Federal Reserve Bank of Minneapolis
Research Department Staff Report 489

Revised: September 2015
(First version: August 2013)

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 less than 15 percent of the decline in goods-sector employment from 1992 to 2012 stems 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
JEL classification: E13, F34, O41

*We thank David Backus, David Strauss, Frank Warnock, Kei-Mu Yi, Vivian Yue, and Jing Zhang for helpful discussions. Kehoe and Ruhl gratefully acknowledge the support of the National Science Foundation under grant SES-0962993. We are grateful to Jack Rossbach for extraordinary research assistance. The data used here are available at http://www.econ.umn.edu/~tkehoe. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

1. Introduction

Between 1992 and 2012 the U.S. net international investment position deteriorated by $4 trillion as households and the government in the United States borrowed heavily from the rest of the world. A commonly-held view on policy circles, expressed, for example, in Bivens (2006) and Scott, Jorgensen, and Hall (2013), is that 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 of 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 intertemporal trade 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 setting. Structural change in our model is driven by faster labor productivity growth in the goods-producing sector compared to the services sector, combined with a low elasticity of substitution between goods and services. We also introduce a *saving glut* —increased demand for saving in the rest of the world — which we calibrate to match the U.S. trade balance. We use our 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.

We calibrate our model's production and demand structure so that the model replicates exactly the 1992 U.S. national accounts and a world input-output matrix we construct from World Input Output Database data. We then feed in two exogenous driving forces: (1) labor productivity growth rates that differ across sectors, which we take from the data; and (2) demand for saving in the rest of the world that we parameterize and calibrate to match the U.S. trade balance during 1992–2012. The equilibrium outcome of this model — our *benchmark saving-glut equilibrium* — accounts for 70.41 percent of the observed decline in the share of employment in the goods sector from 1992 to 2012 and is consistent with several other key facts about the U.S. economy during this period.

We then compare this equilibrium to one in which foreign demand for saving is held constant — our *no-saving-glut counterfactual*. The counterfactual accounts for 55.90 percent of the decline in goods sector's employment share. The difference between these two figures, 14.51 percent, is our assessment of the contribution of the saving glut to this decline; the bulk of the remainder is attributed to faster productivity growth in the goods sector compared to other sectors. This implies that eliminating the trade deficit will not generate a significant increase in increase in goods-sector employment.

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 goods-producing sectors — agriculture, mining, and manufacturing — has fallen dramatically as the trade deficit has grown. The intuition is simply that 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. The implication of this idea is that when the debt has to be repaid, labor will flow back into the U.S. goods sector to produce the extra goods needed to repay the debt. The importance of this channel in driving the decline in U.S. goods-sector employment over the past two decades is the quantitative question at the center of our study.

The notion that trade imbalances cause sectoral reallocation is based on simple intuition but it also has historical precedent. After Spain entered the European Community in 1986 its trade balance deteriorated substantially, and at the same time the share of Spain's GDP produced in the traded sector fell from almost 40 percent to less than 30 percent (Kehoe and Fernandez de Cordoba, 1999). The Baltic countries had similar experiences after opening to international capital markets in the early 1990s (Bems and Jönsson, 2005). Moreover, sudden stops in emerging economies like Mexico have typically been accompanied by sharp reallocations away from services production and into goods (Kehoe and Ruhl, 2009). While the saving-glut-driven trade imbalances in the United States share several similarities with these events, particularly large real exchange rate fluctuations, our results indicate that U.S. sectoral reallocation is not primarily imbalance-driven.

In constructing our 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 increased demand for saving in the rest of the world, such as a lack of financial development (Caballero, Farhi, and Gourinchas, 2008; Mendoza, Quadrini, and Ríos-Rull, 2009), differences in business cycle or structural growth properties (Backus, Henriksen, Lambert, and Telmer, 2006; Perri and Fogli, 2010; Jin, 2012), and even 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 several features in our model that make it uniquely 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 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, our model includes a global input-output structure: firms use intermediate inputs of both goods and services, produced both at home and abroad; and we distinguish between trade in final versus intermediate goods and services. This production and demand structure allows for substitution between domestic products and their foreign equivalents, and complementarity between products from different sectors. We also allow for more substitution between domestic and foreign goods than between domestic and foreign services, which allows us to match the fact that the goods trade balance is more volatile than the services trade balance.

Last, 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. Ngai and Pissarides (2007) embed this mechanism, original due to Baumol (1967), into a closed-economy model with an aggregate balanced growth path. 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). Our model of structural change, however, is the first to allow for intertemporal trade. This unique framework allows us to assess the relative contributions of traditional, closed-economy structural change forces and the saving glut to the dynamics of the U.S. economy.

Buera and Kaboski (2009) identify three possible sources of structural change: differentiral sectoral productivity growth and a low elasticity of substitution between sectors (Ngai and Pissarides, 2007); nonhhomothetic preferences (Kongsamut, Rebelo, and Xie, 2001); and capital deepening and sector-specific capital shares (Acemoglu and Guerrieri, 2008). As argued by Buera and Kaboski (2009), subsistence requirements in Stone-Geary nonhomothetic preferences are most important low income levels, and thus this mechanism is unlikely to be important in explaining structural change in the United States in recent decades. Our study focuses on the first source. We do not allow for nonhomothetic preferences in our study. Kongsamut et al. (2001) and Buera and Kaboski (2009) show that one can obtain a balanced growth path in closed-economy nonhomothetic models by calibrating the subsistence requirements in the right way, but this approach does not work in our open economy model which features a continuum of possible balanced growth paths.[1] We do allow for sector-specific capital shares in our model, but they do not play a quantitatively important role in our results.

2. The U.S. economy, 1992–2012

This section presents our approach to analyzing U.S. data over the past two decades. We view the massive foreign borrowing and the differences 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 perform counterfactual experiments and 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

[1] This is not a problem in open-economy models of structural change like Uy et al. (2013) which do not allow for endogenous intertemporal trade.

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 deficit as what defines the saving glut in our model.

Capital flows are important to our analysis in two ways. First and foremost, the imbalanced flows of goods into the United States directly affect the need to produce goods domestically, and thus, the need for labor 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 our 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-Feretti, 2008; Gourinchas and Rey, 2007). To the extent that revaluation has been in favor of the United States, the smaller future debt burden would decrease the need to reallocate labor back into goods-producing sectors.

Exogenous driving force 2: labor productivity grew fastest in goods-producing sectors

During 1992–2012, labor productivity in the goods sector grew at an average of 4.2 percent per year, while it grew by only 1.3 percent per year in services and fell by 1.2 percent per year in construction. What is essential in our model is the differential between productivity growth in goods compared to services. 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.

Fact 1: the real exchange rate appreciated, then depreciated

Figure 3 presents the first key fact that we ask our model to match. The figure shows that the U.S. real exchange rate was volatile and tracked the trade balance closely during 19922012. 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 yield similar results). The real exchange rate appreciated by 27.9 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. This phenomenon, often attributed to the delay between placing an import order and receiving the shipment, is known as the J-curve (Backus et al., 1994). Our baseline model is unable to replicate this pattern; we revisit it in our sensitivity analysis and concluding remarks.

Fact 2: the goods sector drove aggregate trade balance dynamics

Figure 6 presents our second key fact, plotting disaggregated trade balances for goods and services separately. 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.

Fact 3: Employment in goods decline 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 a 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 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. In other words, reallocation away from goods has, thus far, been permanent, while reallocation into construction was temporary.

3. Model

Our model has two countries: the United States and the rest of the world. The superscripts *us* and *rw* denote prices, quantities, and parameters in the former and the latter, respectively. The length of a period is one year. Representative households in each country work, consume, and save to maximize utility subject to a sequence of budget constraints. Competitive firms produce commodities that serve final and intermediate uses both at home and abroad. We calibrate the model's production structure, which has both intra- and inter-country input-output linkages, to a world input-output matrix from the World Input Output Database (WIOD).

Agents in our model have perfect foresight. We model the saving glut as an unanticipated temporary — though decades-long — change in the rest of the world's willingness to lend. This assumption captures our view that U.S. households in the early 1990s did not anticipate the large trade deficits their country would run over the next two decades.

Gross output production

The United States has three production sectors: goods, services, and construction; the rest of the world produces only goods and services. We use s to index gross output sectors. Goods are 1, services are 2, and construction is 3. Gross output is produced according to a nested CES technology that uses factors of production and intermediate inputs of goods and services from both countries — construction does not serve intermediate uses. Our production structure is most similar to that of Johnson (2014). The input-output structure requires indexing variables by destination, source, country, sector, and time. We use superscripts to index countries, destination first. Subscripts index sector, destination first. Time is also a subscript.

Country i's gross output y^i_{st} in sector s is a CES aggregate of value added v^i_{st} and an intermediate bundle m^i_{st}:

$$y^i_{st} = A^i_s \left\{ \lambda^i_s \left(v^i_{st} \right)^{\eta} + (1 - \lambda^i_s) \left(m^i_{st} \right)^{\eta} \right\}^{\frac{1}{\eta}} \tag{1}$$

The parameter λ_s^i governs the share of value added in gross output, while η governs the elasticity of substitution between value added and intermediate inputs. A_s^i is a constant scaling factor used to facilitate calibration.

In the United States, value added is a Cobb-Douglas aggregate of capital and labor:

(2) $$v_{st}^{us} = B_s^{us}\left(k_{st}^{us}\right)^{\alpha_s}\left(\gamma_{st}^{us}\ell_{st}^{us}\right)^{1-\alpha_s}$$

α_s is capital's share of value added, γ_{st}^{us} is the productivity of labor, and B_s^{us} is another scaling factor. We abstract from capital formation in the rest of the world, so value added is a linear function of labor:

(3) $$v_{st}^{rw} = B_s^{rw}\gamma_{st}^{rw}\ell_{st}^{rw}$$

Labor productivity is exogenous, and grows at a different rate in each sector and country.

The composite intermediate bundle m_{st}^i is composed of intermediate purchases m_{srt}^{ij} from each sector r in each country j :

(3) $$m_{st}^i = C_s^i\left\{\sum_{r=1}^{2}\pi_{sr}^i\left[\sum_{j\in\{us,rw\}}\mu_{sr}^{ij}\left(m_{srt}^{ij}\right)^{\zeta_r}\right]^{\frac{\xi}{\zeta_r}}\right\}^{\frac{1}{\xi}}$$

Intermediate expenditures are aggregated in two stages. First, intermediate inputs from each country are aggregated within the goods and services sectors separately. Second, goods and services intermediates are combined to form the aggregate intermediate bundle. For example, consider the use of tires and steel in the production of automobiles. U.S. car producers first combine domestic and foreign tires into a "tire bundle," and the same for steel. The tire bundle and steel bundle are then combined to form the total intermediate bundle.

