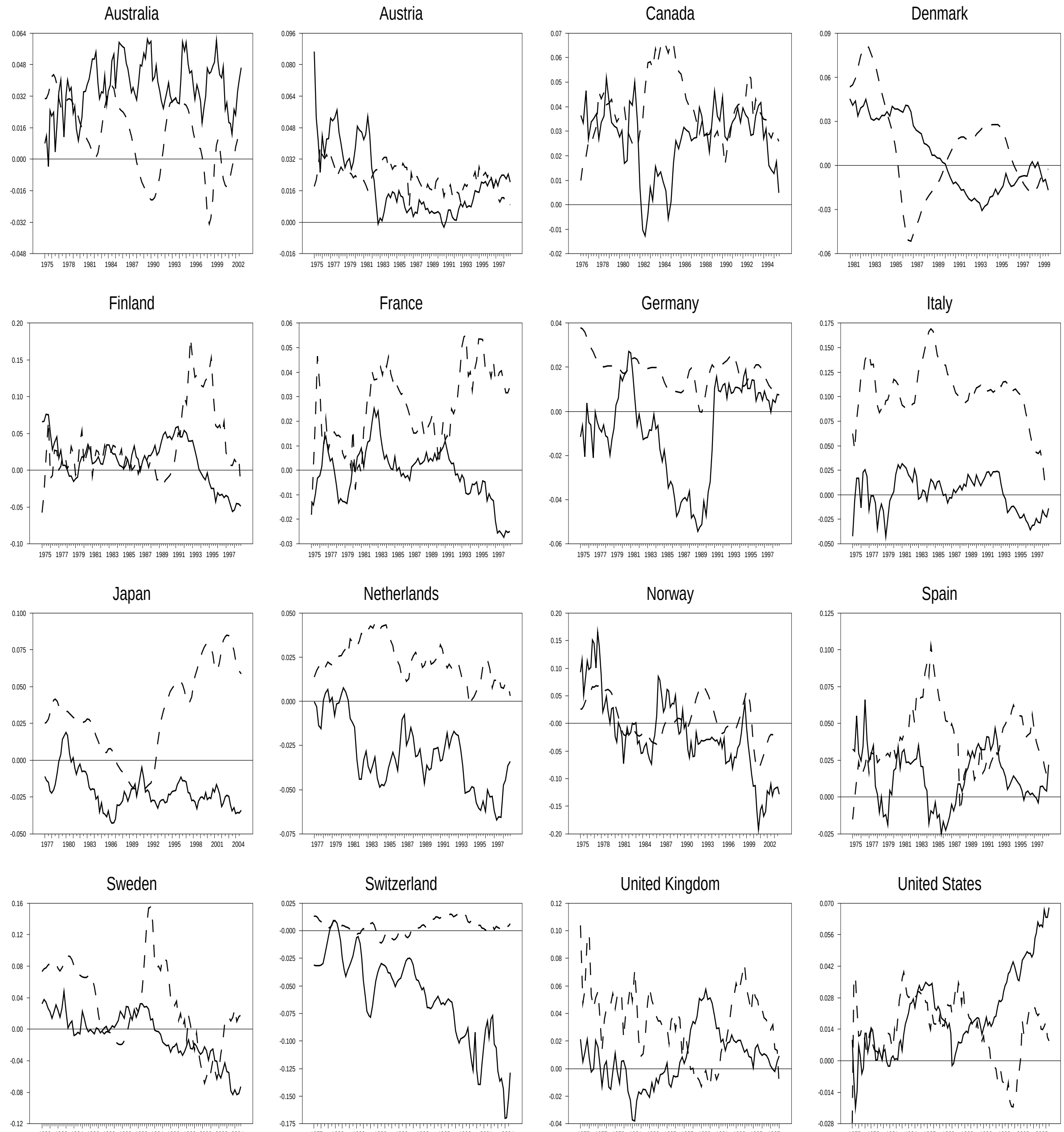
| Country | Quarter | Benchmark | | No Demographic | | No Forecasting | |
|---|---|---|---|---|---|---|---|
| Australia | 1 | −0.470 | [0.360] | −0.355 | [0.257] | 1.634 | [0.000] |
| | 20 | 23.899 | [0.000] | 2.994 | [0.007] | 35.709 | [0.000] |
| | 40 | 45.878 | [0.000] | 8.369 | [0.000] | 76.792 | [0.000] |
| Austria | 1 | 0.875 | [0.000] | 0.251 | [0.078] | 0.394 | [0.000] |
| | 20 | 9.070 | [0.000] | 1.920 | [0.106] | 8.552 | [0.000] |
| | 40 | 18.261 | [0.000] | 3.677 | [0.012] | 18.319 | [0.000] |
| Canada | 1 | 0.772 | [0.077] | 0.106 | [0.727] | 0.586 | [0.000] |
| | 20 | 16.575 | [0.000] | 2.354 | [0.056] | 12.718 | [0.000] |
| | 40 | 32.333 | [0.000] | 4.909 | [0.000] | 27.161 | [0.000] |
| Denmark | 1 | 0.825 | [0.140] | 0.307 | [0.599] | 1.334 | [0.000] |
| | 20 | 36.897 | [0.000] | 11.053 | [0.203] | 62.731 | [0.000] |
| | 40 | 61.036 | [0.001] | 18.994 | [0.126] | 27.161 | [0.000] |
| Finland | 1 | 1.755 | [0.000] | −0.211 | [0.565] | 0.572 | [0.000] |
| | 20 | 25.111 | [0.013] | −2.228 | [0.755] | 12.422 | [0.000] |
| | 40 | 34.869 | [0.049] | −1.562 | [0.745] | 26.600 | [0.000] |
| France | 1 | 1.003 | [0.008] | 0.213 | [0.415] | 0.453 | [0.000] |
| | 20 | 14.571 | [0.108] | 3.180 | [0.528] | 9.813 | [0.000] |
| | 40 | 28.969 | [0.162] | 6.250 | [0.745] | 20.968 | [0.000] |
| Germany | 1 | 0.665 | [0.371] | 0.380 | [0.637] | 1.096 | [0.000] |
| | 20 | 23.428 | [0.017] | 9.279 | [0.389] | 23.921 | [0.000] |
| | 40 | 51.532 | [0.000] | 23.526 | [0.113] | 51.578 | [0.000] |
| Italy | 1 | 1.088 | [0.000] | 0.251 | [0.228] | 1.001 | [0.000] |
| | 20 | 16.254 | [0.000] | 3.364 | [0.004] | 21.824 | [0.000] |
| | 40 | 23.914 | [0.000] | 7.399 | [0.000] | 46.969 | [0.000] |
| Japan | 1 | −1.199 | [0.328] | −0.308 | [0.621] | 1.147 | [0.000] |
| | 20 | 7.518 | [0.743] | 3.163 | [0.698] | 25.025 | [0.000] |
| | 40 | 20.940 | [0.599] | 8.168 | [0.481] | 53.903 | [0.000] |

