Appendix to "On the Source of U.S. Trade Deficits: Global Saving Glut or Domestic Saving Drought?"
(for online publication only)

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Appendix A: Details on wedge accounting in two-period models

A.1 One-good endowment model

Each country $i \in \{us, rw\}$ receives a constant endowment, y, in both periods. The problem of country i's hosuehold is

$$\max_{c_{i,1}, c_{i,2}, b_{i,1}} \log c_{i,1} + \log c_{i,2}$$

subject to

$$c_{i,1} + b_{i,1} = y$$
$$c_{i,2} = y + \tau_{i,s} R b_i + T_i$$

The market clearing conditions are:

$$c_{us,t} + c_{rw,t} = 2y, \ \forall t$$
$$b_{us} + b_{rw} = 0.$$

An equilibrium is an allocation, $(c_{us,1}, c_{us,2}, c_{rw,1}, c_{rw,2}, b_{us}, b_{rw})$, and an interest rate, R, that solves the households' problems and satisfies the market clearing conditions.

The solution to the household's problem is characterized by an Euler equation and an intertemporal

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budget constraint:

$$\frac{1}{c_{i,1}} = R\tau_{i,s}\frac{1}{c_{i,2}}$$
$$c_{i,1} + \frac{c_{i,2}}{R} = y\frac{1+R}{R}$$

Combining these, we find that

$$c_{i,1} = \left(\frac{1}{1+\tau_{i,s}}\right)\left(\frac{1+R}{R}\right)y$$

Thus, the trade balance, $tb_i = y = c_{i,1}$, is given by

$$tb_i = \left[1 - \left(\frac{1}{1+\tau_{i,s}}\right)\left(\frac{1+R}{R}\right)\right]y$$

This expression is increasing in R and $\tau_{i,s}$. Hence, a U.S. trade deficit could be caused by a drop in the interest rate or a drop in the U.S. saving wedge.

The market clearing conditions imply that $tb_{us} + tb_{rw} = 0$. Using this in the previous equation, we can solve for the equilibrium interest rate:

$$R = \frac{\sum_{i=us,rw}\left(\frac{1}{1+\tau_{i,s}}\right)}{2 - \sum_{i=us,rw}\left(\frac{1}{1+\tau_{i,s}}\right)}$$

This expression is decreasing in both saving wedges. Thus, the only way to get a U.S. trade deficit and a drop in the interest rate is by increasing the rest of the world's saving wedge.

A.2 One-good model with investment

Now, each country receives an endowment in the first period, but must invest to produce in the second period. Households now choose consumption in each period, bonds, and investment to maximize their lifetime utility. The budget constraints are

$$c_{i,1} + k_i + b_i = y \qquad\qquad c_{i,2} = \tau_{i,s}\left(Rb_i + \tau_{i,k}k_i^{\alpha}\right) + T_i$$

An equilibrium in this environment is an allocation for each country, $(c_{i,1}, c_{i,2}, k_i, b_i)$, and a world interest rate, R, that solve the household's problem in each country and clear markets for output and bonds:

$$c_{us,1} + c_{rw,1} + k_{us} + k_{rw} = 2y$$
$$c_{us,2} + c_{rw,2} = k_{us}^{\alpha} + k_{rw}^{\alpha}$$
$$b_{us} + b_{rw} = 0$$

National income accounting implies that each country's trade balance is the difference between its saving, $y - c_{i,1}$, and its investment:

$$tb_i = y - c_{i,1} - k_i$$

So now, there are four ways to generate a U.S. trade deficit: U.S. saving (defined as $y_{us} - c_{us}$) can fall, U.S. investment can rise, foreign saving can rise, or foreign saving can fall. Of course, it could be a combination of each of these possibilities. The wedge accounting analysis quantifies the contribution of each force.

The household's problem is characterized by an Euler equation and an arbitrage condition:

$$\frac{1}{c_{i,1}} = R\tau_{i,s}\frac{1}{c_{i,2}}$$
$$R = \tau_{i,k}\alpha k_i^{\alpha-1}$$

The period budget constraints can be combined as an intertemporal budget constraint:

$$c_{i,1} + \frac{c_{i,2}}{R} = y + \frac{k_i^\alpha}{R} - k_i.$$

Using the Euler equation and intertemporal budget constraint yields the following expression for country i's equilibrium trade balance:

$$tb_i = \left(\frac{\tau_{i,s}}{1+\tau_{i,s}}\right) y - R^{\frac{1}{\alpha-1}} \left[\left(\frac{1}{1+\tau_{i,s}}\right)(\alpha\tau_{i,k})^{\frac{\alpha}{1-\alpha}} + \left(\frac{\tau_{i,s}}{1+\tau_{i,s}}\right)(\alpha\tau_{i,k})^{\frac{1}{1-\alpha}}\right]$$

