Global Imbalances and Structural Change in the United States*

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ABSTRACT

Since the early 1990s, as the United States has borrowed from the rest of the world, employment in the U.S. goods-producing sector has fallen. We construct a dynamic general equilibrium model with two mechanisms that could generate declining goods-sector employment: foreign lending and differential productivity growth across sectors. We find that 18 percent of the decline in goods-sector employment from 1992 to 2012 follows from U.S. trade deficits. Most of the decline in employment in the goods sector can be accounted for by differences in productivity growth across sectors. As the United States repays its debt, its trade balance will reverse, but goods-sector employment will continue to fall.

Keywords: Global imbalances; Real exchange rate; Structural change
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1. Introduction

Between 1992 and 2012, households and the government in the United States borrowed heavily from the rest of the world, and the U.S. net international investment position deteriorated by $4 trillion. A commonly held view in policy circles, expressed, for example, by Bivens (2006) and Scott, Jorgensen, and Hall (2013), is that the U.S. trade deficits generated by this borrowing have played an important role in the decline of employment in the U.S. goods-producing sector and that an end to these deficits will reverse a large part of this trend.

We use a dynamic general equilibrium model of the United States and the rest of the world to address the questions: To what extent are trade deficits responsible for the loss of U.S. goods-sector employment? Will employment return to goods-producing sectors when U.S. borrowing ends and trade deficits become trade surpluses?

Our framework combines an open economy model of foreign lending and a model of structural change — the secular shift of employment from goods-producing industries to services-producing industries — that has been typically studied in a closed economy. Structural change in our model is driven by differential productivity growth across sectors as in Ngai and Pissarides (2007). Faster productivity growth in the goods-producing sector, combined with a low elasticity of substitution between goods and services, generates the structural change in the composition of employment. We use this model to quantitatively assess the relative contributions of asymmetric labor productivity growth and the saving glut to the decline in goods-sector employment in the United States.

Our calibrated model of structural change and trade imbalances accounts for 78 percent of the decline in goods sector employment from 1992 to 2012. (Notably, we do not model the U.S. recession in 2007–2009 except through its impact on the trade balance.) In the model, U.S. trade deficits accounted for 17.7 percent of the decline in the goods-producing sector’s employment between 1992 and 2012, with most of the remainder attributed to faster productivity growth in the goods sector relative to other sectors. This implies that eliminating the trade deficit will not generate a significant increase in goods-sector employment. We find that, if the trade deficit gradually changes to a surplus, U.S. borrowing in the 1990s and 2000s has been welfare improving. If the trade balance reverses quickly and unexpectedly — a sudden stop, like that in Mexico in 1995–1996 — then welfare would be greater if the United States had not borrowed.
It is easy to see why some view trade deficits as detrimental to goods-sector employment. Figure 1 shows that the share of employment in the goods sector — agriculture, mining, and manufacturing — has fallen dramatically as the trade deficit has grown. The intuition for this idea is simple: Imported goods are substitutes for domestically produced goods. As the United States trades bonds for foreign goods, labor shifts away from domestically produced goods and is reallocated to producing services and construction, which are less substitutable for foreign goods. When the debt has to be repaid, labor will flow back into the goods sector to produce the extra goods needed to repay the debt. The importance of this channel for U.S. goods-sector employment is the quantitative question at the center of our study.

In constructing the model, we need to specify the driving force behind U.S. borrowing. A common explanation is that foreign demand for saving increased, making foreigners more willing to trade their goods for U.S. bonds. Bernanke (2005) coined the term global saving glut to refer to this idea, and we adopt Bernanke’s global-saving-glut hypothesis. Several explanations have been proposed for the increased demand for saving in the rest of the world, such as a lack of financial development in the rest of the world (Caballero, Farhi, and Gourinchas, 2008; Mendoza, Quadrini, and Rios-Rull, 2009), differences in business cycle or structural growth properties (Backus et al., 2006; Perri and Fogli, 2010; Jin 2012), and demographic differences (Du and Wei, 2013). We do not take a stand on which of these explanations, if any, are correct. Instead, we take the saving glut as given and calibrate a process for the preferences of households in the rest of the world over current versus future consumption so that our model matches exactly the path of the U.S. trade balance between 1992 and 2012.

We include four features in the model that make it well suited to address these issues. First, we model an economy with three sectors: goods, services, and construction. Goods and services can be traded, which allows us to capture the fact that the United States consistently runs a substantial trade surplus in services. International macroeconomic models usually treat goods as the only tradable sector and lump all other sectors into a single nontradable sector. This assumption is at odds with the data: Services are a large component of U.S. exports. Construction is the only nontradable sector and is used almost entirely to produce investment goods, which means that construction is more sensitive than the other sectors to the effects of capital flows and economic fluctuations in general. Second, we build a detailed input-output structure into the production side of the model. This allows us to model the elasticity of
substitution between goods, services, and construction in production as well as consumption. Third, we allow the elasticity of substitution between foreign and domestic inputs to differ across sectors. Our calibration assigns a higher elasticity of substitution between domestic and foreign inputs in the goods sector to match the fact that the goods trade balance is more volatile than the services trade balance, as seen in figure 6.

Fourth, and perhaps most important, we allow labor productivity to grow at different rates across sectors, matching the fact that labor productivity in the goods sector grew at a faster pace than in other sectors over the past two decades, as seen in figure 2. The structural change literature emphasizes asymmetric productivity growth as an important driver of the long-run reallocation of labor across sectors. Recent studies embed this mechanism, originally due to Baumol (1967), into closed-economy models that are consistent with aggregate balanced growth (Ngai and Pissarides, 2007; Buera and Kaboski, 2009). We take a similar approach in an open economy model. Several other recent papers study structural change in open economies (Echevarria, 1995; Matsuyama, 1992, 2009; Sposi, 2012; Uy, Yi, and Zhang, 2013). With the exception of Sposi (2012), these studies use models of balanced trade, abstracting from international capital flows. Allowing for unbalanced trade, we can assess the relative contributions of traditional structural change forces and the saving glut to the dynamics of the U.S. economy.

Buera and Kaboski (2012) identify three possible sources of structural change: differential sectoral productivity growth and a low elasticity of substitution between sectors (Ngai and Pissarides, 2007); nonhomothetic preferences (Kongsamut, Rebelo, and Xie, 2001); and capital deepening and sector-specific capital shares (Acemoglu and Guerrieri, 2008). As argued by Buera and Kaboski (2012), nonhomothetic preferences are most relevant at low levels of income and are thus unlikely to be important for the United States. We allow for sector-specific capital shares in our model, but they do not play a quantitatively important role in our results.

We calibrate our model so that it matches exactly the national accounts and input-output table for the United States in 1992 and the U.S. trade balance during 1992–2012. As figures 5–7 show, our calibrated model endogenously generates outcomes that match several key facts about the U.S. economy during this period: We match the magnitude of the real exchange rate
appreciation and subsequent depreciation, the dynamics of the disaggregated goods and services trade balances, and the changes in sectoral employment shares.

We use the model to conduct two kinds of exercises: historical counterfactuals and predictions about the future. In our counterfactual scenario, we turn off the saving glut, which allows us to answer questions about the path the U.S. economy would have taken had the saving glut never occurred. In our model without a saving glut, the goods sector’s employment share falls from 19.7 percent in 1992 to 15.1 percent in 2012 compared with 14.1 percent in the model with the saving glut and to 12.5 percent in the data. Looking to the future, our benchmark model predicts that the goods sector’s employment share will continue to decline in the long run, and that the trade balance reversal required to repay the debt the United States incurred during the saving glut will have little impact on goods-sector employment. The goods sector’s employment share is 13.1 percent in 2024 in our benchmark, versus 12.6 percent in the counterfactual scenario in which the saving glut never occurs.

Our model allows us to ask: To what extent has the saving glut been good for U.S. households? We construct a measure of the real income of U.S. households in 1992, and compare the welfare of U.S. households in the baseline model to a counterfactual in which the saving glut did not occur. The saving glut itself improves welfare: The lifetime real income of U.S. households in 1992 would have been almost $700 billion lower (about 11 percent of 1992 GDP) if the saving glut had not happened. In our baseline model, we assume that the transition from a trade deficit to a surplus will happen gradually.