The parameter C_s^i is another scaling factor. π_{sr}^i governs the share of sector-r intermediates in the aggregate intermediate bundle, and μ_{sr}^{ij} governs the share of sector-r intermediates from country j in total sector-r intermediates. ξ governs the elasticity of substitution between intermediates from different sectors, while ζ_r governs the elasticity of substitution between sector-r intermediates from different source countries. This allows us to calibrate a production structure in which goods and services intermediates are strong complements, but goods intermediates from the rest of the world are substitutes for goods intermediates from the United States. We also allow the degree of substitutability between intermediates from different countries to vary by sector.

Gross output is produced by perfectly competitive firms. A representative firm in sector s in the United States chooses capital, labor, and intermediate inputs to maximize profits

$$q_{st}^{us} y_{st}^{us} - w_t^{us} \ell_{st}^{us} - r_{kt}^{us} k_{st}^{us} - \sum_{r=1}^{2} \sum_{j \in \{us,rw\}} q_{rt}^{j} m_{srt}^{usj} \tag{4}$$

subject to non-negativity constraints and (1)–(4). Firms in the rest of the world face a similar problem without the choice of capital or the rental cost. q_{st}^{i} denotes the price of gross output from country i's sector s, w_t^i is the wage, and r_{kt}^i the rental cost of capital.

Final demand and investment production

The United States has three types of final demand: private consumption, public consumption, and investment. The rest of the world has only consumption. We use the letters $f \in \{c, g, x\}$ to index the categories of final demand. Households in both countries and the U.S. government consume goods and services produced at home and abroad. Similar to the aggregation scheme for intermediate inputs, final demand of category *f* for products from sector *s* is a "composite" basket of domestic and foreign products from that sector. We construct these composites separately for each category of final demand.

The category-*f*, sector-*s* composite in country *i*, which we denote by f_{st}^{i}, is a CES aggregate of expenditures on commodities of type *s* from each country:

$$f_{st}^{i} = F_s^i \left(\sum_{j \in \{us,rw\}} \theta_{fs}^{ij} \left(f_{st}^{ij} \right)^{\sigma_s} \right)^{\frac{1}{\sigma_s}} \tag{5}$$

where f_{st}^{ij} denotes type-*f* demand for gross output from sector *s* in country j. The parameter σ_s governs the elasticity of substitution in final demand between domestic and foreign products. As with intermediate inputs, we allow for different elasticities for goods and services. θ_{fs}^{ij} governs the share of final expenditures on commodities from sector *s* that come from country *j*. F_s^i is another scaling factor. The price of the composite, p_{fst}^{i}, is given by the standard ideal price formula:

(6) $$p_{fst}^{i} = \frac{1}{F_s^i}\left(\sum_{j\in\{us,rw\}} \left(\theta_{fs}^{ij}\right)^{\frac{1}{1-\sigma_s}} \left(q_{st}^{j}\right)^{\frac{\sigma_s}{\sigma_s-1}}\right)^{\frac{\sigma_s-1}{\sigma_s}}$$

Households and the U.S. government choose quantities c_{st}^{us} and g_{st}^{us} to maximize their respective objective functions which we describe in detail shortly. Investment in the United States is a CES aggregate of investment-specific goods and services composites, x_{1t}^{us} and x_{2t}^{us}, and the output of the U.S. construction sector:

(7) $$x_t^{us} = X^{us}\left(\varepsilon_{x1}^{us}\left(x_{1t}^{us}\right)^{\rho_x} + \varepsilon_{x2}^{us}\left(x_{2t}^{us}\right)^{\rho_x} + \varepsilon_{x3}^{us}\left(y_{3t}^{us}\right)^{\rho_x}\right)^{\frac{1}{\rho_x}}$$

The price of investment is given by

(8) $$p_{xt}^{us} = \frac{1}{X^{us}}\left(\left(\varepsilon_{x1}^{us}\right)^{\frac{1}{1-\rho_x}}\left(x_{1t}^{us}\right)^{\frac{\rho_x}{\rho_x-1}} + \left(\varepsilon_{x2}^{us}\right)^{\frac{1}{1-\rho_x}}\left(x_{2t}^{us}\right)^{\frac{\rho_x}{\rho_x-1}} + \left(\varepsilon_{x3}^{us}\right)^{\frac{1}{1-\rho_x}}\left(y_{3t}^{us}\right)^{\frac{\rho_x}{\rho_x-1}}\right)^{\frac{\rho_x-1}{\rho_x}}$$

Financial assets and exchange rates

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), which is given by

(8) $$\overline{p}_{\mathrm{us},t} = \frac{p_{1t}^{us}c_{1,1992}^{us} + p_{2t}^{us}c_{2,1992}^{us}}{p_{1,1992}^{us}c_{1,1992}^{us} + p_{2,1992}^{us}c_{2,1992}^{us}}$$

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. The real interest rate in units of the U.S. CPI is

(8) $$1 + r_{t+1} = \overline{p}_t^{us} / \mathrm{Q}_t$$

where Q_t is the bond price. We compute the real exchange rate in our model using consumer price indices, just as we do in the data

(9) $$rer_t = \overline{p}_t^{rw} / \overline{p}_t^{us}$$

where the rest of the world's CPI, $\overline{p}_t^{rw}$ is defined analogously to the U.S. CPI in (8).

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 unexpected onset of the savings glut), so the split between public and private debt is essentially irrelevant. We have experimented with a stochastic version of the model in which public and private debt are distinct, but we find this change to be quantitatively insignificant.

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, both within and across countries, on households' incentives to borrow or save. We denote the adult-equivalent and working-age populations in country i by n_t^i and $\overline{\ell}_t^i$ respectively. We then normalize the time available for work and leisure in each period to one.

The representative household in the United States chooses consumption of goods and services, investment, bond holdings, and labor supply to maximize lifetime utility

(10) $$\sum_{t=0}^{\infty}\left(\beta^{us}\right)^t \frac{1}{\psi}\left\{\left(\varepsilon_{c1}^{us}\left(\frac{c_{1t}^{us}}{n_t^{us}}\right)^{\rho_c}+\varepsilon_{c2}^{us}\left(\frac{c_{2t}^{us}}{n_t^{us}}\right)^{\rho_c}\right)^{\frac{\phi^{us}}{\rho_c}}\left(\frac{\overline{\ell}_t^{us}-\ell_t^{us}}{\overline{\ell}_t^{us}}\right)^{1-\phi^{us}}\right\}^{\psi}$$

subject to the budget constraints

(11) $$p_{c1t}^{us}c_{1t}^{us}+p_{c2t}^{us}c^{2t}+p_{xt}^{us}x_t^{us}+Q_t b_{t+1}^{us}=w_t^{us}\ell_t^{us}+\overline{p}_t^{us}b_t^{us}+(1-\tau_k^{us})r_{kt}^{us}k_t^{us}-T_t^{us},$$

the law of motion for capital

(12) $$k_{t+1}^{us}=(1-\delta)k_t^{us}+x_t^{us},$$

appropriate non-negativity constraints, initial conditions for the capital stock and bond holdings, and no-Ponzi condition. U.S. households pay constant proportional taxes τ_k^{us} on capital income and a lump-sum tax or transfer T_t^{us}.

The rest of the world's households solve a simpler problem. They choose consumption. labor supply, and bonds to maximize lifetime utility

(13) $$\sum_{t=0}^{\infty}\left(\beta^{rw}\right)^t \omega_t^{rw}\frac{1}{\psi}\left\{\left(\varepsilon_{c1}^{rw}\left(\frac{c_{1t}^{rw}}{n_t^{rw}}\right)^{\rho_c}+\varepsilon_{c2}^{rw}\left(\frac{c_{2t}^{rw}}{n_t^{rw}}\right)^{\rho_c}\right)^{\frac{\phi^{rw}}{\rho_c}}\left(\frac{\overline{\ell}_t^{rw}-\ell_t^{rw}}{\overline{\ell}_t^{rw}}\right)^{1-\phi^{rw}}\right\}^{\psi}$$

subject to the budget constraints

(14) $$p_{c1t}^{rw}c_{1t}^{rw}+p_{c2t}^{rw}c_{2t}^{rw}+Q_t b_{t+1}^{rw}=w_t^{rw}\ell_t^{rw}+\overline{p}_t^{us}b_t^{rw},$$

Non-negativity constraints, and a no-Ponzi condition. The parameter ω_t^{rw}, which shifts the rest of the world's intertemporal demand, generates the saving glut. We calibrate the series $\{\omega_t^{rw}\}_{t=1992}^{2012}$ so that the U.S. trade balance in our model's saving-glut equilibrium matches the data exactly. After 2012, we assume that this shifter gradually reverts to 1:

(15) $$\omega_{t+1}^{rw}=\rho_\omega\omega_t^{rw}+(1-\rho_\omega)$$

U.S. government

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

(16) $$p_{g1t}^{us}g_{1t}^{us}+p_{g2t}^{us}g_{2t}^{us}+Q_t b_t^{usg}=\tau_k^{us}r_{kt}^{us}k_t^{us}+T_t^{us}+\overline{p}_t^{us}b_t^{usg}.$$

We specify exogenous time paths, $\overline{g}_t^{us}$ and $\overline{b}_t^{us}$, for total government consumption expenditures and debt as fractions of GDP. We set these paths using historical data for 1992–2012 and Congressional Budget Office (CBO) projections for the future. We allow the lump-sum tax T_t^{us} to vary as necessary to ensure that the government's budget constraint is satisfied. The government's objective in each period is to choose goods and services expenditures to maximize a CES "utility function" subject to the constraint that total consumption expenditures are at the required level:

(17) $$\max_{g_{1t}^{us},g_{2t}^{us}}\left(\varepsilon_{1g}^{us}\left(g_{1t}^{us}\right)^{\rho_g}+\varepsilon_{2g}^{us}\left(g_{2t}^{us}\right)^{\rho_g}\right)^{\frac{1}{\rho_g}}$$
$$\text{subject to}\quad p_{1gt}^{us}g_{1t}^{us}+p_{2gt}^{us}g_{2t}^{us}=\overline{g}_t^{us}GDP_t^{us}$$

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 like the saving glut. Unanticipated changes in the time path of government debt can affect the model's equilibrium dynamics, particularly in the short run. In our sensitivity analysis, however, we show that deviations from Ricardian equivalence have little impact on our results.