Using this in the bond market clearing condition yields the solution for the equilibrium interest rate:

$$R = \left\{\frac{\sum_{i=us,rw}\left(\frac{\tau_{i,s}}{1+\tau_{i,s}}\right) y}{\sum_{i=us,rw}\left[\left(\frac{1}{1+\tau_{i,s}}\right)(\alpha\tau_{i,k})^{\frac{\alpha}{1-\alpha}} + \left(\frac{\tau_{i,s}}{1+\tau_{i,s}}\right)(\alpha\tau_{i,k})^{\frac{1}{1-\alpha}}\right]}\right\}^{\frac{1}{\alpha-1}}.$$

These two expressions behave in the same way as the endowment-model versions to saving gluts and saving droughts. The investment wedges have opposite effects, as expected: an "investment surge" (in the parlance of Schmitt-Grohe et al. (2016)) in the U.S. raises the world interest rate and lowers the U.S. trade balance, while an "investment contraction" in the rest of the world lowers the world interest rate and lowers the U.S. trade balance.

A.3 *Two-good endowment model*

Now, each country receives an endowment of a different good. Call the U.S. good x and the rest of the world's good z. The endowments are still constant and symmetric; the U.S. receives a quantity y of good x each period, and the rest of the world receives a quantity y of good z. Each country's consumption basket is an Armington aggregator of the two goods with a home bias parameter ω:

$$c_{us,t} = x_{us,t}^{\omega} z_{us,t}^{1-\omega}$$
$$c_{rw,t} = z_{rw,t}^{\omega} x_{rw,t}^{1-\omega}$$

This is essentially a two-period version of Cole and Obstfeld (1991). Following Heathcote and Perri (2002), let $p_{i,t}$ and $q_{i,t}$ denote the prices of goods x and z in terms of country i's consumption good. The U.S. real exchange rate, e_t, is given by the law of one price:

$$e_t p_{rw,t} = p_{us,t}, \quad e_t q_{rw,t} = q_{us,t}.$$

Bonds are denominated in units of U.S. consumption.

Households have the same preferences as in the one-good world. The U.S. budget constraints are now

$$c_{us,1} + b_{us,1} = p_{us,1} y$$
$$c_{us,2} = p_{us,2} y + \tau_{us,s} R b_{us} + T_{us}$$

The rest of the world's budget constraints are

$$c_{rw,1} + b_{rw,1}/e_1 = q_{rw,1} y$$
$$c_{rw,2} = q_{rw,2} y + \tau_{rw,s} R b_{rw}/e_2 + T_{rw}$$

Armington aggregators choose inputs to maximize profits. The U.S. aggregator's problem is

$$\max_{x_{us,t}, z_{us,t}} c_{us,t} - p_{us,t} x_{us,t} - q_{us,t} z_{us,t}$$

subject to the technology described above. The rest of the world's aggregator solves a similar problem. The market clearing conditions are now

$$x_{us,t} + x_{rw,t} = y, \ \forall t$$
$$z_{us,t} + z_{rw,t} = y, \ \forall t$$
$$b_{us,t} + b_{rw,t} = 0$$

An equilibrium is an allocation, $\left[(c_{i,t}, x_{i,t}, z_{i,t})_{t=1}^2, b_i \right]_{i=us,rw}$, and prices, $\left\{ \left[([p_{i,t}, q_{i,t})_{t=1}^2 \right]_{i=us,rw}, R \right\}$ that solves the households' and aggregators' problems and satisfies the market clearing conditions.

The U.S. Euler equation and intertemporal BC are:

$$\frac{1}{c_{us,1}} = R \tau_{us,s} \frac{1}{c_{us,2}}$$
$$c_{i,1} + \frac{c_{i,2}}{R} = \left(p_{us,1} + \frac{p_{us,2}}{R} \right) y$$

The rest of the world's Euler equation and intertemporal BC are:

$$\frac{1}{c_{rw,1}} = R \left(\frac{e_1}{e_2} \right) \tau_{rw,s} \frac{1}{c_{rw,2}}$$
$$c_{i,1} + \frac{c_{i,2}}{R\left(\frac{e_1}{e_2}\right)} = \left(q_{rw,1} + \frac{q_{rw,2}}{R\left(\frac{e_1}{e_2}\right)} \right) y$$

Combining them, we find that

$$c_{us,1} = \left(\frac{1}{1 + \tau_{us,s}} \right) \left(p_{us,1} + \frac{p_{us,2}}{R} \right) y$$
$$c_{rw,1} = \left(\frac{1}{1 + \tau_{rw,s}} \right) \left(q_{rw,1} + \frac{q_{rw,2}}{R\left(\frac{e_1}{e_2}\right)} \right) y$$