In an extension, we consider the effects of a sharp reversal of the trade balance — a sudden stop — as suggested in Obstfeld and Rogoff (2005, 2007). Our results indicate that a sudden stop in the United States in 2015–2016 would look similar to historical episodes in emerging economies: a large real exchange rate depreciation, a substantial productivity-driven output contraction, and a sharp reallocation of factors across sectors (Calvo, Izquierdo, and Mejía, 2004; Calvo and Talvi, 2005; Kehoe and Ruhl, 2009). As in sudden stops of the past, these effects would be short-lived; several years after the sudden stop ends, the U.S. economy would be on almost the same path on which it would have been if the sudden stop had never happened. Any temporary reallocation of labor to the goods-producing sector during the sudden stop would be quickly reversed and have no long-term effect.
In the sensitivity analysis of our model, we find that our main results are robust to a range of modeling choices, such as altering our assumptions about the path of government spending and abandoning perfect foresight in favor of a stochastic model with rational expectations. The input-output production structure and the tradability of services, however, play important quantitative roles in our model’s predictions for goods-sector employment. Removing the input-output structure raises the elasticity of substitution between goods and services in gross output, which causes our model to capture a significantly smaller fraction of the decline in goods-sector employment we observe in the data during 1992–2012. This change also leads our model to overstate the role of the saving glut in reducing goods-sector employment during this period; making services nontradable has a similar effect.

To justify our assumption that the U.S. trade deficit has been driven by the rest of the world’s demand for saving rather than domestic factors, we study a version of our model in which we alter the preferences of U.S. households — rather than those in the rest of the world — to match the U.S. trade balance. This *domestic-saving-drought* experiment does not significantly affect our main results about goods-sector employment, but it leads to predictions for investment and construction employment that are sharply at odds with the data: The foreign-saving-glut hypothesis fits the data better.


This section presents our approach to analyzing U.S. data over the past two decades. We view the massive foreign borrowing and the differentials in productivity growth across sectors as exogenous driving forces that we take as inputs into the model. Below, we present three key facts about U.S. data that we view as tests for our model. It is our model’s ability to replicate these three facts in response to the exogenous driving forces that gives us confidence in using the model to make predictions about the future of the U.S. economy.

**Exogenous driving force 1: Foreign borrowing increased, then decreased**

Figure 3 illustrates just how much borrowing households and the government in the United States have done. The current account balance measures the exact magnitude of capital flows into the United States, but we see that the trade balance tracks the current account balance almost exactly. Since our model is not designed to accurately capture the difference between these two
series, and the trade balance has an exact model analogue, we use the trade deficit as our measure of U.S. borrowing. Figure 3 shows that between 1992 and 2006, the trade deficit grew steadily, reaching 5.8 percent of GDP, after which it began to shrink. In 2012, the trade deficit remained at 3.6 percent of GDP. We view the path of the trade balance as what defines the saving glut in our model. Our hypothesis is that the U.S. economy is currently in the process of emerging from the saving glut.

Capital flows are important to our analysis in two ways. First and foremost, the imbalanced flow of goods into the United States directly affects the need to produce goods domestically and, thus, the labor needed in that sector. The trade balance is the most appropriate measure of this force. Second, the accumulated debt eventually needs to be repaid, which could affect the future employment needed to produce goods in the United States. In the model, accumulated trade balances are the measure of this accumulated debt, which differs from the U.S. net foreign asset position by any revaluation effects. These revaluation effects have, at times, played a significant role in the value of the U.S. net foreign asset position (Lane and Milesi-Ferretti, 2008; Gourinchas and Rey, 2007). To the extent that revaluation has been in the favor of the United States, the smaller future debt burden would decrease the need to reallocate labor back into the goods-producing sectors.

**Exogenous driving force 2: Labor productivity grew fastest in the goods sector**

During 1992–2012, labor productivity in the goods sector increased by an average of 4.2 percent per year, while it increased by only 1.3 percent per year in the services sector and fell by 1.2 percent per year in construction. What is essential in our model is the differential between productivity growth in the goods sector and that in the services sector. As the data in figure 2 show, this differential has been close to constant since 1980, with average productivity growth of 4.1 percent per year in goods during 1980–2012, compared with 1.3 percent in services. Except for the productivity slowdown of the 1970s, the differential has been persistent since 1960. Our hypothesis is that this productivity differential persists until at least 2030.

**Fact 1: The real exchange rate appreciated, then depreciated**

Figure 3 presents the first key fact that we ask our model to replicate. The figure shows that the U.S. real exchange rate was volatile and tracked the trade balance closely during 1992–2012.
We construct our measure of the U.S. real exchange rate by taking a weighted average of bilateral real exchange rates with the United States’ 20 largest trading partners, with weights given by these countries’ shares of U.S. imports in 1992. (Other weighting schemes do not significantly affect our results.) This approach forms the basis of our concept of the rest of the world in our model. The real exchange rate appreciated by 27.9 \(\left(100 \times \left(\frac{100}{78.2} - 1\right)\right)\) percent between 1992 and 2002, after which it depreciated by 22.1 percent between 2002 and 2012. The intuition for why the real exchange rate and trade balance should move closely is straightforward: As foreign goods and services become cheaper, U.S. households buy more of them. Notice, however, that the timing is off: The maximum appreciation of the real exchange rate occurred in 2002, whereas the largest trade deficit occurred in 2006.

**Fact 2: The goods sector drove aggregate trade balance dynamics**

Figure 6 presents our second key fact. Here we disaggregate the trade balance, plotting the trade balances for goods and services separately. We see that the goods trade balance generates most of the fluctuations in the aggregate trade balance, whereas the services trade balance fluctuates in a band between 0.5 and 1.2 percent of GDP. That the United States has consistently run a trade surplus in services motivates one of the key features of our modeling framework. Standard modeling conventions in international macroeconomics lump services together with construction into a nontradable sector, treating goods as the only sector that produces output that can be traded internationally. By contrast, we allow both goods and services to be traded in our model, and we calibrate home bias parameters — the share parameters in the Armington aggregators — for each sector separately to capture the fact that the United States consistently runs a surplus in services and a deficit in goods.

**Fact 3: Employment in goods declined steadily; construction employment rose, then fell**

Figure 7 presents our third fact: Between 1992 and 2012, the fraction of total labor compensation paid to the goods sector fell from 19.7 percent to 12.5 percent. The fraction of total labor compensation is our preferred measure of the goods sector’s employment share because it maps directly into our model, where we measure labor inputs in terms of effective hours worked, rather than raw hours worked. As figure 1 shows, this measure moves closely with more common measures like the share of employees in the goods sector; the same is true for
the construction sector. The construction sector’s share of labor compensation rose from 4.4 percent in 1992 to 5.7 percent in 2006, as construction boomed prior to the financial crisis in 2008–2009. Employment in construction then started to fall, and by 2012 the construction sector’s share of labor compensation was again 4.4 percent.

3. Model

We model an economy with two countries, the United States and the rest of the world (RW). We use the superscripts us and rw to denote prices, quantities, and parameters in the United States and the rest of the world. The length of a period is one year. Each country has a representative household that works, consumes, and saves to maximize utility subject to a sequence of budget constraints. The model begins in 1992, is subject to transitory — though decades long — changes in sectoral productivity growth rates and the rest of the world’s willingness to lend, and eventually settles onto a long-run balanced growth path.

Each country produces commodities that serve both intermediate and final uses. We model the U.S. production structure in detail, using an input-output structure that we calibrate to the U.S. input-output matrix. We model production in the rest of the world in a simpler fashion, abstracting from investment and domestic input-output linkages. We model the U.S. government in a reduced-form fashion as well — the government’s spending and debt are specified exogenously, and the government levies lump-sum taxes on U.S. households to ensure that its budget constraints are satisfied.

Financial assets

The U.S. government, households in the United States, and households in the rest of the world have access to a one-period, internationally traded bond, \( b_t \), that is denominated in units of the U.S. consumer price index (CPI). U.S. households can also save by investing in the U.S. capital stock, but will be indifferent between holding capital and bonds because they both pay the same return in equilibrium. We model a single bond, but the equilibrium of our baseline model is equivalent to one in which both governments and households issue debt. The deterministic nature of the model gives rise to Ricardian equivalence (except at the onset of the savings glut), so the split between public and private debt is essentially irrelevant. In section 6 we present a
stochastic version of the model in which public and private debt are distinct, but we find this change to be quantitatively insignificant.