Market clearing

Market clearing for gross output of goods and services in each country i requires that gross output y_{st}^{i} equal the sum of all intermediate and final demand:

(18) $$y_{st}^{i} = \sum_{j\in\{us,rw\}} \sum_{r=1}^{2} m_{rst}^{ji} + \sum_{j\in\{us,rw\}} \sum_{f\in\{c,g,x\}} f_{st}^{ji}, \quad s=1,2$$

Construction market clearing is trivial since construction is used only to produce investment. Factor markets also must clear:

(18) $$\ell_{t}^{i} = \sum_{s=1}^{S_i} \ell_{st}^{i}, \quad k_{t}^{us} = \sum_{s=1}^{S_{us}} k_{st}^{us}$$

Finally, bond markets, must clear:

(19) $$b_{t}^{us} + b_{t}^{usg} + b_{t}^{rw} = 0$$

Equilibrium and balanced growth paths

An equilibrium in our model, given a sequence of time-series parameters $\{\omega_t^{rw}, \overline{g}_t^{us}, \overline{b}_t^{us}, \gamma_{jt}, (n_t^i, \overline{\ell}_t^i)_{i\in\{us,rw\}}\}_{t=0}^{\infty}$ and initial conditions $(\overline{b}_0^{ush}, \overline{b}_0^{usg}, \overline{k}_0^{us})$, 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 $\{\omega_t^{rw}, \overline{g}_t^{us}, \overline{b}_t^{us}, (n_t^i, \overline{\ell}_t^i)_{i\in\{us,rw\}}\}_{t=0}^{\infty}$ are constant and labor productivity in each sector grows at the same constant rate, $\{\gamma_{jt} / \gamma_{j,t-1} = g_{\gamma}\}_{t=0}^{\infty}$ for $j = g,s,c$, the model converges to a balanced growth path. A balanced growth path in our model is an equilibrium in which all quantities grow at the constant rate of productivity growth, $g_{\gamma} - 1$, (except for labor supply, which is constant) and all relative prices are constant. Since we allow for unbalanced trade, our model has a continuum of balanced growth paths indexed by U.S. net foreign assets (the sum of public and private bond holdings). The balanced growth path to which a particular equilibrium converges is determined by the equilibrium's initial conditions and the exogenous path of U.S. government bonds. Note that this implies solving model is not merely shooting between a known initial conditions and a known balanced growth path. We must solve for the transition and the balanced growth path simultaneously. This complexity will influence our calibration approach, as we describe in the next section.

We construct two equilibria in our model: a baseline in which the saving glut is followed by a gradual rebalancing of U.S. trade and a counterfactual in which the saving glut does not occur and U.S. trade is roughly balanced forever. We refer to these as the *benchmark* and the *counterfactual* equilibria. When we solve for these equilibria numerically, we require both to converge to balanced growth paths in 2092, 100 years after our initial period.

4. Calibration

We calibrate the model so that the counterfactual equilibrium (the one without the savings glut) replicates the U.S. data in 1992. This implies that the savings glut was not foreseen in 1992. The assumption is inconsequential: Our calibration is not sensitive to calibrating the benchmark equilibrium with the savings glut.

We take the elasticities of substitution from the relevant literature, and then calibrate the remainder of the model's production and preference parameters so that the equilibrium replicates the 1992 world input-output matrix we have constructed from the World Input Output Database (WIOD), contained in table 1. In the next section we show that, while we have not calibrated the elasticities, the model does a good job matching observed changes in several key expenditure shares, suggesting that our chosen elasticities are appropriate. Table 2 summarizes our calibrated parameter values. More details are provided in the online appendix at http://www.econ.umn.edu/~tkehoe.

Gross output parameters

We choose the scaling factors A_s^i, B_s^i, and C_s^i so that U.S. GDP in 1992 is 100 and all gross output prices in 1992 are one. We set the elasticity of substitution between value added and intermediate inputs, $1/(1-\eta)$, to 0.05, the value reported by Enghin (2014). Following Enghin (2014), we set the elasticity of substitution between intermediate inputs from different sectors, $1/(1-\xi)$, to 0.04. For the within-sector elasticities of substitution between intermediates from different countries, $1/(1-\zeta_r)$, we use 3 for goods and 1 for services. These choices are near the upper and lower bounds of aggregate Armington elasticities used in the literature. Given these values, we choose the share parameters π_{sr}^{i} and μ_{sr}^{ij} so that the equilibrium replicates the quantities in our world input-output matrix.

We calculate the sector-level productivity growth rates using data on value added and labor compensation from the BEA for 1992–2012. We find that the average growth rates of labor productivity over this period are 4.4 percent in goods, 1.3 percent in services, and -0.84 percent in construction. In the model, for 1992–2030, labor productivity, γ_{jt}, grows at its respective rate, and from 2030 onward, 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.[2]

Final demand parameters

Again, we choose scaling factors D_f^i so that 1992 final demand prices are one. The WIOD data do not distinguish between public and private consumption so we do not have separate data on changes in public and private consumption expenditure shares. We therefore set both $1/(1-\rho_c)$ and $1/(1-\rho_g)$ to Enghin (2014)'s estimate of 0.65. This is roughly halfway between the commonly-used value of 0.5 and the estimate of 0.85 by Herrendorf et al. (2013). We set the elasticity of substitution between investment purchases from different sectors, $1/(1-\rho_x)$, to 0.97. We set the "final demand" Armington elasticities, $1/(1-\sigma_r)$, to 2 for goods and 1 for services. As with the gross output production structure, given our choice of elasticities, we choose values for the share parameters, ε_{fr}^{i} and θ_{fr}^{ij}, so that the equilibrium replicates the world input-output matrix.

[2] Ngai and Pissarides (2007) state that, under permanent differences across sectors in productivity growth, long-run balanced growth obtains if and only if the elasticity of substitution across sectors in intermediate use is one. We require convergence across sectors in productivity growth rates to ensure balanced growth given that we use a low elasticity of substitution between intermediate goods and services. This assumption has essentially no impact on equilibrium, dynamics between 1992 and 2024, the period on which we focus.

Household and government parameters

We set the elasticity of intertemporal substitution to the standard value of 0.5. We set the U.S. and world discount factors so that the real interest rate in the balanced growth path is 3.0 percent. This ensures a stable capital-output ratio. We then set the share parameters, ϕ^i, so that the input-output data satisfy the households' intratemporal first-order conditions assuming that households in both countries use one-third of their time for work. For the demographic time series n_t^i and $\bar{\ell}_t^i$, we use historical data and future projections from the *World Population Prospects: 2010 Revision* (United Nations, 2011). We construct time series for the rest of the world using an average of the top 20 U.S. trade partners weighted by average annual bilateral trade (exports plus imports) between 1992 and 2012. To ensure existence of balanced growth paths after 100 years, we assume that populations in the United States and the rest of the world 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.

In the no-saving glut counterfactual, we assume that government spending stays at its 1992 level (as a fraction of GDP) forever and that government debt converges quickly from ints 1992 value of 48 percent of GDP (the observed level in 1992) to 60 percent of GDP. When we solve the model with the savings glut, the behavior of government spending and debt will differ — we discuss this equilibrium below.

The initial bond holdings in the model are calibrated to the data. U.S. government debt was 48.1 percent of GDP in 1992, and we use this value directly to set the government's bonds in 1992, $\bar{b}_{1992}^{usg}$. We then set private bond holdings, $\bar{b}_{1992}^{ush}$, so that total net foreign assets $\bar{b}_{1992}^{ush} + \bar{b}_{1992}^{usg}$ are −7.8 percent of GDP as reported in Lane and Milesi-Feretti (2007).

Capital stock, capital tax, and depreciation

Using the method of Backus et al. (2007), we compute U.S. capital stocks for 1992–2012. To calibrate the depreciation rate, we use the capital stock data and the consumption of fixed capital reported by the BEA, to calculate an average annual depreciation rate of 5.3 percent. We set the U.S. capital income tax τ_k^{us} to 39 percent, the statutory rate reported by Devereux et. al (2002). We set the initial capital stock, k_{1992}, to 278 percent of GDP, as it is in the data.

5. Quantitative results

Having calibrated the model, we now present our quantitative results. We start with a comparison of our benchmark saving-glut equilibrium to the data, and then examine the no-saving-glut counterfactual to answer the question: what would have happened to the U.S. economy — and what would happen in the future — but for the saving glut?

The benchmark saving-glut equilibrium

We have calibrated the model in the no-saving-glut counterfactual — the equilibrium in which the saving glut did not occur. We now use the calibrated model to study the impact of the saving glut. In this equilibrium, we keep all of the model parameters as they are in the counterfactual, except for three: We change ω_t to create the saving glut and we change government spending and debt paths to reflect the observed data. In particular, we calibrate the values of ω_t^{rw} for 1993–2012 so that the equilibrium replicates exactly the aggregate U.S. trade balance during this period, and follows (15) thereafter. U.S. government consumption and debt (as a share of GDP) match the data for 1992–2012 and follow projections from the CBO's 2012 *Long-Term Budget Outlook*, which we adjust in later years to be consistent with balanced growth. More details on our construction of projected government spending and debt series are available in the online data appendix. Our results are insensitive to our assumptions about the behavior of government spending and debt, as well as model agents' expectations about this behavior

To compute the equilibrium in the model with the savings glut, we take as initial conditions the 1993 equilibrium values of the model without the savings glut. This model setup embodies the idea that agents in 1992 did not foresee the savings glut, and were surprised by the increase in demand for saving in the rest of the world, as well as the increase in domestic government spending and debt that accompanied it. We view this as the most natural assumption about expectations, but our results are insensitive to it.

Changes in expenditure shares

Before turning to our three key facts, we briefly compare the model to the data along several key dimensions that were not targets of the calibration. These moments are particularly useful in judging the elasticities of substitution that we chose from the literature. We report these extra data in table 3. We focus on *changes* in expenditure shares between 1995 and 2011 calculated using WIOD input-output tables, which map directly to elasticities of substitution. All differences in *levels* of expenditure shares between model and data in 1995 are driven by the adjustments we make to the WIOD data to reconcile it with the U.S. national accounts.

The elasticity of substitution between value added and intermediates, $1/(1-\eta)$, maps to the change in the intermediate share of gross output. We have used Enghin (2014)'s value of 0.05, close to Leontief, which makes this share sensitive to changes in the relative price of intermediates.While other studies like Oberfield and Raval (2014) report values of $1/(1-\eta)$ close to one, table 3 shows that the baseline equilibrium in our model matches the change in the intermediate share of U.S. gross output between 1995 and 2011 closely.

