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A Sudden Stop to the Savings Glut and the Future of the U.S. Economy

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ABSTRACT

Since the early 1990s, world real interest rates have been very low and the United States has borrowed heavily from the rest of the world. We build an intertemporal, multisector, general equilibrium model of the U.S. economy and we show that this model captures key features of the dynamics of the U.S. trade balance, real exchange rate and sectoral labor reallocation between 1992 and 2010. We then use our model to study what will happen when this "savings glut" ends, and how those consequences differ if this end comes as an unexpected sudden stop rather than a gradual rebalancing process. We find that when the savings glut ends and the United States stop borrowing, the U.S. trade deficit will turn to a surplus, the real exchange rate will depreciate by almost 40 percent, and labor will reallocate towards the goods sector from construction. A sudden stop event will cause these changes to occur immediately but will have little effect on the long-run trajectory of the U.S. economy. We also find that long-run reallocation of labor to the goods sector is limited by trade in services and structural change.

1. Introduction

Since the early 1990s the United States has borrowed heavily from the rest of the world. The U.S. current account balance has been negative for twenty straight years, since 1992, and its net foreign asset position has fallen to less than negative twenty percent of GDP (Lane and Milesi-Feretti, 2007). Current yields on U.S. government bonds remain historically low and there has been no sign of trouble in U.S. government debt auctions, but the recent experiences of European countries like Greece, Ireland, Italy, Portugal, and Spain suggest that the current may not always be a good indicator of the future. In this paper we ask two questions. First, what will happen to the U.S. economy if and when foreigners' willingness to lend wanes? Second, what will happen if foreigners stop lending suddenly and unexpectedly rather than gradually, in a sudden stop event like those that hit Latin American and Asian countries in the 1990s and the European countries listed above in recent years?

In order to answer these questions we must first explain why the United States has borrowed so much from the rest of the world in the first place. One common hypothesis about the source of the United States' borrowing is the *global savings glut* theory proposed by Ben Bernanke, Chairman of the Board of Governors of the Federal Reserve System. He coined the term in his March, 2005 address to the Virginia Association of Economists entitled "The Global Saving Glut and the U.S. Current Account Deficit," in which he made the following statement:

> "Why is the United States, with the world's largest economy, borrowing heavily on international capital markets – rather than lending, as would seem more natural? …[O]ver the past decade a combination of diverse forces has created a significant increase in the global supply of saving – a global saving glut – which helps to explain both the increase in the U.S. current account deficit and the relatively low level of long-term real interest rates in the world today."

The essence of the savings glut theory is that increased world demand for saving, primarily in emerging economies, pushed real interest rates below the U.S. rate of time preference, reducing the American saving rate and leading to capital inflows. Figure 1 shows that real interest rates and capital inflows into the U.S. are highly correlated. The figure plots the U.S. trade and current account balances alongside the ex-post real interest rate (measured as the yield on 20-year treasury bonds less CPI inflation) between 1992 and 2010. The two account balances move in lockstep with the interest rate over the entire period. This holds true even during the financial crisis of 2009, during which deflation pushed the real interest rate up just as the collapse in world trade reduced the account deficits. Figure 2 highlights the fact that the movement in the trade balance that accompanied these low interest rates was driven primarily by the goods sector; the services trade balance remained roughly constant at around +2 percent of GDP. Figure 3 shows that the real exchange rate moved substantially during this period, appreciating by more than 16 percent between 1992 and 2000 then depreciating by similar amount by 2010. In this paper we build a model of the U.S. as an open economy that takes the world real interest rate as given and show that the model is consistent with the three key facts above. We then use our model to assess the long-run implications of the end of the savings glut – a long-run increase in real interest rates – for the U.S. economy.

Our view is that the saving glut is a temporary, albeit lengthy, phenomenon, and that the real interest rate will eventually revert to a higher long-run value consistent with balanced growth. Bernanke takes a similar perspective. In the same 2005 speech he states:

> "[T]he underlying sources of the U.S. current account deficit appear to be medium-term or even long-term in nature, suggesting that the situation will eventually begin to improve, although a return to approximate balance may take some time. Fundamentally, I see no reason why the whole process should not proceed smoothly. However, the risk of a disorderly adjustment in financial markets always exists."