Production

The United States produces four commodities: goods $y_{gt}^{us}$, services $y_{st}^{us}$, construction $y_{ct}^{us}$, and investment $y_{it}^{us}$. The rest of the world produces its own goods $y_{gt}^{w}$ and services $y_{st}^{w}$. Prices are denoted analogously. All commodities are sold in perfectly competitive markets. Each U.S. commodity $j = c, g, s, i$ is produced using capital $k_{jt}^{us}$ and labor $\ell_{jt}^{us}$, along with intermediate inputs of U.S. goods $z_{gt}^{us}$, U.S. services $z_{st}^{us}$, U.S. construction $z_{ct}^{us}$, and imports $m_{jt}^{us}$ purchased from the same sector $j$ in the rest of the world:

$$y_{jt}^{us} = M_{jt}^{us} \left[ \mu_{jt}^{us} \left( \min \left[ \frac{z_{gt}^{us}}{a_{gt}^{us}}, \frac{z_{st}^{us}}{a_{st}^{us}}, \frac{z_{ct}^{us}}{a_{ct}^{us}}, A_{jt}^{us} \left( k_{jt}^{us} \right)^{\alpha_j} \left( y_{jt}^{us} \ell_{jt}^{us} \right)^{1-\alpha_j} \right] \right) \right] + (1 - \mu_{jt}^{us}) \left( m_{jt}^{us} \right)^{\gamma_j} \right]^{1/\zeta_j}.$$

This nested production function embeds a Leontief input-output structure in an Armington aggregator. The parameters of the production functions are: $M_{jt}^{us}$ and $A_{jt}^{us}$, the constant scaling factors used to facilitate calibration; $\mu_{jt}^{us}$, which governs the share of imports in production; $\zeta_j$, which governs the elasticity of substitution between domestic and imported inputs; $\left( a_{gt}^{us}, a_{st}^{us}, a_{ct}^{us} \right)$, which govern the shares of goods, services, and construction in gross output; $\gamma_{jt}^{us}$, the sector-specific labor productivity; and $\alpha_j$, capital’s share of value added.

Our assumption of zero substitutability between intermediate inputs is standard in the input-output literature, consistent with empirical findings that direct requirement coefficients vary little over time (Sevaldson, 1970; Miller and Blair, 2009). This assumption implies that the elasticity of substitution between goods and services in both intermediate and final uses is lower than the same elasticity in final uses alone. In section 6, we show that this assumption plays an important role in our model’s ability to capture the reallocation of labor across sectors that we observe in the data.

We allow the Armington elasticities $1/(1 - \zeta_j)$ to differ across sectors to capture the fact that the goods trade balance is more volatile than the services trade balance (see figure 6).
also allow labor productivity $\nu_{jt}$ to grow at different rates across sectors to capture the fact that productivity in the goods sector has grown faster than in other sectors. This differential productivity growth is the driving force behind the structural change mechanism in the model. U.S. producers in all three sectors $j = g, s, c$ choose inputs of intermediates and factors to minimize costs, which implies standard marginal product pricing conditions for capital and labor.

The U.S. investment good is produced using inputs $z_{gjt}$, $z_{sjt}$, and $z_{cjt}$ of goods, services, and construction according to

$$y_{jt}^{us} = G(z_{gjt})^{\theta_g}(z_{sjt})^{\theta_s}(z_{cjt})^{\theta_c}, \quad \theta_g + \theta_s + \theta_c = 1.$$  

This specification is consistent with evidence reported by Bems (2008) that expenditure shares on investment inputs are approximately constant over time across a range of countries.

We model the rest of the world’s production structure in less detail, abstracting from investment and input-output linkages. Goods and services in the rest of the world are produced using labor $\ell_{jt}^{rw}$ and imported intermediate inputs $m_{jt}^{rw}$ from the same sector $j$ in the United States. The production functions are simpler nested Armington aggregators of the form

$$y_{jt}^{rw} = M_j^{rw}\left(\mu_j^{rw}\left(y_{jt}^{rw}\ell_{jt}^{rw}\right)^{\gamma_j} + (1 - \mu_j^{rw})\left(m_{jt}^{rw}\right)^{\gamma_j}\right)^{1/\gamma_j}.$$  

**Households**

Each country is populated by a continuum of identical households. We draw a distinction between the total and working-age populations so that our model can capture the impact of demographic changes on households’ incentives to borrow and save. We denote the total U.S. population by $n_t^{us}$ and the working-age population by $\tilde{t}_t^{us}$. We evaluate consumption per capita on an adult-equivalent basis, defining the U.S. adult-equivalent population as $n_t^{ae} = \tilde{t}_t^{us} + (n_t^{us} - \tilde{t}_t^{us})/2$. The rest of the world’s demographic variables are defined analogously.

We normalize the amount of time available for work and leisure by a U.S. working-age person to one and denote total U.S. labor supply by $\ell_t^{us}$. U.S. households choose labor supply,
consumption of composite goods and services $c^{ush}_{gt}$ and $c^{ush}_{st}$, investment $i^{us}_{t}$, and bond holdings $b^{ush}_{t}$ to maximize utility

$$\sum_{t=0}^{\infty} \beta^t \left( \frac{c^{ush}_{gt}}{n^{ush}_{t}} \right) + (1 - \beta^{ush})(\frac{c^{ush}_{st}}{n^{ush}_{t}}) = \frac{\epsilon^{ush}_{t} - \epsilon^{ush}_{t}}{\beta^{ush}_{t}} \left( \frac{b^{ush}_{t}}{b^{ush}_{t}} \right)^{(1-\eta)^{ush}} \psi^{-1}$$

subject to the budget constraints

$$p^{ush}_{gt}c^{ush}_{gt} + p^{ush}_{st}c^{ush}_{st} + p^{ush}_{it}i^{ush}_{t} + q_{t}b^{ush}_{t} = w^{ush}_{t}w^{ush}_{t} + p^{ush}(p^{ush}_{gt}, p^{ush}_{st})b^{ush}_{t} + (1-\tau^{ush}_{k})r^{ush}_{k}k^{ush}_{t} - T^{ush}_{t},$$

the law of motion for capital

$$k^{ush}_{t+1} = (1-\delta)k^{ush}_{t} + i^{ush}_{t},$$

appropriate non-negativity constraints, initial conditions for the capital stock and bond holdings $k^{ush}_{0}$ and $b^{ush}_{0}$, and a constraint on bond holdings that rules out Ponzi schemes but does not otherwise bind in equilibrium. We use the superscript $ush$ for U.S. households’ consumption and bond holdings to distinguish them from those of the U.S. government, for which we use the superscript $usg$. Households pay constant proportional taxes $\tau^{ush}_{k}$ on capital income and a lump-sum tax or transfer $T^{ush}_{t}$. We use the capital income tax to obtain a sensible calibration for the initial capital stock and depreciation rate. We also allow the tax rate on capital income in 1993 to differ from the constant rate in order to match the level of investment in 1992.

Bonds are denominated in units of the U.S. CPI, defined as


We model discount bonds, so the price $q_{t}$ represents the price in period $t$ of one unit of the U.S. CPI basket in period $t+1$. The real interest rate in units of the U.S. CPI is given by

$$1 + r^{ush}_{t+1} = p^{ush}(p^{ush}_{gt}, p^{ush}_{st}) / q_{t}.$$

During the sudden stop episode that can occur in 2015, bond holdings are fixed and the internal real interest rate is determined endogenously in each country separately. The market clearing condition for bonds is
The rest of the world’s households solve a simpler problem. We abstract from investment dynamics in the rest of the world, so the only way the rest of the world’s households can save is by buying U.S. bonds. We can easily allow for rest-of-the-world bonds as well without changing the equilibrium of the model. Labor supply is endogenous and the rest of the world’s households have a utility function similar to that of U.S. households:

\[
\sum_{t=0}^{\infty} \beta^t \omega^t_r \left[ \varepsilon^r_t \left( \frac{c^r_t}{n^r_t} \right)^{\rho} + \left( 1 - \varepsilon^r_t \right) \left( \frac{c^r_{st}}{n^r_t} \right)^{\rho} \right] \frac{a^r}{\rho} \left( \frac{T^r_t - \varepsilon^r_t}{\bar{\varepsilon}^{r}} \right)^{(1-\eta)\psi}.
\]