**Table 4 (Continued). Cumulative Responses of External Deficits**

| Country | Quarter | Benchmark | | No Demographic | | No Forecasting | |
|---|---|---|---|---|---|---|---|
| Netherlands | 1 | 1.169 | [0.074] | 0.682 | [0.246] | 0.640 | [0.000] |
| | 20 | 19.147 | [0.006] | 10.171 | [0.073] | 13.899 | [0.000] |
| | 40 | 33.856 | [0.000] | 17.761 | [0.020] | 29.772 | [0.000] |
| Norway | 1 | −1.786 | [0.003] | −1.623 | [0.000] | 1.234 | [0.000] |
| | 20 | 24.755 | [0.000] | 1.477 | [0.680] | 26.930 | [0.000] |
| | 40 | 59.934 | [0.000] | 6.814 | [0.119] | 57.891 | [0.000] |
| Spain | 1 | 0.958 | [0.000] | 0.101 | [0.221] | 0.536 | [0.000] |
| | 20 | 11.759 | [0.000] | 1.778 | [0.000] | 11.628 | [0.000] |
| | 40 | 19.506 | [0.000] | 3.942 | [0.000] | 24.892 | [0.000] |
| Sweden | 1 | 1.883 | [0.031] | 1.496 | [0.609] | 0.685 | [0.000] |
| | 20 | 31.152 | [0.130] | 30.288 | [0.636] | 14.898 | [0.000] |
| | 40 | 43.764 | [0.249] | 58.269 | [0.672] | 31.963 | [0.000] |
| Switzerland | 1 | 1.246 | [0.084] | 1.073 | [0.361] | 0.747 | [0.000] |
| | 20 | 20.776 | [0.116] | 9.942 | [0.669] | 16.265 | [0.000] |
| | 40 | 43.171 | [0.109] | 19.510 | [0.681] | 34.956 | [0.000] |
| United Kingdom | 1 | 0.920 | [0.000] | 0.145 | [0.071] | 0.545 | [0.000] |
| | 20 | 12.752 | [0.000] | 2.089 | [0.003] | 11.831 | [0.000] |
| | 40 | 21.247 | [0.001] | 4.290 | [0.000] | 25.328 | [0.000] |
| United States | 1 | 0.780 | [0.061] | 0.092 | [0.932] | 0.590 | [0.000] |
| | 20 | 12.143 | [0.267] | 0.317 | [0.987] | 12.796 | [0.000] |
| | 40 | 19.358 | [0.329] | −0.595 | [0.987] | 27.329 | [0.000] |