The elasticity of substitution between intermediate inputs of goods and services, $1/(1-\xi)$, affects the sensitivity of the share of goods in total intermediate use to the relative price of goods. Again, we have used Enghin's estimate of 0.04. Our model generates a smaller drop in the goods share of U.S. intermediate inputs than we see in the data, implying an even lower elasticity, but we cannot get closer without losing numerical tractability. Buera and Kaboski (2009) document a similar finding.

The elasticities of substitution between goods and services in public and private consumption, $1/(1-\rho_c)$ and $1/(1-\rho_g)$, which we have both set to Enghin (2014)'s value of 0.65, govern the sensitivity of the goods share of aggregate consumption to the relative price of goods. Our model also generates a smaller drop in this share than we see in the data. When we experiment with this elasticity we have found that even if we use a value of zero we cannot capture the full extent of this drop in the goods share of consumption. Again, this is similar to what Buera and Kaboski (2009) find in their attempts to calibrate this elasticity to match the sectoral employment shares. In light of this, we have chosen to use an independently-estimated value of this elasticity. Enghin (2014)'s estimate derives from a framework with an explicit input-output structure and distinct elasticities of substitution between sectoral output in final and intermediate uses, so in light of Herrendorf et al. (2013) we view this as the best choice.

We do much better matching the change in the goods share of investment, which is driven by the elasticity of substitution $1/(1-\rho_x)$. Our value of 0.97 is close to Cobb-Douglas, consistent with Bems (2008), and captures the slight drop in the goods share of investment we see in the data.

Finally, our model also closely matches sectoral trade balance volatilities, which map to our intermediate and final "Armington" elasticities, $1/(1-\zeta_s)$ and $1/(1-\sigma_s)$ We have chosen lower elasticities in services than in goods to capture the lower services trade balance volatility. We use a lower value for the final goods demand Armington elasticity, $1/(1-\sigma_g)$, than the intermediate goods Armington elasticity, $1/(1-\zeta_g)$, because the literature suggests intermediate trade is more volatile than trade in final purchases

Replicating the three key facts

Figure 5 plots the 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 between 1992–2012: The real exchange rate appreciated by 27.90 percent in the data and 28.46 percent in the model before beginning to depreciate. The baseline 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. The lag between real exchange rate and trade balance movements in the data, often referred to as the "J-curve" (Backus, et al., 1994), is difficult to generate in models of aggregate trade such as ours. Alessandria and Choi (2015), for example, show that incorporating heterogeneous firms that price to market and make dynamic decisions about entering/exiting the export market is crucial to generating a realistic J-curve. In section 5 we add "wedges" in the style of Char et al. (2007) so that the model matches the time paths of both the trade balance and real exchange rate during 1992–2012, and we show that this has little impact on our model's predictions for sectoral labor reallocation. Figure 6 plots the sector-level trade balances in the model and data. The model matches both the goods and services trade balances closely between 1992 and 2012. This aspect of the model's performance is due in part to our choice of Armington elasticities. Table 3 shows that in both model and data, the goods trade balance is more volatile than the services trade balance. Had we used the same elasticities in both sectors, the goods trade balance would have not moved enough, while the services trade balance would have been too volatile.

Figure 7 plots the employment shares for goods and construction 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. The decline in the goods sector's employment share between 1992 and 2012 in the model is 69.91 percent of the decline in the data. One reason we do not capture the full extent of the reallocation of labor away from the goods sector is that our model has homothetic preferences. Nonhomothetic preferences play a significant role in the structural change literature, although work by Buera and Kaboski (2009) suggests that they are not important in explaining recent structural change in the United States. Incorporating Stone-Geary preferences used by Kongsamut et al. (2001) and others into our model of unbalanced growth is impossible. We do, however, conduct another "wedge" analysis in section 5 in which we match the data on the goods sector's employment share exactly during 1992–2012.

Figure 7 also shows that the model captures several aspects of the construction sector's employment share between 1992 and 2012. Between 1993 and 2006, the construction sector's employment share rises in both the model and the data, although our model generates a larger increase. 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.

The no-saving-glut counterfactual

Comparing the baseline saving-glut equilibrium with the no-saving glut counterfactual tells us what the dynamics of the U.S. economy would have been *but for the saving glut, both in the past and the future.* We have calibrated the rest of the world's preference parameter ω_t^{rw} so that the baseline equilibrium matches the U.S. trade balance between 1992 and 2012, so our first *but-for* question concerns the trade balance: what would the U.S. trade balance have been during this period had the rest of the world's effective discount factor remained constant? Figure 4 shows that in the absence of the saving glut U.S. trade would have been roughly balanced throughout the 1992–2012 period. In other words, the entire U.S. cumulative trade deficit during this period is due to increased demand for saving in the rest of the world. This is not an obvious or trivial result — initial conditions, differences in demographic change across countries, and differences in industrial structure across countries coupled with asymmetric productivity growth across sectors can generate differences across countries in desire to save. Our results tell us that these factors are not important in explaining the behavior of the U.S. trade balance over the past two decades. Looking into the future, our model predicts that the U.S. trade balance will be about 1 percent of GDP higher by 2024 than it would have been but for the saving glut as the U.S. economy repays the debt is has incurred.

Examining the counterfactual sector-level trade balances in figure 6, we see that the impact of the saving glut on the U.S. trade balance has been concentrated in the goods sector; the U.S. services trade balance would have been similar had the saving glut not occurred. This is true both in the past and the future. The trade surpluses the U.S. will run in the future to pay back its saving-glut debt will come almost entirely from the goods sector; the U.S. will run a surplus in services as well, but by 2024 this surplus would be the same regardless of whether the saving glut occurred or not.

Our counterfactual real exchange rate results mirror our trade balance results. In the counterfactual equilibrium, the real exchange rate appreciates slowly over time as seen in figure 5. Our experiments indicate that this is due primarily to asymmetric demographic change across countries — the U.S. population grows faster than the rest of the world's population, but also becomes older. Comparing the counterfactual to the baseline, we see that all of the real exchange rate depreciation between 1992 and the mid-2000s is attributable to the saving glut, as is the subsequent appreciation. As the U.S. repays its debt to the rest of the world in the future, its real exchange rate will depreciate above its time path in the no-saving-glut counterfactual.

Our primary contribution is our assessment of the impact of the saving glut on labor reallocation in the United States — what portion of the decline in the goods sector's employment share during 1992–2012 is attributable to the saving glut? To answer this question, we compare the drop in the goods sector's labor share during this period in the counterfactual equilibrium to the same drop in the baseline. We measure both in the same units: the percent of the decline in the goods sector's employment share in the data. The decline in the no-saving-glut counterfactual is 55.03 percent of the observed decline. Comparing this to the baseline saving-glut equilibrium's 69.91 percent, we get a difference of 14.88 percent. In other words, the *saving glut is responsible for 14.88 percent of the drop in the goods sector's employment share.* Looking to the future, figure 7 shows that the reversal of the saving glut will have negligible implications for goods-sector employment. The share of employment in the goods sector would be about the same in 2024 if the saving glut did not happen; the surplus in goods trade necessary to repay debt will have little impact on the allocation of labor across sectors. In other words, eliminating the U.S. trade deficit will not bring employment back to goods production.

The saving glut has a larger impact on employment in the construction sector in our model. In the no-saving-glut counterfactual the share of employment in the construction sector rises slightly over time due to slow construction productivity growth. In the baseline equilibrium with the saving glut, the share of employment in construction rises substantially between 1992 and 2006 before dropping back down sharply in 2008–2009. As figure 7 shows, our model overexplains the boom in construction employment in this period just by introducing the saving glut. The figure also shows that the effects of the saving glut on the construction sector are short-lived; by 2024 the construction sector's employment share is about the same in both the counterfactual and the baseline equilibria.

6. Sensitivity analysis

We have conducted a wide range of additional experiments with our model, and our main result —the impact of the saving glut on U.S. structural change — is very robust. We limit our discussion to four sets of sensitivity analyses. The first two add additional ingredients to the model to improve its ability to replicate the key facts. In the third set of analyses we calibrate our model to several counterfactual input-output tables to shed light on the role of intermediate input linkages in driving structural change. The last analysis explores our assumption that U.S. trade deficits were driven by increased demand for saving in the rest of the world rather than domestic factors.

Trade wedges and the J-curve

Figure 5 shows that our model matches the extent of the real exchange rate depreciation in the data but misses on the timing. The data display a lag of several years between real exchange rate and trade balance movements — the real exchange rate begins to appreciate in 2002, but the trade deficit does not start to shrink until 2006.

In order to understand the importance of this phenomenon, often called the J-curve (see, e.g., Backus et al., 1994) for our results, we have studied a version of our model with "trade wedges" as in Alessandria, Kaboski, and Midrigan (2012) and Alessandria, Choi, Kaboski, and Midrigan (2014) that we calibrate to match both the trade balance and real exchange rate exactly during 1992–2012. Here we assume that producers in the world maximize the following objects instead of profits, taking the value of the trade wedge $\tau_{trd,t}^{rw}$ as given:

(19) $$q_{st}^{rw} y_{st}^{rw} - w_t^{rw} \ell_{st}^{rw} - \sum_{r=1}^{2} \left((1+\tau_{trd,t}^{rw}) q_{rt}^{us} m_{srt}^{rw,us} + q_{rt}^{rw} m_{srt}^{rw,rw} \right)$$

The prices indices of goods and services consumption in the rest of the world are now given by

(19) $$p_{cst}^{rw} = \frac{1}{C_s^{rw}} \left(\left(\theta_{cs}^{rw,\mathrm{us}} \right)^{\frac{1}{1-\sigma_s}} \left((1+\tau_{trd,t}^{rw}) q_{st}^{us} \right)^{\frac{\sigma_s}{\sigma_s-1}} + \left(\theta_{cs}^{rw,\mathrm{rw}} \right)^{\frac{1}{1-\sigma_s}} \left(q_{st}^{rw} \right)^{\frac{\sigma_s}{\sigma_s-1}} \right)^{\frac{\sigma_s-1}{\sigma_s}}$$

The wedges thereby enter producers' and consumers' first order conditions for their choices expenditures on products from the United States. We choose the trade wedge for each year between 1993 and 2012 so that the baseline equilibrium with the saving glut matches the real exchange rate during this period exactly.