The only differences from the U.S. households’ utility function are the share parameter \( \varepsilon^r_t \) and the utility weight \( \omega^r_t \). The latter is an intertemporal demand shifter, which we calibrate to match the U.S. trade balance during 1992–2012. During this period \( \omega^r_t \) falls, reflecting a reduction in utility gained from consumption at \( t \) compared with future consumption. This is the driving force behind the saving glut. The rest of the world’s representative household chooses labor supply \( \varepsilon^r_t \), consumption of goods and services \( c^r_{gt} \) and \( c^r_{st} \), and bond holdings \( b^r_t \) to maximize utility subject to the budget constraints,

\[
p^r_{gt} c^r_{gt} + p^r_{st} c^r_{st} + q_t b^r_{t+1} = w^r_t \varepsilon^r_t + p^w (p^w_{gt}, p^w_{st}) b^r_t,
\]

and non-negativity and no-Ponzi constraints similar to those that U.S. households face. The rest of the world’s CPI is defined analogously to the U.S. CPI in (7). The real exchange rate is

\[
re^r_t = p^w (p^w_{gt}, p^w_{st}) / p^w (p^w_{gt}, p^w_{st}).
\]

**U.S. government**

The government in the United States levies taxes and sells bonds to finance exogenously required expenditures on consumption of goods and services. The budget constraint is

\[
p^w_{gt} c^w_{gt} + p^w_{st} c^w_{st} + q_t b^w_{t+1} = \tau^w_t K^w_t + T^w_t + p^w (p^w_{gt}, p^w_{st}) b^w_t.
\]

We specify exogenous time paths for total government consumption expenditures and debt as fractions of GDP, using historical data for 1992–2012 and Congressional Budget Office (CBO)
projections for the future. We use \( \nu_t \) and \( \nu_{t+1} \) to denote these time series. We allow the lump-sum tax \( T_t^{US} \) to vary as necessary to ensure that the government’s budget constraint is satisfied. To allocate its total expenditure between goods and services, in each period, the government chooses \( c_{gt}^{avg} \) and \( c_{st}^{avg} \) to maximize

\[
\left( c_{gt}^{avg} \right)^{\omega_g} \left( c_{st}^{avg} \right)^{\omega_s}
\]

subject to the constraint that the government makes its required total expenditures. We assume that government spending does not enter the household’s utility function (or equivalently, enters in a separable fashion), nor does it enter any of the production functions.

Because of the lump sum tax, our model exhibits near-Ricardian equivalence. That is, the timing of taxes and government borrowing is almost irrelevant. Ricardian equivalence breaks down only when we introduce unexpected events — the saving glut and the sudden stop. Unanticipated changes in the time path of government debt that accompany these events do affect the model’s equilibrium dynamics, particularly in the short run.

**Equilibrium**

An equilibrium in our model, for a given sequence of time-series parameters \( \{\omega_{t}^{uw}, \nu_{t}, \nu_{t+1}\}_{t=0}^{\infty} \) and initial conditions \( \{b_{0}^{wh}, b_{0}^{avg}, k_{0}^{wu}\} \), consists of a sequence of all model variables such that households in the United States and the rest of the world maximize their utilities subject to their constraint sets, prices and quantities satisfy marginal product pricing conditions for all commodities, prices and quantities are such that all production activities earn zero profits, all commodity, factor, and bond market clearing conditions are satisfied, and the U.S. government solves its consumption-spending allocation problem in each period. When we solve the model numerically, we require that equilibria converge to balanced growth paths after 100 years. There are an infinite number of possible balanced growth paths — indexed by the sum of public and private U.S. debt — but our model’s equilibrium is unique, because the initial conditions determine onto which balance growth path the economy settles.

**4. Calibration**

We calibrate the model’s parameters and initial conditions so that the equilibrium replicates the U.S. input-output matrix and national accounts for 1992. We do this for a model in which the
agents do not foresee the savings glut. We view this as the most natural way to think about the agents’ expectations in the early 1990s: We do not think that U.S. households in 1992 foresaw the kind of borrowing the United States would do over the subsequent two decades. Table 2 lists our calibrated parameter values. More details are provided in the online appendix at http://www.econ.umn.edu/~tkehoe.

**U.S. production parameters**

We choose units so that U.S. GDP is equal to 100 and all prices are equal to 1 in 1992. We compute the parameters in the Leontief portion of the U.S. production functions in (1) directly from the input-output matrix shown in table 1. For example, to compute \( a_{gc} \), the amount of goods needed to produce one unit of gross output in the construction sector, we divide the value in the goods row and construction column (3.7) by gross output in construction (10.7). We use a similar procedure to calculate factor shares in value added for each sector. For the Armington aggregators in (1), we first specify values for the elasticities of substitution between domestic and imported inputs. There is some debate over this elasticity because business cycle models tend to imply a low elasticity, whereas analysis of trade policy changes often suggests a much higher elasticity; see Ruhl (2008) for a detailed discussion. Because the services trade balance is less volatile than the goods trade balance, we choose a lower elasticity of substitution between domestic and foreign inputs in the services sector. We set the elasticity in goods \( 1/(1-\zeta_g) \) to 3 and that in services \( 1/(1-\zeta_s) \) to 1. We then use equilibrium conditions (marginal product pricing and zero profits) to calibrate \( \mu_j^{aw} \) from the input-output matrix. The scale factors \( M_j^{aw} \) are set so that equilibrium outputs match their respective entries in the input-output table. We use a similar procedure to calibrate the production function for investment.

**Household and government parameters**

We set the elasticity of intertemporal substitution \( 1/(1-\psi) \) to 0.5. We set the long-run interest rate to 3 percent (U.S. Congress, Congressional Budget Office, 2012) and the discount factor \( \beta \) so that this interest rate is consistent with balanced growth. We set the elasticity of substitution between goods and services in consumption, \( 1/(1-\rho) \), to 0.5, as in Stockman and Tesar (1995). We calibrate the parameters \( \epsilon^{ush} \) and \( \eta \) of the households’ preferences using private
consumption data from the input-output table and data on hours worked. A similar procedure yields the government’s share parameter $\varepsilon^{wrg}$.

**U.S. initial conditions**

To calculate the initial capital stock, we set the 1992 real interest rate to 4 percent. The real interest rate in 1992 is not an equilibrium object in our model; it would have been determined in 1991, but 1992 is our initial model year. The real interest rate on 10-year U.S. Treasury bonds was approximately 4 percent in 1992. Given a tax rate on capital income $\tau^u_k$, we can compute our initial capital stock using data on depreciation from the 1992 national income accounts and data on payments to capital in the input-output table. We choose $\tau^u_k = 0.4$, which implies a depreciation rate of 6.6 percent per year, well within the standard range of annual depreciation rates found in the literature. Our results are not sensitive to alternative approaches to calibrating the initial capital stock. U.S. government debt was 48.1 percent of GDP in 1992, and we use this value directly to set the level of government debt in 1992, $\bar{b}_{1992}^{avg}$. We then set private bond holdings, $\bar{b}_{1992}^{ush}$, so that total net foreign assets $\bar{b}_{1992}^{ush} + \bar{b}_{1992}^{avg}$ are −7.8 percent of GDP as reported in Lane and Milesi-Ferretti (2007).

**Calibrating the rest of the world**

To calibrate the remaining parameters, we need to define the rest of the world. We select the United States’ top 20 trading partners, ranked by average annual bilateral trade (exports plus imports) between 1992 and 2012, and weight them by their average share of U.S. total annual trade during this period. We use these countries’ weights to construct a composite trading partner, thinking of the rest of the world as being composed of 20 identical countries that all look like this composite. To calculate the size of the rest of the world relative to the United States, we take a weighted average of goods and services consumption of these 20 countries and multiply these figures by 20 to get total consumption of goods and services in the rest of the world. We use equilibrium conditions in a similar manner as before to calibrate the rest of the world’s Armington aggregators and preference parameters.
Exogenous processes

We use historical data and future projections from the World Population Prospects: 2010 Revision (United Nations, 2011) to construct time series for the demographic parameters for both the United States and the rest of the world (using the same 20 countries and weights as before). The United States and the rest of the world are projected to grow at different rates well past the 100-year terminal date in our model, so to ensure balanced growth, we assume that the populations in both countries begin to converge to constant levels after 2050. Our model’s equilibrium dynamics during 1992–2024, the period on which we focus, are not sensitive to this assumption.

We calculate sector-level productivity growth rates using data on value added and labor compensation by sector from the BEA for 1992–2012. We find that the average growth rates of labor productivity over this period are 4.3 percent in goods, 1.3 percent in services, and −1.2 percent in construction. We use these values in the model between 1992 and 2030, and in the years following we assume that all of the sector-level growth rates converge slowly to 2 percent per year, to ensure that the equilibrium converges to a balanced growth path.