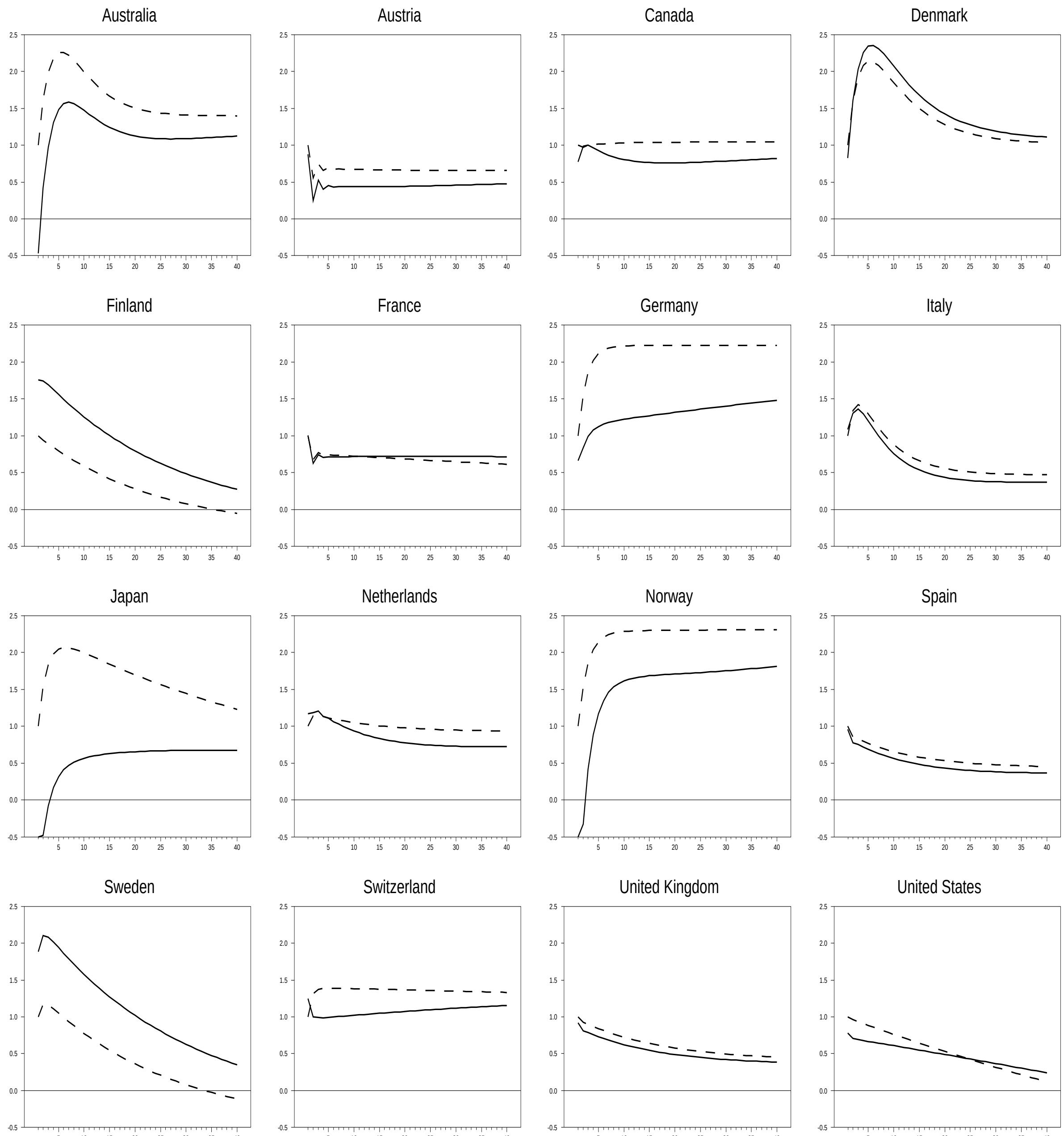
Note: Entries are the cumulated responses of the external deficit to a tax cut innovation. Benchmark refers to the version of the model with the actual birth rate and no restrictions on the law of motion for forcing variables. No Demographic refers to a variant of the benchmark that uses the lower bound of the birth rate. No Forecasting refers to a variant that restricts the law of motion to univariate AR processes. Numbers in brackets are the probability values associated with the test that the cumulated response is null.