Trade balances are thus given by

$$tb_{us} = p_{us,1}y - c_{us,1} = \left[\left(\frac{\tau_{us,s}}{1+\tau_{us,s}}\right)p_{us,1} - \left(\frac{1}{1+\tau_{us,s}}\right)\frac{p_{us,2}}{R}\right]y$$
$$tb_{rw} = q_{rw,1}y - c_{rw,1} = \left[\left(\frac{\tau_{rw,s}}{1+\tau_{rw,s}}\right)q_{rw,1} - \left(\frac{1}{1+\tau_{rw,s}}\right)\frac{q_{rw,2}}{R\left(\frac{e_1}{e_2}\right)}\right]y$$

The bond market clearing condition implies

$$tb_{us} + e_1 tb_{rw} = 0$$

Using this in the previous with the LOOP yields

$$\left[\left(\frac{\tau_{us,s}}{1+\tau_{us,s}}\right)p_{us,1} - \left(\frac{1}{1+\tau_{us,s}}\right)\frac{p_{us,2}}{R}\right]y + \left[\left(\frac{\tau_{rw,s}}{1+\tau_{rw,s}}\right)q_{us,1} - \left(\frac{1}{1+\tau_{rw,s}}\right)\frac{q_{us,2}}{R}\right]y = 0 \qquad (*)$$

With the two-good setup, we also need to use the marginal product pricing conditions for the aggregators:

$$p_{us,t} = \omega\left(\frac{c_{us,t}}{x_{us,t}}\right)$$
$$q_{us,t} = (1-\omega)\left(\frac{c_{us,t}}{z_{us,t}}\right)$$
$$p_{rw,t} = (1-\omega)\left(\frac{c_{rw,t}}{x_{rw,t}}\right)$$
$$q_{rw,t} = \omega\left(\frac{c_{rw,t}}{z_{rw,t}}\right)$$

Using these and the market clearing conditions in (*), we find

$$0 = \left\{\left(\frac{\tau_{us,s}}{1+\tau_{us,s}}\right)[\omega c_{us,1} + e_1(1-\omega)c_{rw,1}] - \left(\frac{1}{1+\tau_{us,s}}\right)\frac{1}{R}[\omega c_{us,2} + e_2(1-\omega)c_{rw,2}]\right\}$$
$$+\left\{\left(\frac{\tau_{rw,s}}{1+\tau_{rw,s}}\right)[(1-\omega)c_{us,1} + e_1\omega c_{rw,1}] - \left(\frac{1}{1+\tau_{rw,s}}\right)\frac{1}{R}[(1-\omega)c_{us,2} + e_2\omega c_{rw,2}]\right\}$$

Use the Euler equations again:

$$0 = \left\{\left(\frac{\tau_{us,s}-\tau_{rw,s}}{1+\tau_{us,s}}\right)e_1 c_{rw,1}\right\} + \left\{\left(\frac{\tau_{rw,s}-\tau_{us,s}}{1+\tau_{rw,s}}\right)c_{us,1}\right\}$$

Simplify:

$$\left(\frac{1}{1+\tau_{us,s}}\right)e_1 c_{rw,1} = \left(\frac{1}{1+\tau_{rw,s}}\right)c_{us,1}$$

Again:

$$\frac{c_{us,1}}{c_{rw,1}} = e_1\left(\frac{1+\tau_{rw,s}}{1+\tau_{us,s}}\right)$$

Using Eulers again,

$$\frac{c_{us,2}}{c_{rw,2}} = e_2\frac{\tau_{us,s}}{\tau_{rw,s}}\left(\frac{1+\tau_{rw,s}}{1+\tau_{us,s}}\right)$$

Rewrite these slightly as

$$\frac{c_{us,1}}{c_{rw,1}}\frac{1}{e_1} = \left(\frac{1+\tau_{rw,s}}{1+\tau_{us,s}}\right) \tag{\#}$$

$$\frac{c_{us,2}}{c_{rw,2}}\frac{1}{e_2} = \frac{\tau_{us,s}}{\tau_{rw,s}}\left(\frac{1+\tau_{rw,s}}{1+\tau_{us,s}}\right) \tag{\#\#}$$

Now, if we combine the MPPs for good x, we find that

$$\frac{p_{us,t}}{p_{rw,t}} = e_t = \left(\frac{\omega}{1-\omega}\right)\left(\frac{c_{us,t}}{c_{rw,t}}\right)\left(\frac{x_{rw,t}}{x_{us,t}}\right)$$

Rewrite this as

$$\frac{x_{us,t}}{x_{rw,t}} = \left(\frac{\omega}{1-\omega}\right)\left(\frac{c_{us,t}}{c_{rw,t}}\right)\frac{1}{e_t} \tag{\$}$$

Similar logic implies

$$\frac{z_{us,t}}{z_{rw,t}} = \left(\frac{1-\omega}{\omega}\right)\left(\frac{c_{us,t}}{c_{rw,t}}\right)\frac{1}{e_t} \tag{\$\$}$$