We need to specify the exogenous time paths for government expenditure and government debt. We use historical data on government consumption and debt for the years 1992–2012. From 2012 onward, we use CBO projections and make adjustments to retain consistency with the national income accounts and to allow for balanced growth in the long run. Some of the CBO projections made for the path of government debt are implausible, however; the CBO’s extended baseline scenario predicts that government debt will drop below zero by 2070, and the CBO’s extended alternative scenario predicts that debt will surpass 250 percent of GDP by 2045. We therefore assume that government debt as a fraction of GDP will remain constant at the 2023 value of 77.0 percent of GDP in 2024 and beyond. More details about the construction of the government’s variables are available in the appendix.

Recall that we are calibrating the model under the assumption that the savings glut was unforeseen in 1992. Formally, this means that we calibrate the rest of the world’s preference parameter \( \omega_{1992}^{rw} \) to match the U.S. trade balance in 1992, and we assume that it converges gradually to a constant value of 1 thereafter.
The saving glut

At this point, we have calibrated and solved the model in which agents believe that the intertemporal rate of substitution in the rest of the world will remain relatively constant. To calibrate the savings glut, we need to calibrate the values of $\omega_t^w$ for 1993–2012 so that the equilibrium replicates exactly the aggregate U.S. trade balance during this period. Note that this is the only time series from the data that we use in the calibration. We assume that $\omega_t^w$ gradually converges to 1 after 2012. We refer to the model’s post-2012 dynamics in this scenario as a gradual rebalancing, representing the outcome of a slow, orderly end to the forces driving the saving glut. The saving glut, which manifests in our model as temporarily reduced utility from consumption and leisure in the rest of the world, is an unanticipated event: Model agents in 1992 do not expect it to occur, but they have perfect foresight thereafter. In our sensitivity analysis, we relax the perfect foresight assumption and allow for agents to be uncertain about the length of the saving glut.

5. Quantitative results

This section presents the baseline quantitative results and demonstrates that the model replicates our three key facts. We then compare the outcomes of the baseline model with those from a model in which the savings glut does not occur.

Replicating the three key facts

Prices, quantities, and the trade balance from 1992 onward are endogenous outcomes of the model. Here we show that the equilibrium of the calibrated model matches the U.S. data in the three key dimensions laid out in section 2. As figure 4 shows, our calibration procedure implies that the U.S. trade balance matches exactly the data from 1992–2012. In this figure we have also plotted the trade balance from the model in which the saving glut never occurs. Notice that, in this counterfactual scenario, trade is approximately balanced throughout the period. In the baseline model, however, the saving glut has occurred, so the United States must repay its debt in the long run. The figure shows that the U.S. trade balance will switch from a deficit to a surplus in 2018, and will reach a surplus of more than 1 percent of GDP by 2024.

Even though goods-sector productivity growth is rapid, there is little incentive for the agents to borrow to smooth consumption in the absence of the savings glut. The weighted-
average productivity growth rate in the economy in 1992–2012 is very close to the long-run productivity growth rate of 2 percent: In the aggregate, there is little reason for intertemporal trade. The small amount of intertemporal trade in figure 4 is due to differences in population growth rates between the United States and the rest of the world.

Figure 5 plots the model’s real exchange rate in the baseline model against the data and the no-saving-glut counterfactual. Our model does a good job of matching the magnitude of the appreciation during 1992–2012: The real exchange rate appreciated by 27.9 percent in the data and 26.1 percent in the model before beginning to depreciate. The model, however, fails to capture the timing of the depreciation. In the data, the real exchange rate begins to depreciate in 2002, four years before the trade deficit begins to shrink. In our model, the real exchange rate moves in tandem with the trade balance, so it does not begin to depreciate until 2006. In our model, consumers and firms begin to import fewer foreign goods and services only once they begin to become more expensive.

Figure 5 also shows that if the saving glut had never occurred, the U.S. real exchange rate would appreciate slowly over the long run, due in large part to the increase in the relative price of services, in which the United States has a comparative advantage. The saving glut did occur, however, and because the United States must run a trade surplus in the long run, its goods and services must become cheaper. Our model predicts that the real exchange rate will continue to depreciate for several years, eventually converging to a level that is 5.9 percent higher — that is, more depreciated — than that in the no-saving-glut counterfactual.

Figure 6 plots the sector-level trade balances in the model and the data. The model matches both the goods and services trade balances closely between 1992 and 2012. This aspect of the model’s performance is mostly due to our choice of Armington elasticities. Had we used the same elasticity in both sectors, the goods trade balance would not have moved enough, while the services trade balance would have been too volatile. The figure also shows that in the absence of the saving glut, the services trade balance would not have been substantially different, while the goods trade balance, reflected in the aggregate trade balance, would have been almost flat. In the long run, the model predicts that the goods trade balance will be 1.4 percent of GDP higher by 2024 than it would have been if the saving glut had never occurred. Despite this, the model predicts that the goods trade balance will be negative in the balanced growth path: The services sector will be the source of the entire long-run trade surplus.
Figure 7 plots the employment shares for goods and services in the model and the data. The baseline model matches the data closely between 1992 and 2001, after which the goods employment share falls more in the data than in the model. For 1992–2012, our baseline model captures 78.0 percent of the decline in the goods sector’s employment share that we observe in the data. In the no-saving-glut counterfactual, however, the model still captures 64.2 percent of the decline. The figure suggests that, while the saving glut did temporarily accelerate the decline in goods-sector employment, the bulk of the decline is attributable to the fact that labor productivity has grown faster in the goods sector than in the rest of the economy.

This result implies that that the end of the saving glut will have little impact on employment in the goods sector. By 2024, the goods sector’s share of employment will be almost exactly the same regardless of whether or not the saving glut happened. Even though the U.S. economy must run a trade surplus in the long run to repay its debt, the goods sector’s employment share will continue to decline once the saving glut ends. There are two main reasons for this result. First, labor productivity continues to grow faster in goods than in other sectors in our model even after the saving glut ends. This aspect of structural change has been a consistent force in the U.S. economy since the 1960s, and we see no reason that it should end when the saving glut does. Second, the United States can repay its debt with the trade surplus generated by the services sector; our model predicts that the United States will continue to run a deficit in goods trade once the saving glut ends and the aggregate U.S. trade balance reverses.

Figure 7 also shows that the model captures several aspects of the construction sector’s employment share between 1992 and 2012. Between 1992 and 2006, the construction sector’s employment share rises in both the model and the data, although our model generates a larger increase. Our model overexplains the boom in construction sector employment just by introducing the saving glut. The subsequent bust is smaller in the model than in the data — primarily because we have not introduced the financial crisis of 2008–2009 in any form other than the way in which it affected the trade balance. If we were to introduce additional features to the model to more accurately model the crisis, we would undoubtedly do better in this regard, but this is not the focus of our study. As the figure shows, our model suggests that the effects of the saving glut on the construction sector will largely dissipate by 2016; as in the goods sector, the construction sector’s long-run employment share dynamics will be driven primarily by productivity growth rather than the rebalancing process.
Welfare implications of the saving glut

Did the saving glut make U.S. households better off? To answer this question, we construct a measure of real income in 1992 denominated in 1992 U.S. dollars. This real income index is the cost of achieving the equilibrium sequence of utility from 1992 onward in units of the U.S. CPI in 1992:

\[
\sum_{t=1992}^{\infty} \left( \prod_{s=1992}^{t-1} q_s \right) \left( p_{gt}^{us} c_{gt}^{us} + p_{st}^{us} c_{st}^{us} + w_t^{us} \left( \bar{y}_t - \ell_t^{us} \right) \right).
\]

The prices and quantities in (15) represent equilibrium objects in our benchmark model. To convert this object to 1992 dollars, we scale it so that consumption expenditures in the model are equal to 1992 private consumption in the national income and product account (NIPA) tables. We use the resulting scaling factor to calculate real income in alternative scenarios, like the counterfactual in which the saving glut does not occur or the scenario in which both the saving glut and a sudden stop occur.