## Figure 1. Budget and External Deficits



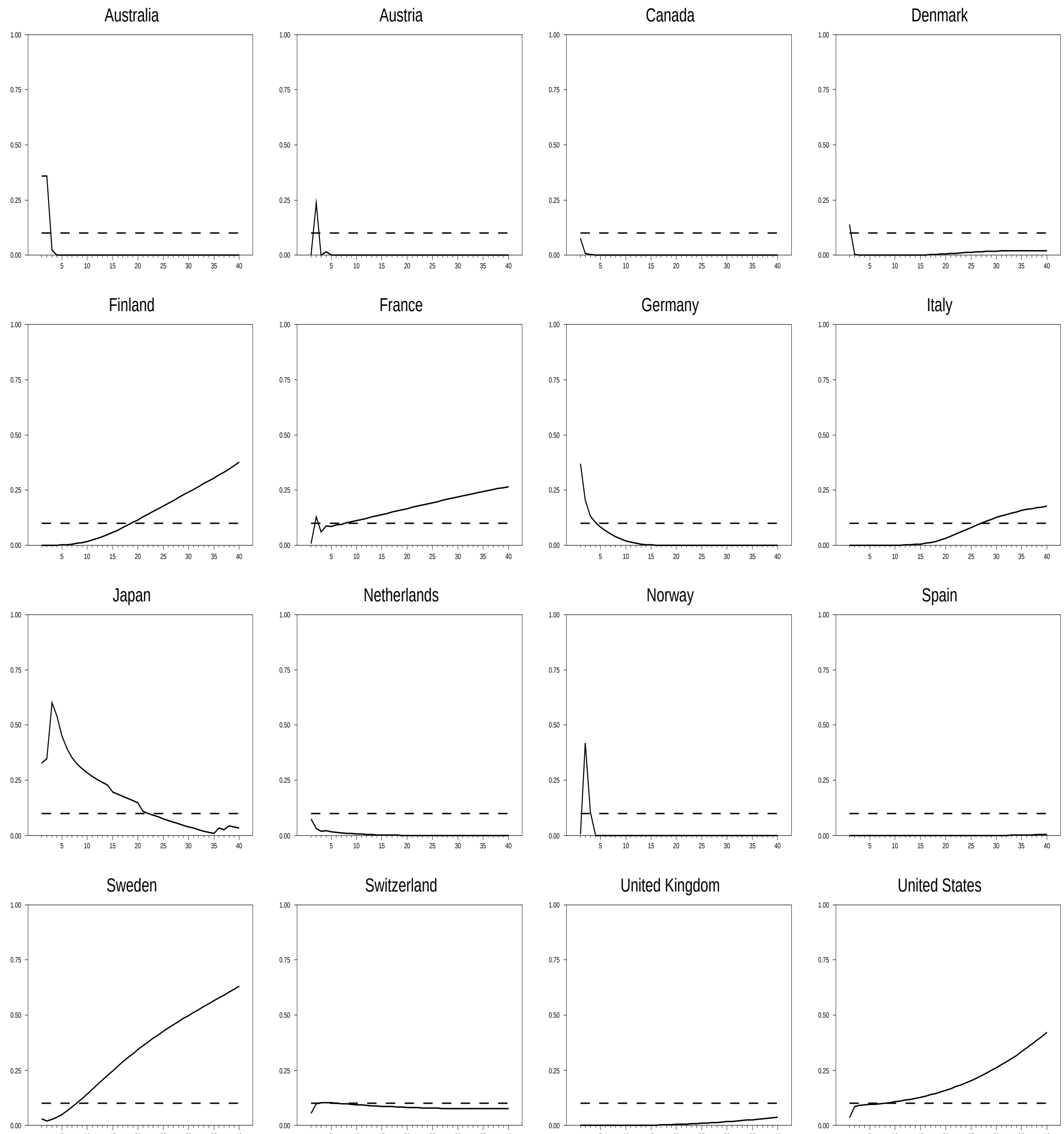

Note: The solid (dashed) lines represent the external deficit (budget deficit) to output ratios.