Figure 8 shows that this "trade-wedge model" and the baseline model have similar implications for the goods sector's employment share. The two models have almost identical predictions between 1992 and 2004, and the trade-wedge model generates less movement in the goods-employment share thereafter. The baseline saving-glut equilibrium in the trade wedge model generates 63.95 percent of the observed decline in the goods sector's employment share between 1992 and 2012, versus the baseline model's 69.91 percent. The no-saving-glut counterfactual is the same in both models. Thus, the trade wedge model attributes a smaller portion of the decline in the goods sector's employment share during 1992–2012 to the saving glut than the baseline model (8.92 percent vs. 14.88 percent).

These results indicate that comovement between the real exchange rate and the trade balance played little role in sectoral labor reallocation during 1992–2002, but during 2002–2012 this phenomenon may have mitigated structural change — employment in U.S. goods production would likely have fallen further during this period if the real exchange rate and trade balance had commoved perfectly.

Non-homothetic preferences

Our baseline model captures 69.91 percent of the decline in the goods sector's share of employment between 1992 and 2012. Our analysis has focused on two possible sources of structural change: the saving glut; and asymmetric productivity growth across sectors. As Herrendorf et al. (2013) — henceforth HRV — and others show, income effects driven by non-homothetic preferences also play an important role in structural change.

Here we present a version of our model with non-homothetic Stone-Geary preferences as in Buera and Kaboski (2009) and HRV. Households preferences are now given by

$$\sum_{t=0}^{\infty}\left(\beta^{i}\right)^{t}\frac{1}{\psi}\left\{\left(\varepsilon_{c1}^{i}\left(\frac{c_{1t}^{i}-\overline{c}_{1t}^{i}}{n_{t}^{i}}\right)^{\rho_c}+\varepsilon_{c2}^{i}\left(\frac{c_{2t}^{i}+\overline{c}_{2t}^{i}}{n_{t}^{i}}\right)^{\rho_c}\right)^{\frac{\phi^{i}}{\rho_c}}\left(\frac{\overline{\ell}_{t}^{i}-\ell_{t}^{i}}{\overline{\ell}_{t}^{i}}\right)^{1-\phi^{i}}\right\}^{\psi}$$

The subsistence requirement for goods, $\overline{c}_{1t}^{i}$, and the endowment of services, $\overline{c}_{2t}^{i}$, vary over time to ensure that the model retains consistency with balanced growth.[3] We calibrate the initial values of these parameters to results reported by HRV. Our strategy is as follows. We interpolate values for $\overline{c}_{s,1992}^{us}/c_{s,1992}^{us}$ using the figures for 1947 and 2010 in HRV's Table 2[4], and assume that the rest of the world's nonhomotheticity parameters are the same as those of the United States in per-capita terms: $\overline{c}_{s,1992}^{rw}=(\overline{\ell}_{1992}^{rw}/\overline{\ell}_{1992}^{us})\overline{c}_{s,1992}^{us}$. Similar to the sectoral productivity growth rates, $\overline{c}_{st}^{i}$ remain constant at their initial levels for 50 periods, after which they begin to converge to zero. Convergence is reached after an additional 25 periods.

[3] Kongsamut et al. (2001) show that, in a closed-economy model with Stone-Geary preferences, one can ensure existence of a balanced growth path by choosing each sector's subsistence requirement so that they cancel each other out in the representative household's budget constraint. In closed-economy models, balanced growth paths are unique. Our model has `` to services, hence for all possible values for the subsistence parameters Kongsamut et al. (2001)'s knife-edge condition is not satisfied generically.

[4] HRV disaggregate the "goods" sector into manufacturing and agriculture, and assume a subsistence requirement in agriculture ($\overline{c}_a > 0$) and homotheticity in manufacturing ($\overline{c}_m = 0$). We use the ratio of agricultural consumption to goods consumption for the United States in the disaggregated WIOD data to calculate the implied value of $\overline{c}_{1,1992}^{us}$.

Figure 9 compares the results for the goods sector's employment share in the non-homothetic model to the baseline. In the nonhomothetic model, the benchmark equilibrium generates 76.68 percent of the observed decline in the goods sector's labor share, and the saving glut's contribution is 15.69 percent. The fact that adding non-homothetic preferences does not lead our model to account for a substantially larger fraction of U.S. structural change is consistent with Buera and Kaboski (2009), who calculate large wedges in firms' first-order conditions in a closed-economy model similar to ours. We have experimented with a similar "wedge" analysis in which we construct a model that matches exactly the observed reallocation of labor between 1992 and 2012. In this model, the saving glut's contribution to the decline in the goods sector's labor share is similar to our baseline result.

The input-output structure

There are two potential roles for input-output linkages in driving U.S. structural change. First, and services are stronger compliments intermediate use than final use in our calibration, so expenditures on intermediate goods fall more than expenditures on final goods in response to asymmetric productivity growth. The WIOD data bear this out: table 3 shows that the goods share of U.S. intermediates fell much more than the goods share of U.S. consumption between 1995 and 2011. Second, the ratio of gross output to GDP is higher in goods than other sectors — goods are used more intensively as intermediates than services. We construct three counterfactual versions of out input-output table to help understand the role of these two mechanisms.

In our first analysis, we set all intermediate inputs to zero and keep sectoral value added fixed. This exercise captures the full extent of the contribution input-output linkages to U.S. structural change. When we leave all elasticities of substitution unchanged from their baseline values, the benchmark equilibrium in this version of the model accounts for only 27.90 percent of the observed decline in the goods sector's labor share. This suggests that input-output linkages play a large role in driving U.S. structural change. This exercise may, however, overstate the role of input-output linkages. HRV find that when one interprets sectoral output as value added rather than gross output — as we do in this exercise — a much lower elasticity of substitution between goods and services in consumption is warranted. When we use HRV's suggested elasticity of 0.02 — essentially Leontief — with this counterfactual input-output table, the benchmark equilibrium accounts for 49.82 percent of the decline in the goods sector's labor share. This figure is still substantially lower than the baseline model's 69.91 percent, indicating after one accounts for differences in elasticities of substitution between intermediate and final uses, there remains an important role for input-output linkages in driving U.S. structural change.

Our second counterfactual input-output table is intended to help understand this additional margin. Here we retain the input-output structure, but equalize gross output/value added ratios across sectors. This exercise helps us determine whether the fact that goods are more intensively used as intermediates than services hastened the decline in goods-sector employment. Our results suggest yes: the benchmark equilibrium in this version of the model accounts for 62.26 percent of the observed decline in the goods sector's employment share. The economic intuition is that when goods are used less intensively as intermediate inputs, there is less room for expenditures on intermediate goods to fall in response to relative price changes driven by asymmetric productivity growth.

In the third counterfactual, we set intermediate inputs to zero *and* set value added shares equal to observed gross output shares. Here the benchmark accounts for 23.72 percent of the decline.

Global saving glut or 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 causes of U.S. borrowing. To weight the merit of these hypotheses we study a version of our model in which the preferences of U.S. households, rather than households in the rest of the world, drive the U.S. trade balance. Following Chinn and Ito (2007), we call this the *domestic-saving-drought* model. In the saving-drought model, the preferences of U.S. households take the same form as (13), and we calibrate the U.S. preference parameter ω_t^{us} in the same manner as the baseline model.

To assess which of the models is more consistent with the data we focus on investment. Figure 11 shows that, before the financial crisis of 2009, U.S. investment as a fraction of GDP rose steadily. This is consistent with the saving-glut hypothesis: 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 domestic demand for saving, U.S. households should have reduced investment in favor of consumption. Figure 11 shows that, except for the year 1993, the investment rate in the baseline model moves in the same direction as the data. By contrast, the investment rate 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 incorporated into our model). During the financial crisis of 2008–2009 (which we have modeled solely through the increasing trade balance), the investment rate falls in the baseline model and the data, but rises in the saving-drought model. Overall, the correlation between the saving-glut model's investment rate and the data in first differences is 0.76; the same correlation for the saving-drought model is -0.56.

7. Directions for future research and concluding remarks

We have developed a model of the United States and the rest of the world with two exogenous driving forces: increased foreign demand for saving — the "saving glut" — and faster productivity growth in goods compared to 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 towards services and construction. We have used our model to show that while faster productivity growth in the goods sector is responsible for the bulk of the long-run shift in employment away from that sector, the saving glut hastened this change during 1992–2012.

Although the saving 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 benchmark saving glut equilibrium against the no-saving-glut counterfactual. 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 remain permanently depreciated by about 6 percent compared to its path in the no-saving-glut counterfactual.

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 after 2002? 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, et al., 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; the real exchange rate begins to depreciate in 2002, but the trade balance keeps falling until 2006. Another, perhaps more plausible, explanation, is the increase in the importance of China in U.S. borrowing during the period. In figure 12 we decompose the U.S. real exchange rate into two components: (1) the bilateral real exchange rate with China; and (2) the real exchange rate 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 using time-varying country weights in calculating our real exchange rate. Instead, it would involve distinguishing between the countries that have purchases the bulk of U.S. bonds during the saving glut, like China, Japan, and Korea, with those that have run more balanced trade with the United States. To accurately capture this, we would need to model an economy 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) judgement, the saving glut has only had a small effect on U.S. real interest rates in the model. As seen in figure 13. The largest difference between the interest rate in the benchmark saving-glut equilibrium and the no-saving glut counterfactual is 50 basis points (2.57 percent versus 2.07 percent). This is in line with Greenspan's (2005) judgement 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 depend 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 but, as figure 13 shows, not the right magnitude in the drop of the U.S. real interest rate. If we make foreign foods more substitutable for U.S. goods we can generate more of a drop in the U.S. real interest rate during 2006–2012 — although still not 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 13, our model predicts that the U.S. interest rate is driven up by real exchange rate appreciation and down by depreciation. The falling prices of foreign goods during 1993–2006 in the benchmark saving-glut equilibrium induce U.S. households to increase consumption faster than they do in the no-saving-glut counterfactual, 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 U.S. real exchange rate depreciates during 2006–2012, consumption grows more slowly in the benchmark than in the counterfactual 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:

(19) $$1+r_{t+1}^{us}=(1+r_{t+1}^{rw})\frac{rer_{t+1}}{rer_t}.$$

As the demand for saving 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 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 benchmark saving-glut equilibrium than in the no-saving-glut counterfactual is the requirement that the saving glut generates the observed trade deficit, which implies that consumption in the United States increases faster during the saving glut than it would have had the saving glut not occurred.

To account for the very low U.S. real 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 we have studied is successful in generating lower U.S. real 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.