Now we have everything we need to solve for the allocations as functions of parameters only! First do it for period 1. Use (#) in ($):

$$\frac{x_{us,1}}{x_{rw,1}} = \left(\frac{\omega}{1-\omega}\right)\left(\frac{1+\tau_{rw,s}}{1+\tau_{us,s}}\right)$$

Market clearing implies that

$$x_{us,1} = \frac{y}{1+\left(\frac{1-\omega}{\omega}\right)\left(\frac{1+\tau_{us,s}}{1+\tau_{rw,s}}\right)} = \frac{\omega(1+\tau_{rw,s})y}{\omega(1+\tau_{rw,s})+(1-\omega)(1+\tau_{us,s})}$$

Using (#) in ($$) yields

$$\frac{z_{us,1}}{z_{rw,1}} = \left(\frac{1-\omega}{\omega}\right)\left(\frac{1+\tau_{rw,s}}{1+\tau_{us,s}}\right)$$

and thus

$$z_{us,1} = \frac{y}{1+\left(\frac{\omega}{1-\omega}\right)\left(\frac{1+\tau_{us,s}}{1+\tau_{rw,s}}\right)} = \frac{(1-\omega)(1+\tau_{rw,s})y}{(1-\omega)(1+\tau_{rw,s})+\omega(1+\tau_{us,s})}$$

Note that if the wedges are all one, then $x_{us,t} = \omega y$ and $z_{us,1} = (1-\omega)y$, which is right. In this case, $c_{us,1} = \omega^{\omega}(1-\omega)^{1-\omega}y$, which is also right. With distortions, we have

$$\begin{aligned} c_{us,1} = &\left\{[\omega(1+\tau_{rw,s})+(1-\omega)(1+\tau_{us,s})]^{-\omega}\,[(1-\omega)(1+\tau_{rw,s})+\omega(1+\tau_{us,s})]^{\omega-1}\right\} \\ &\times (1+\tau_{rw,s})\omega^{\omega}(1-\omega)^{1-\omega}y \end{aligned} \tag{\&}$$

This gives us U.S. consumption in period 1 as a function of model parameters only.

Now do it for period 2. Use (##) in ($) to get

$$\frac{x_{us,2}}{x_{rw,2}} = \left(\frac{\omega}{1-\omega}\right)\frac{\tau_{us,s}}{\tau_{rw,s}}\left(\frac{1+\tau_{rw,s}}{1+\tau_{us,s}}\right)$$

Market clearing implies that

$$x_{us,2} = \frac{y}{1+\left(\frac{1-\omega}{\omega}\right)\frac{\tau_{rw,s}}{\tau_{us,w}}\left(\frac{1+\tau_{us,s}}{1+\tau_{rw,s}}\right)} = \frac{\omega\tau_{us,s}(1+\tau_{rw,s})y}{\omega\tau_{us,s}(1+\tau_{rw,s})+(1-\omega)\tau_{rw,s}(1+\tau_{us,s})}$$

Using (##) in ($$) yields

$$\frac{z_{us,2}}{z_{rw,2}} = \left(\frac{1-\omega}{\omega}\right) \frac{\tau_{us,s}}{\tau_{rw,s}} \left(\frac{1+\tau_{rw,s}}{1+\tau_{us,s}}\right)$$

and thus

$$z_{us,2} = \frac{y}{1 + \left(\frac{\omega}{1-\omega}\right) \frac{\tau_{rw,s}}{\tau_{us,s}} \left(\frac{1+\tau_{us,s}}{1+\tau_{rw,s}}\right)} = \frac{(1-\omega)\tau_{us,s}(1+\tau_{rw,s})y}{(1-\omega)\tau_{us,s}(1+\tau_{rw,s}) + \omega\tau_{rw,s}(1+\tau_{us,s})}$$

Now, we use these in the aggregator to compute $c_{us,2}$:

$$\begin{aligned} c_{us,2} = &\left\{ [\omega\tau_{us,s}(1+\tau_{rw,s}) + (1-\omega)\tau_{rw,s}(1+\tau_{us,s})]^{-\omega} [(1-\omega)\tau_{us,s}(1+\tau_{rw,s}) + \omega\tau_{rw,s}(1+\tau_{us,s})]^{\omega-1} \right\} \\ &\times \tau_{us,s}(1+\tau_{rw,s})\omega^{\omega}(1-\omega)^{1-\omega} y \end{aligned} \tag{\&\&}$$

This gives us U.S. consumption in period 2 as a function of model parameters only.