**Figure 2. Dynamic Responses: Benchmark**



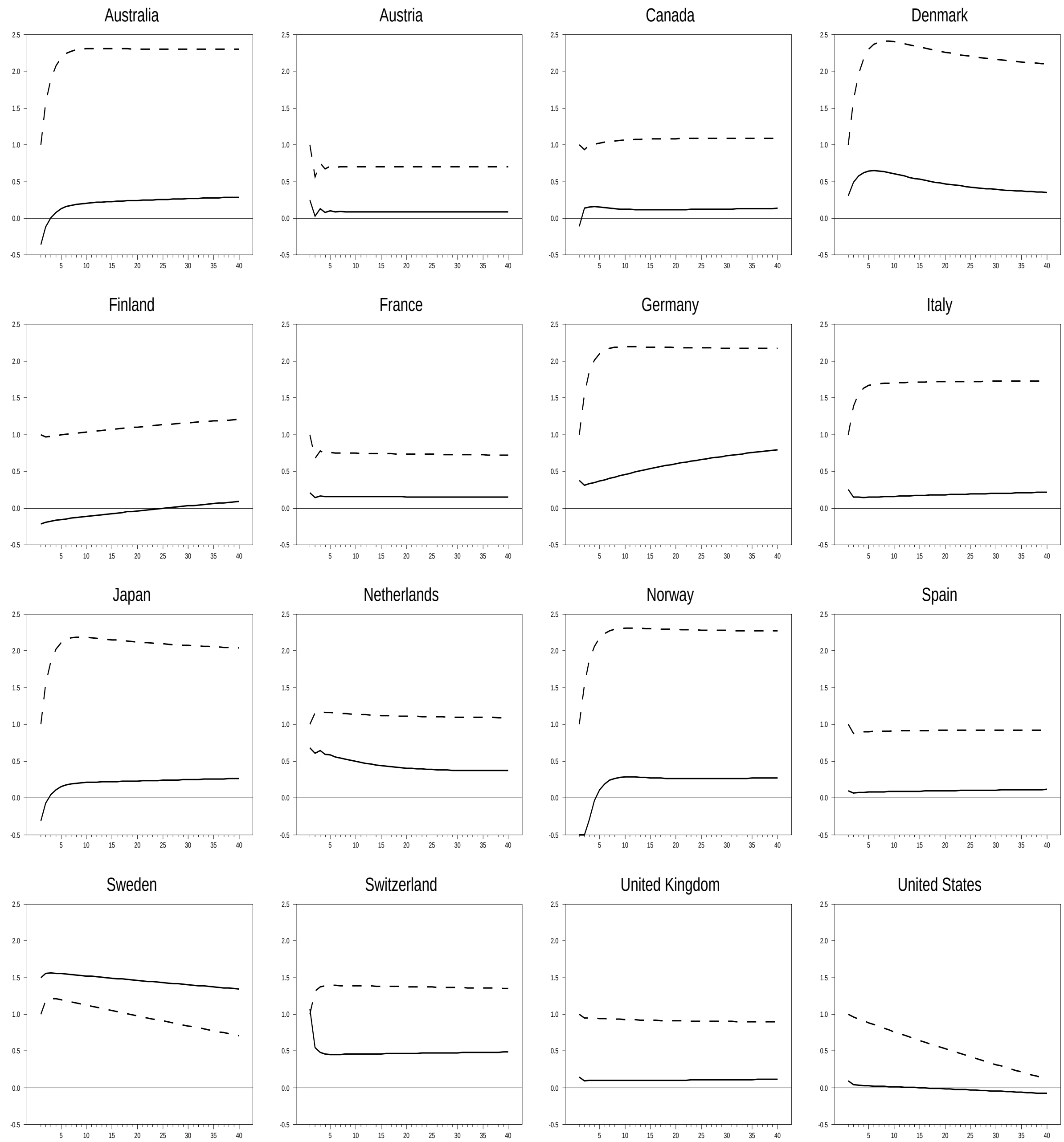

Note: The solid (dashed) lines correspond to the dynamic responses of external (budget) deficits computed with the actual values of the birth rates and no restrictions of the law of motion for forcing variables.