In our baseline model we assume that, in 1992, model agents expect government consumption expenditures to remain fixed at the 1992 level of 16.6 percent of GDP, but when the saving glut begins, an unforeseen change in government spending policy occurs: Government spending as a fraction of GDP tracks the data between 1993 and 2012, then rises to 22.9 percent over time. This reflects policy changes that have occurred over the past two decades, such as increased health care and defense spending, that people likely did not anticipate in the early 1990s. This increase in government consumption gives U.S. households an incentive to save for the future. We report our welfare results under an alternative assumption: In 1992, agents expect government consumption, as a fraction of GDP, to follow the path it actually took between 1992 and 2012, and then follow the same trajectory to 22.9 percent that we used in the saving-glut scenario in our main exercise. In the saving-glut scenario, we require that government consumption, in terms of actual quantities of goods and services, stay constant in all three stages of the exercise: the no-saving-glut counterfactual, the saving glut with gradual rebalancing, and the sudden stop. This modification has virtually no impact on any of the results reported above, and it allows for direct welfare comparisons across the three scenarios even if government spending enters the utility function — as long as it enters in an additively separable fashion — allowing us to ask whether the saving glut is good or bad, and just how costly a sudden stop would be.
The first column of table 3 presents our results on the welfare impact of the saving glut for our baseline model. In row 1, column 1, we report real income of U.S. households in 1992 relative to the gradual rebalancing scenario. Our model indicates that the real income of U.S. households in 1992 would have been $689 billion lower if the saving glut had never occurred: 10.9 percent of U.S. GDP in 1992. Twenty years of increased consumption of foreign imports have made U.S. households substantially better off — as long as the saving glut ends in gradual rebalancing.

6. Sensitivity analysis

We have performed extensive sensitivity analysis with our model. Our main results about the reallocation of labor across sectors are robust to all the modeling alternatives that we have tried. In this section, we discuss five modeling alternatives in detail: (1) We allow the savings glut to end abruptly in a sudden stop. (2) We relax our baseline model’s assumption of perfect foresight by studying a version of our model in which the duration of the saving glut is uncertain — \( \omega_t \) now follows a stochastic process — and agents have rational expectations. (3) We remove the input-output relationships between sectors. (4) We do not allow services to be traded internationally. (5) We calibrate the preferences of U.S. households, rather than those of households in the rest of the world, to generate observed U.S. borrowing — a *domestic saving drought* instead of a global saving glut.

**Alternative endings to the savings glut**

In the baseline model, the rebalancing process is gradual and orderly. In this section, we use our model to explore the implications of a sudden end to the savings glut.

We model a sudden stop to capital inflows in 2015–2016 as a surprise. Agents in the model have perfect foresight before and after the sudden stop, but when the sudden stop occurs, it is completely unexpected. We model the sudden stop as a surprise because U.S. interest rates currently indicate that financial markets do not assign a significantly positive probability to a U.S. debt crisis — just as they did not assign significantly positive probabilities to a crisis in Mexico in 1995 or to the currently ongoing debt crises in the Eurozone. (See, for example, Arellano, Conesa, and Kehoe, 2012.) We think of the possibility of a debt crisis striking the

We model a sudden stop as a two-year period during which the United States is restricted from borrowing further from the rest of the world, after which foreigners are again willing to purchase U.S. bonds. We assume that the rest of the world’s preference parameter $\omega_t^w$ converges to its long-run value of 1 more quickly than in the previous scenario to capture the idea that a sudden stop is associated with a faster end to the forces that drove the saving glut. Furthermore, we assume that a sudden stop generates a disorderly adjustment in financial markets that causes total factor productivity (TFP) in all three production sectors to fall by 10 percent in 2015, to recover half of this drop in 2016, and to fully recover in 2017. This TFP drop captures the sort of disruption and rapid recovery that occurred in sudden stop episodes like that in Mexico in 1995–1996. We also assume that the U.S. government’s debt as a fraction of GDP falls to a lower long-run level (60 percent) than in the baseline model, representing the idea that a sudden stop is associated with, or perhaps triggers, a long-term change in U.S. government debt policy.

The sudden stop triggers an immediate reversal in capital flows and a large real exchange rate depreciation. The trade balance rises from $-1.5$ percent of GDP to $2.8$ percent on impact, and the real exchange rate depreciates by $12.7$ percent. The trade balance reversal induces the goods sector’s labor compensation share to rise from $14.3$ percent to $15.1$ percent on impact. These effects, however, would be short-lived. By 2024 the trade balance and real exchange rate would be almost identical to their levels in the gradual rebalancing scenario. Although a sudden stop involves quicker debt repayment, the effect on the long-term need to repay is small in our model. The United States has borrowed so much from the rest of the world in the last two decades that two years of rapid repayment do not make much of a dent in the overall stock of debt.

We report the welfare effects of a sudden stop in table 3. If the savings glut ends in a sudden stop, the real income of U.S. households will fall by $1,019$ billion compared with the baseline model: If the saving glut ends in a sudden stop rather than gradual rebalancing, U.S. households would have been better off if the saving glut had never occurred. We also report welfare in a version of our model in which a sudden stop occurs but TFP does not fall. In this case, welfare falls by only $386$ billion—a sudden stop without an accompanying TFP shock
would be painful, but would not completely wipe out the welfare gains generated by the saving glut.

**Stochastic saving glut**

In our baseline model, agents in both the United States and the rest of the world have perfect foresight once the saving glut begins: They know exactly when it will end and the rate at which it will rebalance. We have also run numerical experiments with a model in which there is uncertainty about the length of the saving glut and model agents have rational expectations. In this version of the model, once the saving glut begins, in each year 1993–2011, there is a 10 percent chance that the saving glut will end in the following year, and the rest of the world’s demand for saving will begin to decrease. The other 90 percent of the time, the saving glut will continue into the next year. The realized path the economy takes is the one in which the saving glut persists through 2012, and, while this is unconditionally the most likely path the economy can take, it is not very likely from the perspective of agents in 1992. Our experiments indicate that this kind of uncertainty has no discernible impact on our results, so we do not report them here.

The introduction of uncertainty into our model represents a substantial technical departure from our baseline model. Due to the presence of asymmetric, time-varying growth rates in productivity, demographics, and other variables, our modeling framework does not admit a stationary dynamic program. In the model with uncertainty, the current value of the stochastic saving-glut process is not a sufficient statistic for the exogenous state of the economy — the entire history of shocks matters. As a consequence, we must solve for the growth paths of the world economy along all possible sequences of shocks simultaneously. The number of possible sequences increases in proportion to the number of periods with uncertainty, so the dimensionality of the problem increases rapidly. Although the introduction of uncertainty does not have a significant impact on our results in this paper, the stochastic model should be useful in other contexts.
No input-output production structure

In our baseline model, goods and services are used as intermediate inputs as well as consumption, but models in the closed economy structural change literature typically abstract from intermediate goods. Here we use a version of our model without intermediate inputs to demonstrate the importance of this feature in accounting for structural change. To do so, we set all of the intermediate input values in the input-output matrix to zero, and then adjust the remainder of the matrix so that it is once again consistent with the national accounts and sectoral labor compensation data for 1992. We then recalibrate our model and perform the same quantitative exercises as before.

Removing the input-output structure from the model has little impact on our model’s predictions for the disaggregated trade balances or the real exchange rate, so we focus on the employment results, which we report in figure 8. In the no-saving-glut scenario (the dashed lines in figure 8), the goods sector’s labor share in the model without intermediate inputs falls less than in the model with intermediate inputs: Differential sectoral productivity growth has a much smaller effect on goods-sector employment when production does not require intermediate inputs. The intuition for this result lies in the substitutability of goods and services in both intermediate and final uses. The elasticity of substitution between goods and services in intermediate use is zero (Leontief production), while the elasticity in consumption is 0.5. When we remove intermediate inputs, the overall elasticity of substitution in both final and intermediate uses rises substantially, lowering the amount of reallocation of labor from goods to services in the long run.

In the model with the savings glut (the solid lines), removing intermediate inputs leads us to attribute a much larger decline in goods-sector employment to the saving glut than we do in the baseline model. Relative to the no-savings-glut scenario, goods-sector employment falls and then recovers more when production does not require intermediate inputs. This result is also a function of the substitutability of goods and services. Goods and services become more substitutable in the model without intermediate goods, so agents can make a larger shift into services and away from the less-needed domestic goods.
Nontradable services

Here we study how our results change when we adopt the standard modeling convention in which services are nontradable. We recalibrate our model as in the previous section so that the goods sector is responsible for total U.S. imports and exports in 1992 and then perform the same quantitative exercises described above.