Now use the Euler equation to solve for R:

$$\begin{aligned} R &= \frac{c_{us,2}}{c_{us,1}} \frac{1}{\tau_{us,s}} \\ &= \frac{\left\{ [\omega\tau_{us,s}(1+\tau_{rw,s}) + (1-\omega)\tau_{rw,s}(1+\tau_{us,s})]^{-\omega} [(1-\omega)\tau_{us,s}(1+\tau_{rw,s}) + \omega\tau_{rw,s}(1+\tau_{us,s})]^{\omega-1} \right\}}{\left\{ [\omega(1+\tau_{rw,s}) + (1-\omega)(1+\tau_{us,s})]^{-\omega} [(1-\omega)(1+\tau_{rw,s}) + \omega(1+\tau_{us,s})]^{\omega-1} \right\}} \end{aligned}$$

This expression is a bit ugly, but it is straightforward to verify that is is decreasing in both saving wedges (as it should be), and, more importantly, that it is less sensitive to the saving wedges when the home bias parameter, ω is high. Formally,

$$\frac{\partial R}{\partial \tau_{i,s}} < 0$$
$$\frac{\partial^2 R}{\partial \tau_{i,s} \partial \omega} > 0$$

This suggests that real exchange rate dynamics may mute the response of interest rates to saving gluts/droughts. We need to do more work to verify this, though.

First, we need to solve for the rest of the world's consumption allocations. Using our solutions for $x_{us,1}$ and $z_{us,1}$, market clearing implies

$$x_{rw,1} = \frac{(1-\omega)(1+\tau_{us,s})y}{\omega(1+\tau_{rw,s}) + (1-\omega)(1+\tau_{us,s})}$$
$$z_{rw,1} = \frac{\omega(1+\tau_{us,s})y}{(1-\omega)(1+\tau_{rw,s}) + \omega(1+\tau_{us,s})}$$

Then

$$\begin{aligned} c_{rw,1} = &\left\{ [\omega(1+\tau_{rw,s}) + (1-\omega)(1+\tau_{us,s})]^{-\omega} [(1-\omega)(1+\tau_{rw,s}) + \omega(1+\tau_{us,s})]^{\omega-1} \right\} \\ &\times (1+\tau_{us,s})\omega^{\omega}(1-\omega)^{1-\omega} y \end{aligned}$$

Similarly,

$$x_{rw,2} = \frac{(1-\omega)\tau_{rw,s}(1+\tau_{us,s})y}{\omega\tau_{us,s}(1+\tau_{rw,s}) + (1-\omega)\tau_{rw,s}(1+\tau_{us,s})}$$
$$z_{rw,2} = \frac{\omega\tau_{rw,s}(1+\tau_{us,s})y}{(1-\omega)\tau_{us,s}(1+\tau_{rw,s}) + \omega\tau_{rw,s}(1+\tau_{us,s})}$$

and

$$c_{rw,2} = \left\{ [\omega\tau_{us,s}(1+\tau_{rw,s}) + (1-\omega)\tau_{rw,s}(1+\tau_{us,s})]^{-\omega} \left[(1-\omega)\tau_{us,s}(1+\tau_{rw,s}) + \omega\tau_{rw,s}(1+\tau_{us,s})\right]^{\omega-1} \right\}$$
$$\times\, \tau_{rw,s}(1+\tau_{us,s})\omega^{\omega}(1-\omega)^{1-\omega}y$$

Now we can solve for the exchange rates. The period-1 exchange rate is

$$e_1 = \frac{c_{rw,1}}{c_{us,1}}\left(\frac{1+\tau_{us,s}}{1+\tau_{rw,s}}\right) = \left(\frac{1+\tau_{us,s}}{1+\tau_{rw,s}}\right)^2$$

This expression is increasing in the U.S. saving wedge and decreasing in the rest of the world's saving wedge. In other words, a global saving glut (or a domestic saving drought) will cause the first-period U.S. real exchange rate to fall (i.e., appreciate) as we see in the data. The period-2 exchange rate is

$$e_2 = \frac{c_{rw,2}}{c_{us,2}}\frac{\tau_{rw,s}}{\tau_{us,s}}\left(\frac{1+\tau_{us,s}}{1+\tau_{rw,s}}\right) = \left[\frac{\tau_{rw,s}}{\tau_{us,s}}\left(\frac{1+\tau_{us,s}}{1+\tau_{rw,s}}\right)\right]^2$$

This expression is decreasing in the U.S. saving wedge and increasing in the rest of the world's saving wedge (the opposite of e_1); a global saving glut (or domestic saving drought) will cause the second-period U.S. real exchange rate to depreciate, again as we see in the data. To summarize,

$$\frac{\partial e_1}{\partial \tau_{us,s}} > 0, \quad \frac{\partial e_1}{\partial \tau_{rw,s}} < 0$$
$$\frac{\partial e_1}{\partial \tau_{us,s}} < 0, \quad \frac{\partial e_1}{\partial \tau_{rw,s}} > 0$$

I.e., a global saving glut (or domestic saving drought) will cause the U.S. real exchange rate to appreciate when the U.S. runs a trade deficit, and then depreciate when the U.S. runs a trade surplus.