## Figure 3. Probability Values: Benchmark



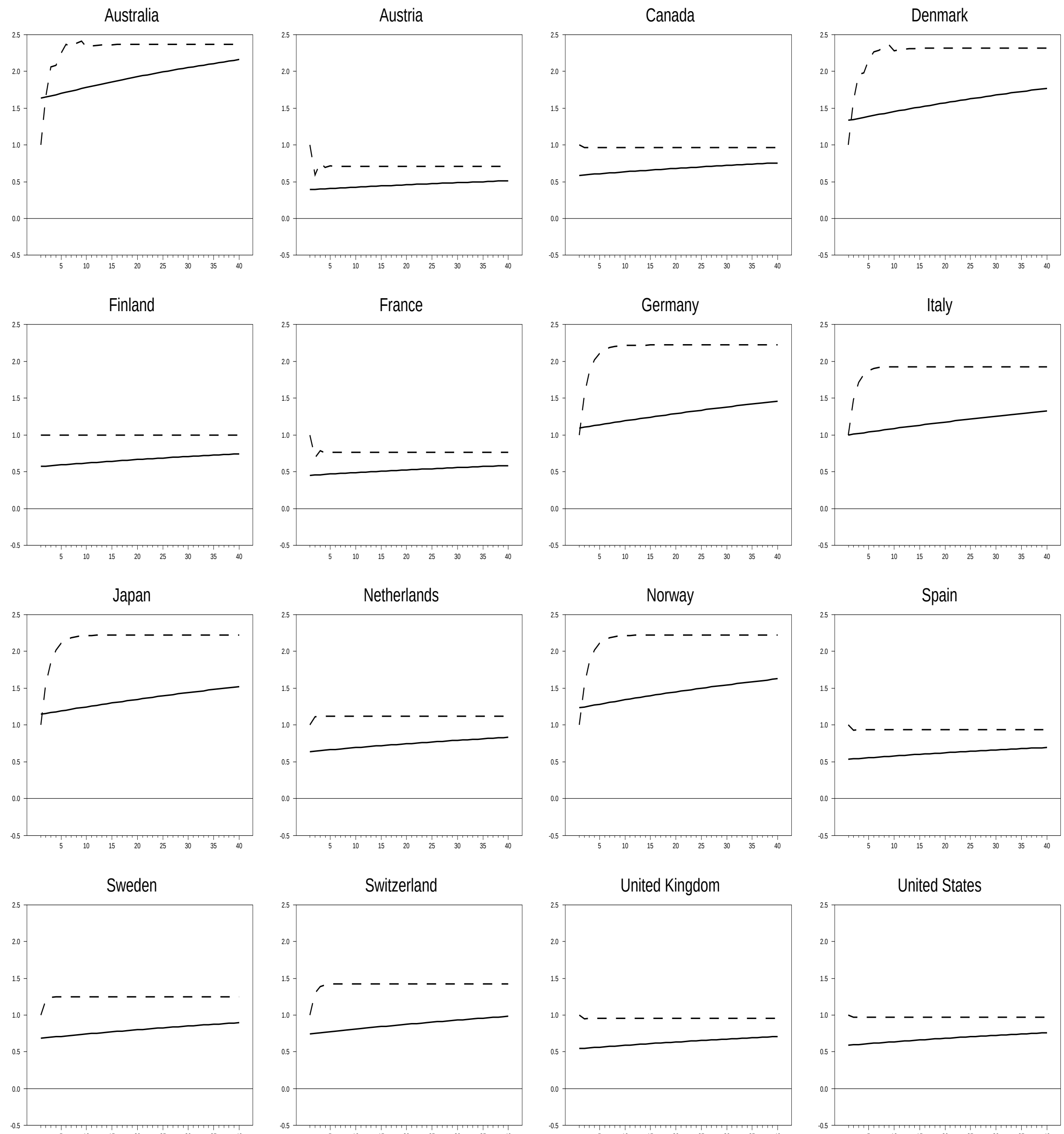

Note: The solid lines show the probability values that the dynamic responses of the external deficit are null, where the responses are computed with the actual values of the birth rates and no restrictions of the law of motion for forcing variables. The dashed lines show the 10 percent level of significance.

## Figure 4. Dynamic Responses: No Demographic




The solid (dashed) lines correspond to the dynamic responses of external (budget) deficits computed with the lower bound values of the birth rate and no restrictions of the law of motion for forcing variables.

**Figure 5. Dynamic Responses: No Forecasting**




Note: The solid (dashed) lines correspond to the dynamic responses of external (budget) deficits computed with the actual values of the birth rates and univariate AR processes for the law of motion.