In the no-saving-glut counterfactual, ignoring services trade has no impact on the goods sector’s labor compensation share in the short or long run. Once we introduce the saving glut, however, ignoring services trade makes the goods sector’s labor compensation share fluctuate more. When the U.S. trade deficit rises between 1992 and 2006, the goods sector’s employment share falls from 19.7 percent to 14.2 percent in the no-services-trade version of the model, versus 14.6 percent in the baseline model. Once the U.S. trade deficit begins to fall in 2007, there is a larger temporary recovery in goods-sector employment in the no-services-trade model, since the United States must run a trade surplus in goods to repay its debt. By 2024, however, the goods sector’s employment share is on almost the same trajectory in both the no-services-trade and baseline models. Services trade is quantitatively important in explaining the impact of the saving glut on goods-sector employment over the past two decades, but it is not important in explaining longer-term trends in structural change.

Domestic saving drought

In our baseline model, we have adopted the global-saving-glut hypothesis proposed by Bernanke (2005), which posits that U.S. borrowing from the rest of the world since the early 1990s has been driven primarily by increased demand for saving in the rest of the world. A number of other authors, such as Chinn and Ito (2007), Gruber and Kamin (2007), and Obstfeld and Rogoff (2009), argue that domestic factors such as monetary policy, housing market policy, and innovations in financial markets were the primary cause of U.S. borrowing. In this section, we study a version of our model in which the preferences of U.S. households, rather than the preferences of households in the rest of the world, drive the U.S. trade balance. Following Chinn and Ito (2007), we refer to this version of the model as the domestic-saving-drought model. In the saving-drought model, the preferences of U.S. households take the same form as in (10) and
we calibrate the U.S. preference parameter \( \omega^* \) so that the model matches the U.S. trade balance exactly during 1992–2012, after which it gradually converges to its long-run level of one.

To assess which of the models is more consistent with the data, we focus on investment. Figure 9 shows that, before the financial crisis of 2009, U.S. investment rose steadily as a fraction of GDP. This is consistent with the saving-glut theory: U.S. households took advantage of cheap foreign goods to increase both investment and consumption, since the relative value they placed on future consumption remained unchanged. If U.S. borrowing was instead driven by reduced demand for saving in the United States, U.S. households should have reduced investment in favor of increased consumption. Figure 9 shows that, except for the year 1993, investment in the baseline model moves in the same direction as the data. By contrast, investment in the saving-drought model falls dramatically beginning in 1997 while it continues to rise in the data (except during the 2001 recession, which we have not attempted to incorporate into the model). During the financial crisis of 2008–2009 (which we have modeled solely through the increasing trade balance), investment falls in the baseline model and the data, but rises in the saving-drought model. Overall, the correlation between investment in the saving-glut model and the data in first differences is 0.7; the same correlation between investment in the saving-drought model and the data is \(-0.6\).

7. Directions for future research and concluding remarks

We have developed a model of the United States and the rest of the world and have shown that, when we incorporate increased foreign borrowing and productivity growth in the goods sector that is faster than in services and construction, the model accounts for three key facts about the U.S. economy during 1992–2012: (1) The real exchange rate appreciated, then depreciated; (2) the trade balance dynamics are driven almost entirely by the goods trade balance; and (3) labor shifted away from the goods sector toward services and construction. We use our model to show that while the faster productivity growth in the goods sector is responsible for the long-run shift in employment away from the goods sector, the saving glut strengthened this effect during 1992–2012.

Although the savings glut’s impact on goods-sector employment is temporary, this does not imply that the saving glut has not had a major long-run impact on the U.S. economy: The U.S. economy’s current long-run trajectory is very different from the one it would have taken
had the saving glut not occurred. Figures 4 and 5 illustrate this point by plotting the aggregate trade balance and real exchange rate in our gradual rebalancing scenario against the counterfactual in which the saving glut never happened. In the counterfactual, U.S. trade is approximately balanced in the long run, since the United States has little debt to repay. Because the saving glut did happen, however, our model predicts that the United States will have to run a trade surplus of around 1 percent of GDP in perpetuity. To do so, the U.S. real exchange rate will depreciate by about 6 percent compared with what it would have been if the saving glut had not taken place.

Our analysis identifies two puzzles. Here we discuss these puzzles and point out directions that future research could take in addressing them.

The first puzzle is: Why did U.S. borrowing continue to increase once the U.S. real exchange rate began to depreciate? In other words, why did U.S. purchases of foreign goods and services continue to increase once foreign goods and services stopped getting cheaper and started getting more expensive, as seen in the data in figure 3? A partial resolution to this puzzle might be found in the J-curve literature (Backus, Kehoe, and Kydland, 1994), in that time-to-build and import pattern adjustment frictions can delay quantities adjusting to price changes. This mechanism is not likely to explain the substantial four-year lag, however. A more plausible resolution to the puzzle is the increase in the importance of China in U.S. borrowing during the period. In figure 10 we decompose the U.S. real exchange rate into the real exchange rates with China and with the United States’ other major trade partners. We see that the overall real exchange rate and the exchange rate with non-China countries move closely in the early part of the period, but diverge in the latter part. Following 2002, the aggregate real exchange rate behaves much like the real exchange rate with China. Incorporating the increasing importance of China into our model is not simply a matter of changing weights in our real exchange rate. Instead, it would involve distinguishing between the countries that have purchased the bulk of U.S. bonds during the saving glut, like China, Japan, and Korea, and those that have run more balanced trade with the United States. To accurately capture this, we would need to model a world with (at least) three countries and some sort of asset market segmentation, where countries like China choose to lend to the United States rather than to other countries.

The second puzzle is that, in contrast to Bernanke’s (2005) judgment, the saving glut has had only a small effect on U.S. interest rates in the model, as seen in figure 11. The largest fall
in the U.S. real interest rate in the model with the saving glut over 1992–2012, compared with the model with no saving glut, is 44 basis points (3.70 percent per year compared with 3.26 percent) in 2009. This is in line with Greenspan’s (2005) judgment that foreign lending accounted for less than 50 basis points of the drop in interest rates. Warnock and Warnock (2009) have estimated that foreign lending drove down U.S. real interest rates by a somewhat larger amount, about 80 basis points, throughout the period. Krishnamurthy and Vissing-Jorgensen (2007) provide similar estimates.

In our model, the impact of the saving glut on interest rates depends on how substitutable foreign goods are for U.S. goods. With the Armington elasticities that we have chosen, we find that the saving glut generates the right magnitude of appreciation of the U.S. real exchange rate in figure 5, but not the right magnitude in the drop in the U.S. real interest rate in figure 11. If we make foreign goods more substitutable for U.S. goods, we can generate more of a drop in the U.S. real interest rate in 2006–2012 — although still nowhere near as large as the drop observed in the data — but the model would then predict a much smaller appreciation in the U.S. real exchange rate.

Notice that in figure 11, our model predicts that the U.S. interest rate is driven up by appreciation of the dollar and is driven down by depreciation. The falling prices of foreign goods during 1993–2006 induce U.S. households to increase consumption faster than they do in the model without a saving glut, generating the observed trade deficit. The first-order conditions for utility maximization imply that U.S. households are willing to do this only if interest rates are higher. As the dollar depreciates during 2006–2012, consumption grows more slowly than in the no-saving-glut model and interest rates are lower.

Since our model’s results contradict Bernanke’s (2005) reasoning that the saving glut is responsible for the low level of U.S. interest rates in the early 2000s, it is worth examining how the saving glut is compatible with high interest rates in the United States. Consider the interest rate parity condition that makes households in the rest of the world indifferent between holding U.S. bonds and the rest of the world’s bonds:

\[
1 + r_t = (1 + r_t^{rw}) \frac{rer_t}{rer_t}. \tag{16}
\]

As the demand for savings increases in the rest of the world, the interest rate there increases. At the same time, the fall in the relative price of goods in the rest of the world causes the U.S. real
exchange rate to appreciate, that is, to fall. Our interest rate parity condition does not pin down
the direction of change in the U.S. interest rate; in principle, it could go up or down. What tells
us that the interest rate is higher in the saving-glut model than it is in the no-saving-glut model is
the requirement that the saving glut generates the observed increase in the U.S. trade deficit,
which implies that consumption in the United States increases faster during the saving glut than
it would have with no saving glut.