Appendix B: Additional sensitivity analyses

In addition to the two sensitivity analyses discussed in the main text, I have conducted a wide range of other analyses to study the robustness of my results. I have found that the main result—that the rest of the world's saving wedge is the primary driver of U.S. trade deficits—is not sensitive to assumptions about the model's production structure or assigned parameter values. This section of the appendix lists the results of these additional analyses. Table 1 shows the results of the wedge accounting exercise for the U.S. trade balance in these analyses.

B.1 Sectoral heterogeneity and input-output linkages

My quantitative model features a rich production and demand structure with multiple sectors and international input-output linkages. I have included these features to capture key facts about the U.S. trade balance and its relationship to investment: trade deficits consist of goods, particularly intermediate goods, not services; and the largest input to U.S. investment production, construction, is completely nontraded. Here, I ask: how do these features shape the results of my wedge accounting analysis?

To answer this question, I repeat my analysis using two more versions of the model with alternative production and demand structures. In the first, I eliminate input-output linkages by constructing a hypothetical input-output table with no intermediate inputs.[1] In the second analysis, I aggregate all industries into a single sector rather than three; this version of the model is, in essence, a workhorse international macro model Backus et al. (1994, 1995) with intermediate inputs. In both analyses, I recalibrate all expenditure share parameters before conducting the wedge accounting procedure.

Table 1 shows that the rest of the world's trade wedge accounts for about the same fraction of cumulative U.S. trade deficits in these two analyses as in the baseline analysis. In the no-IO version, the rest of the world's saving wedge accounts for 103 percent of the CED, and in the one-good model it accounts for 94 percent. The dynamics of the U.S. trade balance are similar in the one-good model to the baseline. In the no-IO model, the trade balance is more volatile in the no-wedge counterfactual and so the RMSE is higher. The RMSE for the counterfactual with only the rest of the world's saving wedge is similar to the baseline; the RMSE's for the other one-wedge counterfactuals are higher because these wedges do not drive the U.S. trade balance.

B.2 Assigned parameters

I have also analyzed the sensitivity of my results to several (potentially) important assigned parameters. Here is a list of the alternative calibrations considered in this appendix:

- Lower capital adjustment costs ($\varphi = 0.9$).
- Higher capital adjustment costs ($\varphi = 0.7$).
- Lower Armington elasticities for goods ($1/(1-\zeta) = 2$ and $1/(1-\sigma) = 1.5$).
- Higher Armington elasticities for goods ($1/(1-\zeta) = 6$ and $1/(1-\sigma) = 3$).
- Lower wedge persistence post-2011 ($\rho_\tau = 0.5$).
- Higher wedge persistence post-2011 ($\rho_\tau = 0.8$).

[1] To construct this matrix, I set all elements in the intermediate-input portion of Table 1 to zero and then use the RAS procedure (Bacharach, 1965) to "balance" the matrix, thereby ensuring that all markets clear. See section C.1 below.

- Lower long-run interest rate of 0.5%.

Table 1 also lists the main results for these calibrations.

Looking at the fifth column of panel (b), we can see that the most important result, the fraction of the CED accounted for by the rest of the world's saving wedge, is not sensitive to any of these choices. It ranges from 0.94 to 1.03 compared to 0.96 in the baseline calibration. Thus, a global saving glut is always the dominant force behind U.S. trade deficits. Changing the Armington elasticities affects the contribution of the U.S. saving wedge. When Armington elasticities are low, the U.S. saving wedge acts as a countervailing force, pushing the U.S. trade balance upward; when Armington elasticities are high, the U.S. saving wedge contributes more to U.S. trade deficits.

Looking at panel (a) of the table, we can see that trade balance dynamics are similar to the baseline in most of these alternative analyses; RMSEs in all counterfactuals are similar in the alternatives to the baseline. The no-IO model and the low/high Armington calibrations do affect trade balance dynamics. Removing input-output linkages and raising the Armington elasticities increases trade balance volatility in the no-wedge counterfactual, increasing the distance from the data, lowering the Armington elasticities has the reverse effect. This is because higher Armington elasticities make it easier to run large trade deficits or trade surpluses, so permanent-income motives have larger effects on the trade balance. Input-output linkages appear to dampen trade balance volatility as well. This is likely because there is stronger homee bias in intermediates than in final demand.

Appendix C: Data

This section of the appendix contains additional details on data sources and processing. All raw data sources are contained in the "data" folder of the online supplement. All python scripts referenced below are contained in the "programs/python" folder.