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Table 1: 1992 Input-output matrix (U.S. GDP = 100)

	Intermediate inputs					*Final demand*				*Gross output*
	USA			**ROW**		**USA**			**ROW**	
	Goods	**Services**	**Construction**	**Goods**	**Services**	**Consumption**	**Government**	**Investment**	**Consumption**	
Goods	21.52	9.96	3.14	3.10	1.14	7.66	1.91	5.26	2.72	***56.41***
Services	11.74	39.23	2.99	0.90	1.35	54.97	13.68	3.01	0.47	***128.33***
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.05	0.00	***10.05***
Goods	3.17	1.11	0.33	89.56	41.13	1.64	0.41	1.68	82.31	***221.33***
Services	0.44	1.08	0.10	42.59	88.67	0.19	0.05	0.02	205.37	***338.51***
Value added	19.55	76.96	3.50	85.18	206.22	0.00	0.00	0.00	0.00	***391.40***
Gross output	***56.41***	***128.33***	***10.05***	***221.33***	***338.51***	***64.47***	***16.05***	***20.02***	***290.87***	

Table 2: Calibration

Parameter	Value	Target
Gross output parameters		
$1/(1-\eta)$	0.05	Enghin (2014)
$1/(1-\xi)$	0.04	Enghin (2014)
$1/(1-\zeta_r)$	3.0, 1.0	International macro literature
A_s^i, B_s^i, C_s^i	See data appendix	1992 gross output, value added, and intermediate levels
λ_s^i	See data appendix	1992 value added shares of gross output
π_{sr}^i	See data appendix	1992 shares of goods and services in intermediate use
μ_{sr}^{ij}	See data appendix	1992 country shares of intermediate use by sector
α_s^{us}	0.33, 0.35, 0.17	Aggregate capital share of 0.34, 1992 sectoral labor shares
$\{\gamma_s^i\}_{t=1992}^{2092}$	See data appendix	Value added and labor compensation data from U.S. BEA
Final demand parameters		
$1/(1-\rho_f)$	0.65, 0.65, 0.99	Enghin (2014), Bems (2008)
$1/(1-\sigma_r)$	2.00, 1.00	International macro literature
D_s^i	See data appendix	1992 final demand levels
ε_{sr}^i	See data appendix	1992 sectoral shares of final demand
θ_{sr}^{ij}	See data appendix	1992 country shares of final demand by sector
Household and government parameters		
β^i	0.99, 0.99	Long-run real interest rate of 3.4 percent, constant capita/GDP
$1/(1-\psi)$	0.50	Intertemporal elasticity of substitution = 0.5
ϕ^i	0.33, 0.33	1992 leisure time = 2/3
$\{n_t^i, \bar{\ell}_t^i\}_{t=1992}^{2092}$	See data appendix	*World Population Prospects: 2010 Revision*
U.S. gov't requirements	See data appendix	U.S. BEA and CBO
Capital formation parameters		
k_{1992}^{us}	277.89	Backus et al. (2007)
δ	0.05	U.S. fixed capital consumption, 1951–2004 (U.S. BEA)
τ_k^{us}	0.39	Devereux et al. (2002)
$\tau_{i,1993}^{us}$	0.94	1992 investment/GDP

Table 3: Model and data, non-targeted moments

Statistic	Data	Model
Intermediate share of U.S. gross output, 1995	44.71	48.00
Intermediate share of U.S. gross output, 2011	43.68	47.04
Change	-1.04	-0.96
Goods share of U.S. intermediates, 1995	43.21	39.93
Goods share of U.S. intermediates, 2011	36.40	36.57
Change	-6.81	-3.36
Goods share of U.S. consumption, 1995	15.30	14.24
Goods share of U.S. consumption, 2011	13.63	13.44
Change	-1.66	-0.79
Goods share of U.S. investment, 1995	40.46	34.62
Goods share of U.S. investment, 2011	40.26	34.43
Change	-0.19	-0.19
Std. dev. Of U.S. goods trade balance, 1992-2012	1.54	1.46
Std. dev. Of U.S. services trade balance, 1992-2012	0.24	0.18

Table 4: Goods sector's employment share decline in baseline model vs. alternatives

Model	**Benchmark**	**No-saving-glut counterfactual**	**Difference**
Baseline	69.91	55.03	14.88
Models with additional features to improve fit			
Trade wedges	63.95	55.03	8.92
Nonhomothetic preferences	76.68	60.99	15.69
Models with alternative input-output matrices			
No-IO, baseline consumption elasticity	27.90	18.43	9.46
No-IO, Leontief consumption elasticity	49.82	37.23	12.58
Same GO/GDP in all U.S. sectors	62.26	50.31	11.94
No-IO, match GO shares	23.72	14.44	9.28