To account for the very low U.S. interest rates seen in the data, we need to look
elsewhere, possibly to the sorts of U.S. policies discussed by Obstfeld and Rogoff (2009) and
Bernanke et al. (2011). It is worth pointing out, however, that modeling the source of the global
imbalances over 1992–2012 as being generated by U.S. savings behavior does not work well.
The domestic-saving-drought model is successful in generating lower U.S. interest rates during
1993–2006, as the dollar appreciates, but it generates higher U.S. interest rates during 2006–
2012, as the dollar depreciates. The low interest rates during the entire period pose a puzzle for
both models.
References


<table>
<thead>
<tr>
<th>Industry</th>
<th>Inputs</th>
<th>Final demand</th>
<th>Total demand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Goods</td>
<td>Services</td>
<td>Construction</td>
</tr>
<tr>
<td>Goods</td>
<td>1,345</td>
<td>424</td>
<td>240</td>
</tr>
<tr>
<td>Services</td>
<td>638</td>
<td>1,488</td>
<td>179</td>
</tr>
<tr>
<td>Construction</td>
<td>26</td>
<td>139</td>
<td>1</td>
</tr>
<tr>
<td>Labor compensation</td>
<td>849</td>
<td>3,273</td>
<td>188</td>
</tr>
<tr>
<td>Returns to capital</td>
<td>488</td>
<td>1,474</td>
<td>71</td>
</tr>
</tbody>
</table>

**Total gross output** | **3,346** | **6,798** | **679** | **4,237** | **1,050** | **1,088** | **635** | **-668** |

Note: We have adjusted the benchmark make and use tables published by the BEA to obtain a symmetric input-output table that contains our desired three sectors (four including investment) and is consistent with the national accounts.
### Table 2: Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Statistic</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Producer parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$A_g, A_s, A_c$</td>
<td>(2.59,1.56,2.95)</td>
<td>Gross output in 1992 less imports, percent GDP</td>
<td>(52.8,107,10.7)</td>
</tr>
<tr>
<td>$a_{gg}, a_{se}, a_{cg}$</td>
<td>(0.40,0.19,0.01)</td>
<td>Share of intermediates in goods in 1992</td>
<td>(0.41,0.19,0.01)</td>
</tr>
<tr>
<td>$a_{gs}, a_{as}, a_{cs}$</td>
<td>(0.06,0.22,0.02)</td>
<td>Share of intermediates in services in 1992</td>
<td>(0.07,0.22,0.02)</td>
</tr>
<tr>
<td>$a_{gc}, a_{ac}, a_{cc}$</td>
<td>(0.35,0.26,0.001)</td>
<td>Share of intermediates in construction in 1992</td>
<td>(0.35,0.26,0.001)</td>
</tr>
<tr>
<td>$\alpha_g, \alpha_s, \alpha_c$</td>
<td>(0.37,0.31,0.27)</td>
<td>Capital’s share of value added in goods/svcsvs/const in 1992</td>
<td>(0.37,0.31,0.27)</td>
</tr>
<tr>
<td>$\theta_g, \theta_s, \theta_c$</td>
<td>(0.32,0.21,0.47)</td>
<td>Share of intermediates in investment in 1992</td>
<td>(0.32,0.21,0.47)</td>
</tr>
<tr>
<td>$G$</td>
<td>2.85</td>
<td>Investment in 1992, percent GDP</td>
<td>17.2</td>
</tr>
<tr>
<td><strong>Household parameters and initial conditions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{F}^{ush}_{1992}$</td>
<td>40.3</td>
<td>Net foreign assets in 1992, percent GDP</td>
<td>7.75</td>
</tr>
<tr>
<td>$\bar{F}^{us}_{1992}$</td>
<td>176.25</td>
<td>Real interest rate in 1992, percent per year</td>
<td>4.00</td>
</tr>
<tr>
<td>$\beta^{us}, \beta^{rw}$</td>
<td>(0.996,0.996)</td>
<td>Long-term real interest rate, percent per year</td>
<td>3.00</td>
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<tr>
<td>$\epsilon^{ush}, \epsilon^{rw}$</td>
<td>(0.07,0.19)</td>
<td>Share of goods in private consumption in 1992</td>
<td>21.0</td>
</tr>
<tr>
<td>$\rho$</td>
<td>-1.00</td>
<td>Elasticity of substitution, goods to services</td>
<td>0.50</td>
</tr>
<tr>
<td>$\eta$</td>
<td>0.28</td>
<td>Ratio of hours worked to available hours in 1992</td>
<td>0.29</td>
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<tr>
<td>$\psi$</td>
<td>-1.00</td>
<td>Intertemporal elasticity of substitution</td>
<td>0.50</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.066</td>
<td>Depreciation to GDP in 1992, in percent</td>
<td>11.7</td>
</tr>
<tr>
<td><strong>Trade parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M^{us}_g, M^{us}_s$</td>
<td>(1.78,1.09)</td>
<td>Gross output in goods/services in 1992 including imports</td>
<td>(61.3,109.1)</td>
</tr>
<tr>
<td>$\mu^{us}_g, \mu^{us}_s$</td>
<td>(0.65,0.98)</td>
<td>U.S. imports in 1992</td>
<td>(8.59,1.94)</td>
</tr>
<tr>
<td>$M^{rw}_g, M^{rw}_s$</td>
<td>(1.67,1.10)</td>
<td>RW goods/services consumption in 1992</td>
<td>(78.0,161.7)</td>
</tr>
<tr>
<td>$\mu^{rw}_g, \mu^{rw}_s$</td>
<td>(0.69,0.98)</td>
<td>U.S. exports in 1992 in 1992</td>
<td>(7.06,2.95)</td>
</tr>
<tr>
<td>$\zeta_g, \zeta_s$</td>
<td>(0.67,0.01)</td>
<td>Elasticity of substitution, domestic to foreign</td>
<td>(3.00, 1.00)</td>
</tr>
<tr>
<td><strong>Government parameters and initial conditions</strong></td>
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<td></td>
</tr>
<tr>
<td>$\bar{F}^{usg}_{1992}$</td>
<td>-48.1</td>
<td>U.S. government debt in 1992, percent GDP</td>
<td>48.1</td>
</tr>
<tr>
<td>$\tau^{us}_k$</td>
<td>0.415</td>
<td>Depreciation rate, percent per year</td>
<td>6.6</td>
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<tr>
<td>$\tau^{us}_{1993}$</td>
<td>0.396</td>
<td>Investment in 1992, percent GDP</td>
<td>17.2</td>
</tr>
<tr>
<td>$\tau^{usg}$</td>
<td>0.19</td>
<td>Share of goods in government consumption</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>Time series parameters</strong></td>
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</tr>
<tr>
<td>${\tilde{p}^{us}_t, \tilde{n}^{us}_t, \tilde{f}^{us}_t, \tilde{f}^{rw}<em>t\infty</em>{t=0}^{\infty}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>${\omega^{usw}<em>t}</em>{t=0}^{\infty}$</td>
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</tr>
<tr>
<td>${\gamma^{usw}_j, \gamma^{usw}<em>j\infty</em>{j=0}^{\infty}$</td>
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<td>${\nu^{usw}_j, \nu^{usw}<em>j\infty</em>{j=0}^{\infty}$</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

*World Population Prospects: 2010 Revision*

*U.S. trade balance, 1992–2012*

*Labor productivity growth in goods/svcsvs/const, 1992–2011*

*CBO historical data and projections*
Table 3: Welfare impact of saving glut and sudden stop

<table>
<thead>
<tr>
<th>Change in real income compared with rebalancing scenario (billions of dollars)</th>
<th>Baseline</th>
<th>Nontradable services</th>
<th>No intermediates</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-saving-glut counterfactual</td>
<td>−689</td>
<td>−696</td>
<td>−492</td>
</tr>
<tr>
<td>Sudden stop (no TFP shock)</td>
<td>−386</td>
<td>−378</td>
<td>−429</td>
</tr>
<tr>
<td>Sudden stop (TFP shock)</td>
<td>−1,019</td>
<td>−1,020</td>
<td>−1,063</td>
</tr>
</tbody>
</table>
Figure 1: U.S. trade balance vs. goods sector’s employment share

Figure 2: Labor productivity in goods, services, and construction
Figure 3: U.S. trade balance, current account balance, and real exchange rate

Figure 4: U.S. trade balance in the model and the data
Figure 5: U.S. real exchange rate in the model and the data

Figure 6: Disaggregated trade balances in the model and the data

Figure 7: Goods and construction employment shares in the model and the data
Figure 8: Goods employment share in no-input-output model vs. baseline model
Figure 9: Investment in domestic saving-drought model vs. baseline model

Figure 10: U.S. real exchange rates with China and other trade partners
Figure 11: U.S. real interest rate in the model and the data