C.1 Input-output data

The input-output data come from the World Input Output Database (Timmer et al., 2015). This database contains a world input-output table for each year from 1995 through 2011. Each input-output table contains gross output, value added, intermediate inputs, consumption, and investment for 40 countries and 35 sectors. Final demand and intermediate use are listed by source and destination; the dataset distinguishes imports and exports by use as well as sector.

In addition to the 40 countries in the dataset, the WIOD data include a composite "rest of the world" which represents the group of developing countries that do not have good national input-output data. The rest of the world's gross output and value added are implied by world market clearing conditions; they are constructed by reconciling the national accounts of the 40 countries included in the database with world output and final demand in the UN National Accounts. The rest of the world's intermediate-input matrix is constructed by averaging the data for Brazil, China, India, Indonesia, Mexico, and Russia. Thus, we can think of the rest of the world as an additional composite emerging economy.

I aggregate all countries other than the United States into a single region. Thus, the rest of the world in my analysis includes the 39 non-US countries in the WIOD database as well as composite constructed by the WIOD authors. I aggregate the industries into three sectors. The goods sector includes the agriculture, forestry, and fishing industry (industry codes 1 in the WIOD), the mining industry (code 2), and all manufacturing industries (codes 3–16) The construction sector includes only the industry by the same name (code 18). The services sector contains all other industries.

The raw WIOD data are contained in the Stata file `wiot_full.dta`. There are three python scripts used to process the WIOD data:

1. The script `wiod_dta_to_pik.py` converts the Stata file to a Python pickle file.
2. The script `wiod_preproc.py` performs the aggregation.
3. The input-output matrix used in the calibration (Table 1) is created simply by reshaping the aggregated data for 1995; the python script `iomat.py` performs this step, and writes the latex file for Table 1 and a CSV file used in the wedge accounting program. This script also performs the RAS procedure to balance the no-intermediates version of the input-output matrix used in the sensitivity analysis described above.
4. Finally, the script `wiod_weights.py` calculates the time-varying weights for the constituent countries in the rest of the world that are used to construct the demographic and labor productivity series. These weight for each country in a given year is equal to that country's GDP divided by the total GDP of the rest of the world (my rest of the world, not the WIOD's).

These steps should be performed in order.

C.2 Demographics

The demographic time series parameters are are computed using the UN World Population Prospects: 2015 Revision dataset (United Nations, Department of Economic and Social Affairs, Population Division, 2015). This dataset contains demographic data on every country in the United Nations from 1950 onwards, as well as projections running through 2100. I use data on total populations[2] and dependency ratios[3] to compute

[2] Contained in the file `WPP_2015_INT_F2A_Annual_Population_Indicators.csv`

[3] Contained in the file `WPP_2015_INT_F2A_Annual_Population_Indicators_DependencyRatios.csv`

adult-equivalent and working-age populations using standard procedures.

The working-age population for a country is equal to

$$WA_{i,t} = POP_{i,t} - DEP_{i,t} * POP_{i,t}/(1 + DEP_{i,t},$$

where $POP_{i,t}$ is the country's total population and $DEP_{i,t}$ is its dependency ratio. The adult-equivalent population is equal to

$$AE_{i,t} = (WA_{i,t} * 0.5608 + 0.5 * (POP_{i,t} - WA_{i,t} * 0.5608))/1.5608. \tag{1}$$

I compute these measures for each country in the dataset and then normalize them to one in 1995. To compute the rest of the world's demographic series, I take a weighted average of the series for the 39 non-US countries in the WIOD dataset, using the weights computed from the WIOD GDP data above. The python script `demo.py` performs these steps and writes a CSV file used as an input in the wedge accounting program.

C.3 Labor productivity

The labor productivity parameters are computed using the Conference Board's Total Economy Database.[4] I use the variable "labor productivity per hour, 2015 USD" (lp_hr_2015usd) and normalize for each country to 1 in 1995. For the United States, I take the data directly. For the rest of the world, I use the same procedure as in the demographic data construction: I take a weighted average of the labor productivities in the 39 non-US WIOD countries, using the time-varying weights computed above. The python script `lp.py` performs this step and writes a CSV file used as an input to the wedge accounting program.

C.4 Initial conditions

The initial conditions for bonds are taken directly from the Lane and Milesi-Feretti dataset (Lane and Milesi-Feretti, 2007). I use the variable "NFA/GDP." The U.S. initial bondholdings are set to the 1995 value of this variable for the United States. The rest of the world's initial bondholdings are set to the negative of this value.

The initial conditions for capital are taken from the Penn World Tables version 9.0. I compute each country's 1995 capital-output ratio using the variables CK and $CGDPO$. For the United States, I take use the resulting value directly as the initial condition for aggregate capital. For the rest of the world, I take a weighted average of the capital-output ratios of the 39 non-US countries in the WIOD dataset, using the 1995 weights computed above. The python script `k.py` performs this step.

[4]The data are contained in the file `ted.csv`.