Figure 1: U.S. trade balance vs. goods sector's employment share

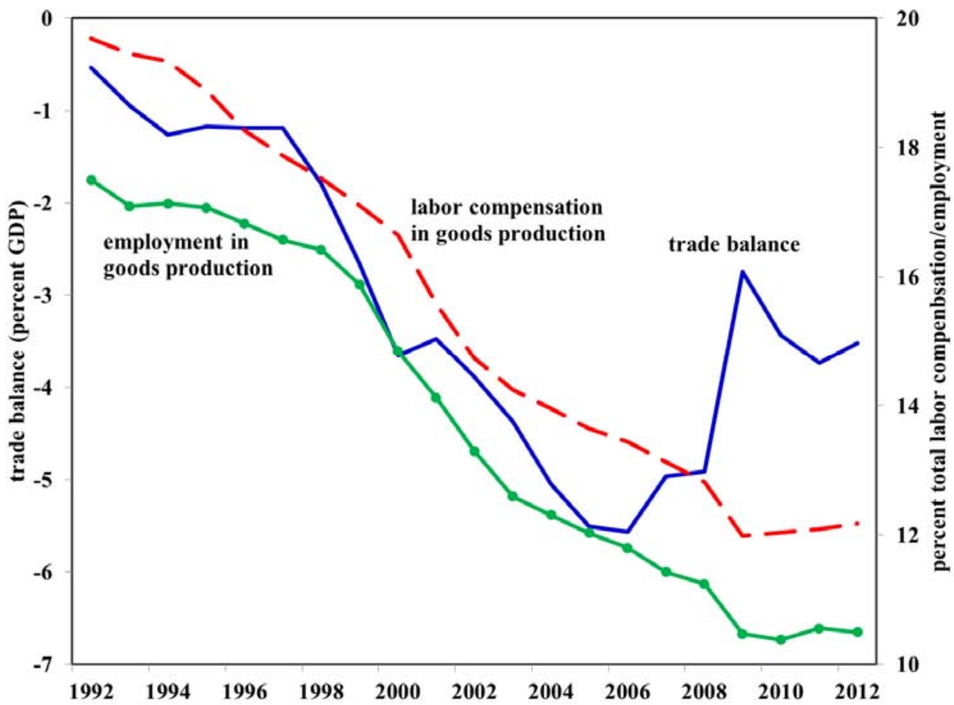

Figure 2: Labor productivity in goods, services, and construction

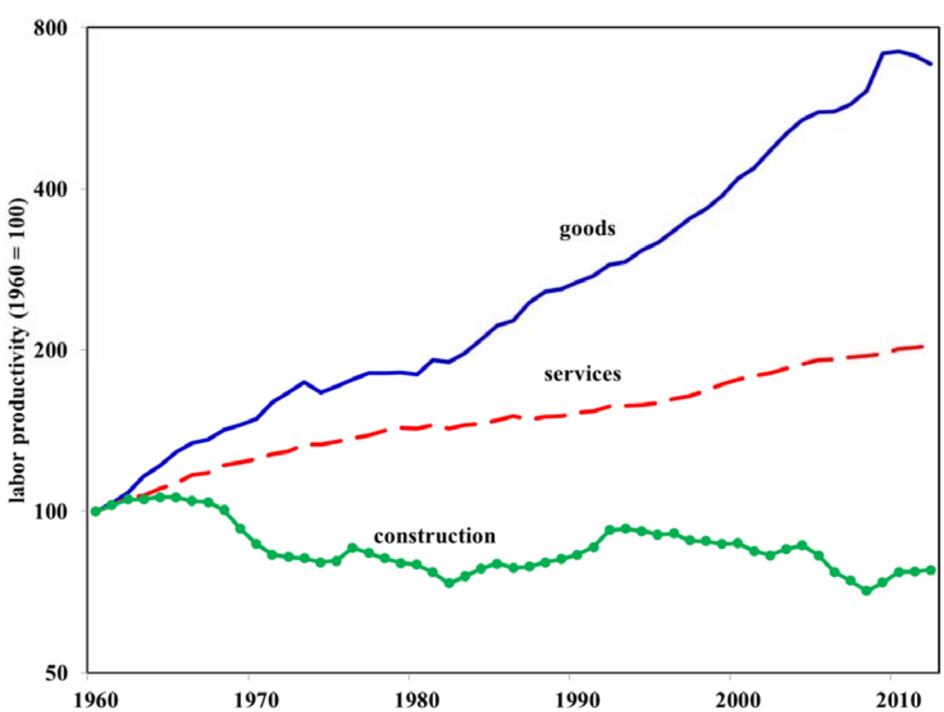

Figure 3: U.S. trade balance, current account balance, and real exchange rate

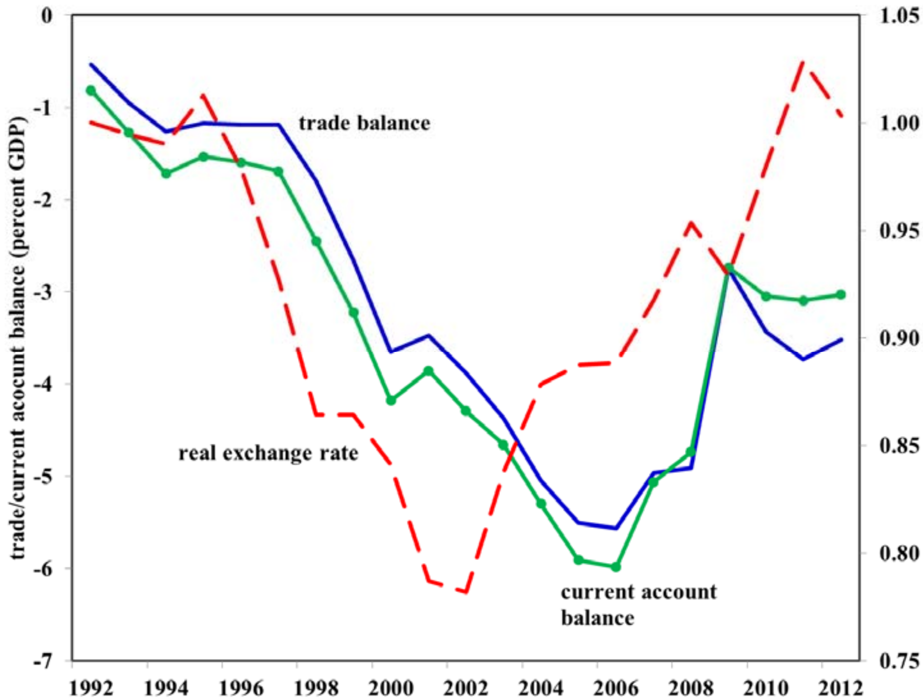

Figure 4: U.S. trade balance in baseline model vs. data

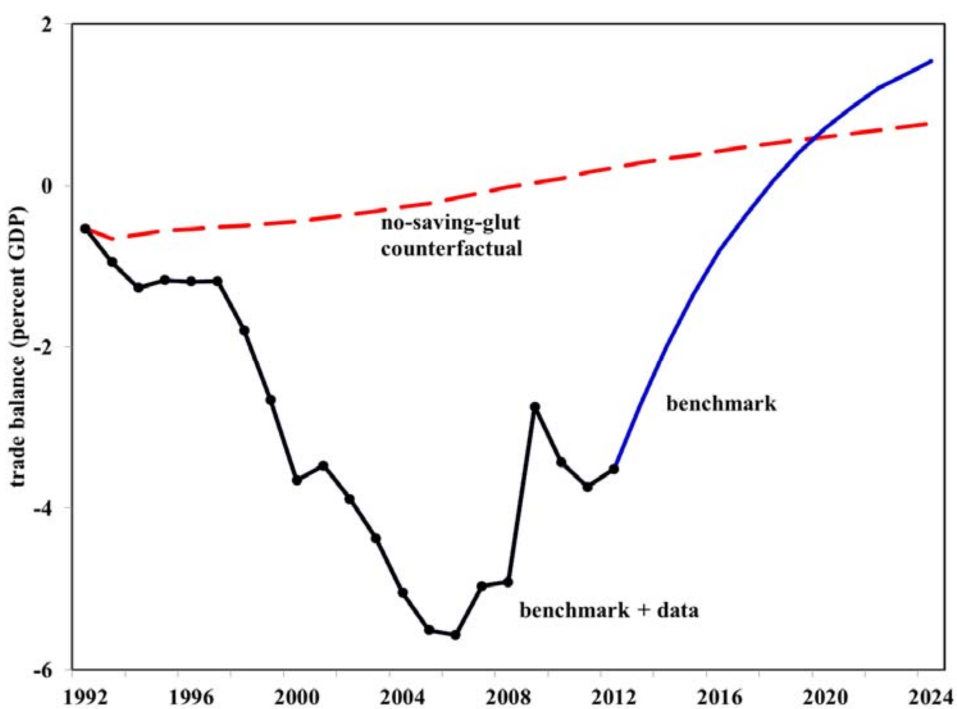

Figure 5: U.S. real exchange rate in baseline model vs. data

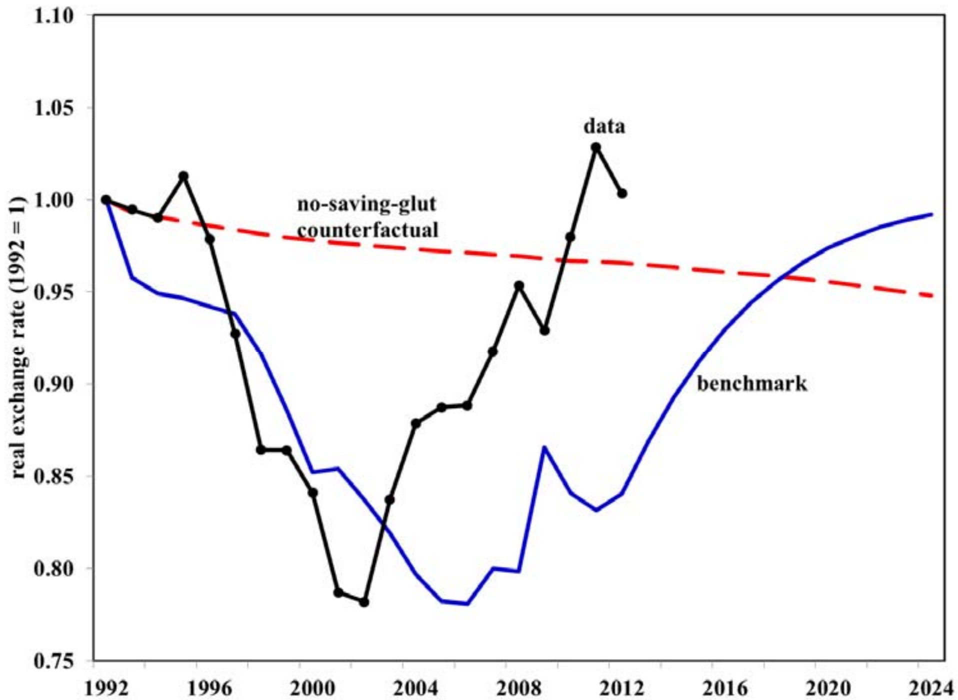

Figure 6: Disaggregated trade balances in baseline model vs. data

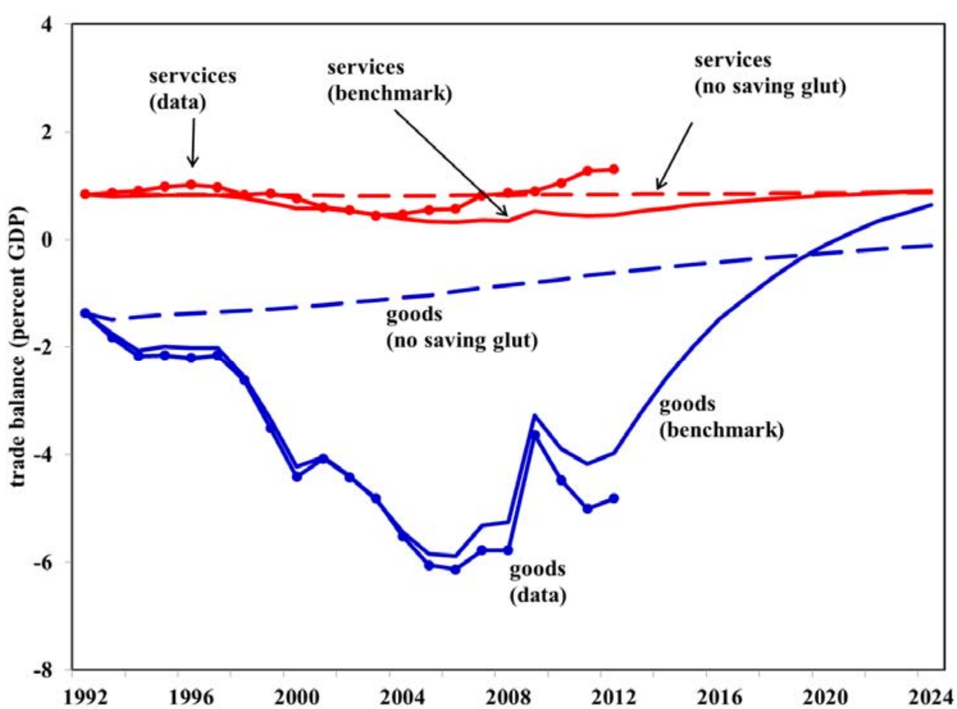

Figure 7: Goods and construction employment shares in baseline model vs. data

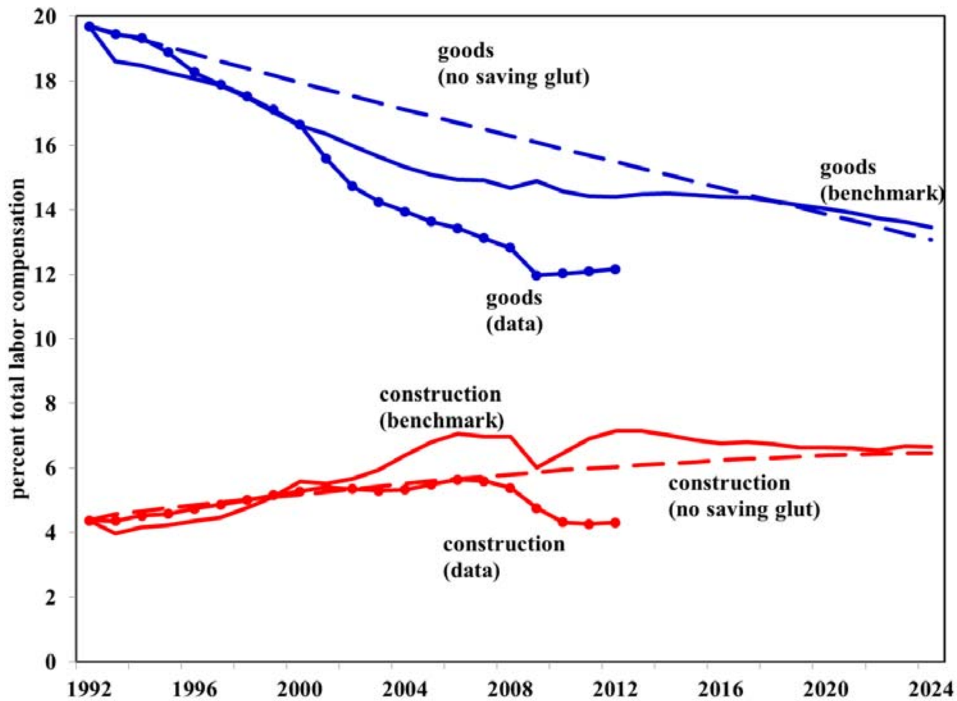

Figure 8: Goods employment share in trade-wedge model vs. baseline model

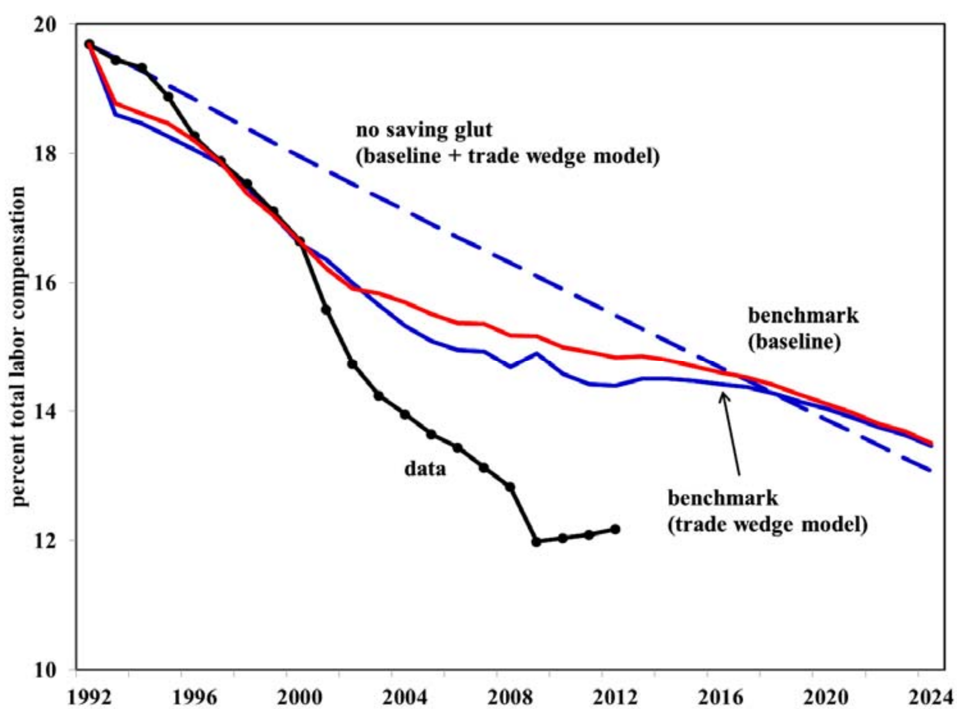

Figure 9: Goods employment share in goods-wedge models vs. baseline model

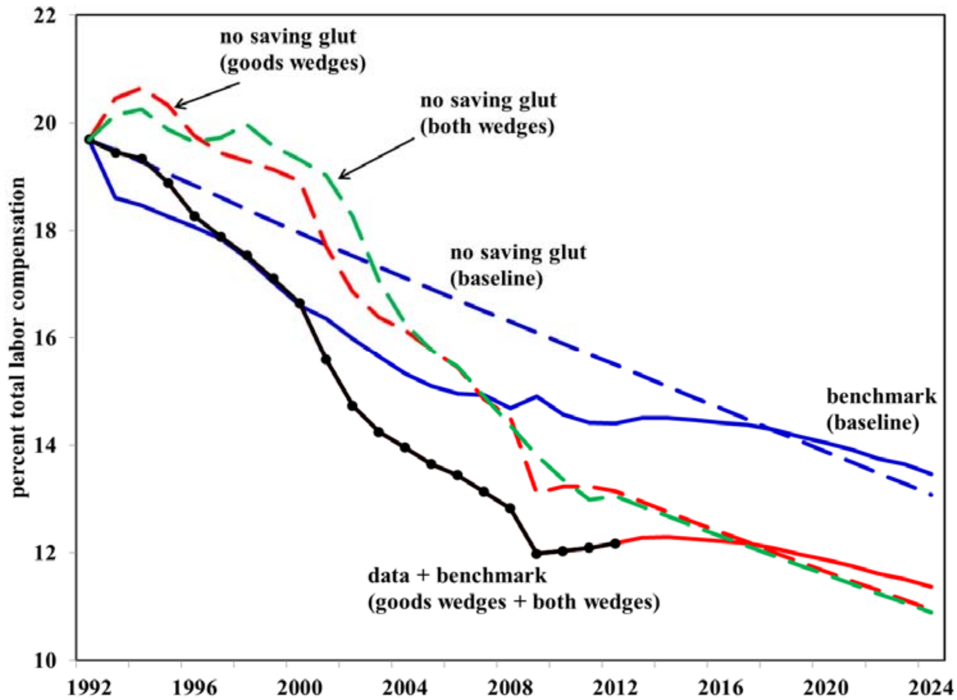

Figure 10: Goods employment share in no-IO models vs. baseline model

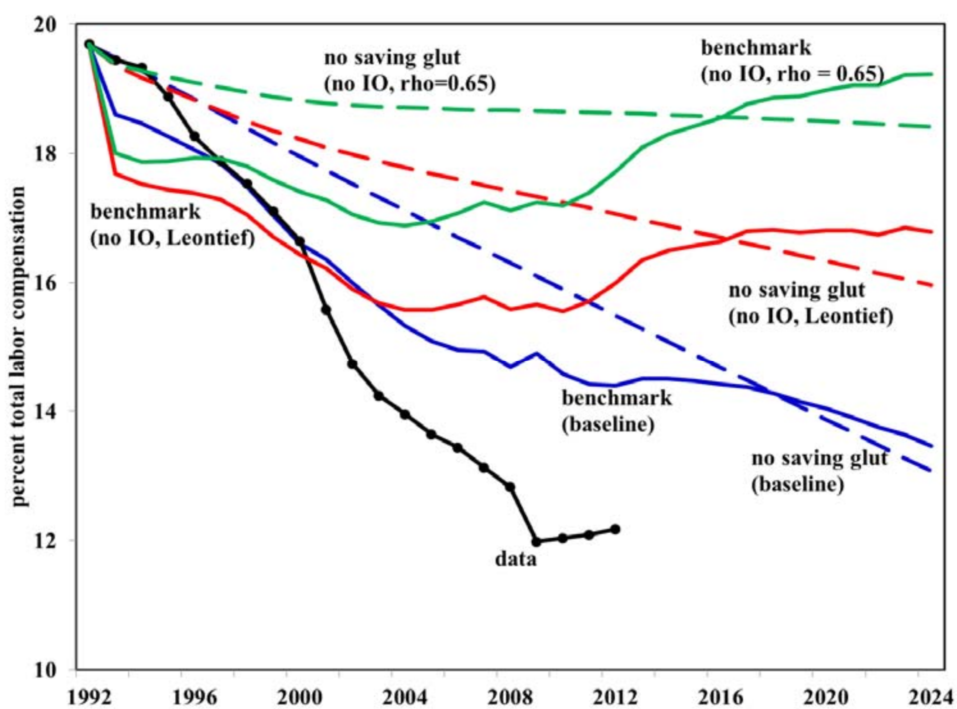

Figure 11: Investment in domestic saving drought model vs. baseline model

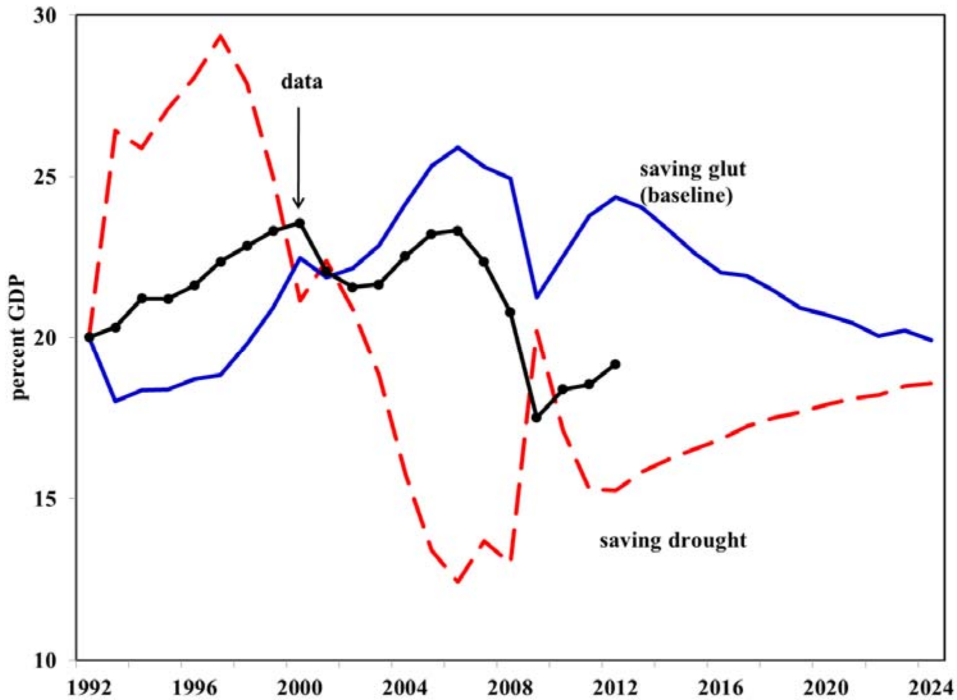

Figure 12: U.S. real exchange rates with China and other trade partners

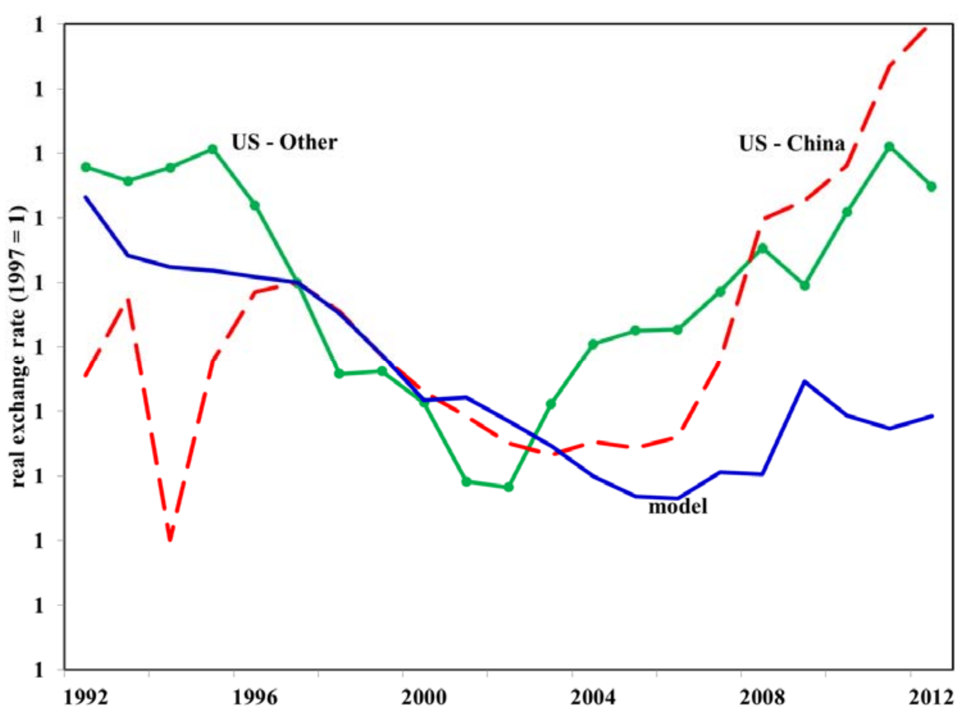

Figure 13: U.S. real interest rate in baseline model vs. data