C.5 Wedge accounting targets

The python script `wiod_preproc.py` also creates a CSV file with the following wedge-accounting target variables: U.S. trade balance, U.S. investment rate, rest of the world investment rate, U.S. real exchange rate, and U.S. real interest rate. The trade balance and investment rates are computed directly from the WIOD data. The real exchange rate is taken from the IMF IFS dataset (variable Real Effective Exchange Rate). The real interest rate is computed using the 10-year yield on U.S. Treasury Bonds and the CPI for all urban consumers (all items less food and energy) downloaded from the St. Louis Fed FRED database. The IMF and FRED data are stored in the file "forpython.csv." The aforementioned python script merges these additional data onto the WIOD data, and then saves a set of CSV files used by the wedge accounting program as inputs.

C.6 Capital account openness and financial development

The measures for the rest of the world's capital account openness and financial development are constructed using the Chinn and Ito (2006) dataset and the Beck et al. (2000) dataset, respectively.[5] For the former I use the variable "KA_OPEN" (capital account opennness relative to the United States). For the latter I use the variable "PCRDBOFGDP" (credit to the domestic private sector as a fraction of GDP). I use the same procedure as in the demographic and labor productivity data construction: I take a weighted average of the capital account openness/financial development in the 39 non-US WIOD countries, using the time-varying weights computed above. The python script `kaopen_findev.py` performs this step and writes text files used by the plotting script, `plots.py`.

Appendix D: Wedge accounting program

The wedge accounting program is written in C. It is contained in the folder "programs/c" in the online supplement. The top level of this folder contains a makefile that compiles the program. The source code is contained in the "src" subfolder. The "bin" folder contains the binary executable produced by the makefile. Run it from the top level using the shell command "./bin/gsg_dsd." The program has a number of command line options that trigger various sensitivity analyses; run "./bin/gsg_dsd -h" to see a list of these options. After running the program, run the python scripts `tables.py`, `tables_sens.py` and `plots.py` to produce the tables and figures shown in the paper.

[5]The raw data are contained in the files `kaopen_2015.dta` and `FinStructure_November_2013.csv`.

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Table 1: Wedge accounting for U.S. trade balance in baseline model and additional sensitivity analyses

		United States		Rest of the world		
Model	No wedges	Saving wedge	Inv. wedge	Saving wedge	Inv. wedge	Trade wedge
(a) RMSE from data						
Baseline	8.21	7.89	8.73	1.90	7.80	8.86
No input-output linkages	11.22	11.02	11.85	1.70	10.65	13.68
One sector	8.01	7.49	8.39	2.06	7.69	8.82
Low capital adj. costs	8.21	7.89	8.79	1.94	7.74	8.98
High capital adj. costs	8.21	7.89	8.68	1.88	7.84	8.78
Low Armington elasticities	6.19	6.03	6.63	1.87	5.87	5.91
High Armington elasticities	12.67	11.79	13.39	2.26	12.17	15.62
Low wedge persistence	8.21	7.73	8.71	1.96	7.76	8.85
High wedge persistence	8.21	8.30	8.76	1.83	7.88	8.88
Lower long-run real interest rate	12.87	5.52	13.73	6.34	12.19	13.76
(b) Fraction of CED explained						
Baseline	0.00	0.03	-0.06	0.96	0.05	-0.03
No input-output linkages	0.00	0.01	-0.05	1.03	0.05	-0.12
One sector	0.00	0.06	-0.04	0.94	0.04	-0.06
Low capital adj. costs	0.00	0.04	-0.06	0.96	0.05	-0.03
High capital adj. costs	0.00	0.03	-0.06	0.96	0.05	-0.04
Low Armington elasticities	0.00	-0.29	-0.41	0.95	-0.27	-0.38
High Armington elasticities	0.00	0.38	0.32	0.98	0.39	0.33
Low wedge persistence	0.00	0.03	-0.06	0.96	0.05	-0.03
High wedge persistence	0.00	0.03	-0.06	0.96	0.05	-0.03
Lower long-run interest rate	0.00	0.39	0.33	0.98	0.40	0.35

Notes: The second column reports counterfactual model outcomes when all wedges are set to one. Columns 3–7 report counterfactual model outcomes with one wedge set to its calibrate value in each period and all other wedges held constant. Fraction of CED explained calculated as (cumulative difference between trade balance in model and no wedge counterfactual) divided by (cumulative difference between trade balance in data and no-wedge counterfactual). The low (high) capital adjustment cost models set φ to 0.9 (0.7). The low (high) Armington elasticity models set $1/(1-\zeta^1)$ to 2 (6) and $1/(1-\sigma^1)$ to 1.5 (3). The low (high) wedge persistence models set ρ_τ to 0.5 (0.8). The lower long-run real interest rate model sets the long-run real interest rate to 0.5%.