In other words, the current imbalances associated with the saving glut will end eventually. The only question is whether the rebalancing process will be gradual or sudden. Our goal in this paper is to provide a quantitative assessment of the consequences of an end to the savings glut. In particular, we ask how these consequences depend on the manner in which the savings glut ends. We study three scenarios: a *gradual rebalancing* in which interest rates rise slowly over the next few decades, an *orderly sudden stop* in which foreigners suddenly stop lending to the United States and the real interest rate jumps but the U.S. economy is otherwise unscathed, and a *disorderly sudden stop* in which total factor productivity falls as lending ceases and interest rates spike. In all three scenarios, the U.S. trade balance will reverse in the long run as the United States stops borrowing and begins to service its debt. This will be accompanied by a large real exchange rate depreciation, almost 40 percent relative to the real exchange rate's lowest level during the 2000s. A sudden stop will cause these changes to occur immediately and may cause short-term economic pain if accompanied by a drop in TFP, but our results indicate that long-run trade balance and real exchange rate dynamics are not sensitive to the occurrence of a sudden stop. In other words, the primary effect of a sudden stop will be to hasten inevitable long-run changes.

The savings glut period of the last two decades saw large reallocations in employment across sectors: construction employment grew rapidly during the housing boom and fell even more quickly after the financial crisis, and employment in goods is 30 percent below its 1993 level. The end of the savings glut, regardless of whether it is gradual or swift, will require that the United States export more than it imports, and as a consequence the composition of the U.S. economy must back shift towards traded sectors, reversing some of the sectoral reallocations that occurred during the savings glut. Bernanke makes a similar point in his 2005 speech:

> "A… concern with the pattern of capital flows arises from the indirect effects of those flows on the sectoral composition of the economies that receive them. In the United States, for example, the growth in export-oriented sectors such as manufacturing has been restrained by the U.S. trade imbalance… while sectors producing nontraded goods and services, such as home construction, have grown rapidly. To repay foreign creditors, as it must someday, the United States will need large and healthy export industries. The relative shrinkage in those industries in the presence of current account deficits--a shrinkage that may well have to be reversed in the future--imposes real costs of adjustment on firms and workers in those industries."

Our model is well-equipped to assess the impact of both the savings glut and a future sudden stop on the composition of the U.S. economy. We have three sectors that contribute to GDP: goods (manufacturing, agriculture and minerals), services and construction. Many studies in the international macro literature treat the goods sector as the only traded sector. The United States, though, engages in a significant amount of services trade as well. Moreover, the U.S. exports more services than it imports, while the reverse is true for goods – services are relatively *export-oriented*. We incorporate these features into our model, and we will see that they play an important role in the effects of the savings glut and its end. Construction is our only nontraded sector and it is used almost entirely to produce investment goods. This makes construction more sensitive than the other sectors to the savings glut and a future sudden stop. The construction sector bears the brunt of the shifts into and away from nontraded commodities[1], but it also responds strongly as investment, which is quite volatile, waxes and wanes. Finally, we use an input-output production structure to capture the flows of intermediate goods that link sectors together. This feature plays an especially prominent role in our results for a disorderly sudden stop. A sudden drop in TFP reduces demand for intermediates, and since goods are used disproportionately as intermediate inputs the TFP shock hits the goods sector harder than services.

We find low real interest rates since 1992 cause reallocation of resources across sectors during the savings glut period that is qualitatively consistent with observed trends in the data. We match the fact that aggregate trade balance dynamics during this period were driven primarily by the goods trade balance; the services trade balance has remained roughly constant around +2 percent of GDP. Employment shares in goods, services and construction all move in the same direction in our model as in the data. Our model captures a large fraction of observed employment share dynamics in the construction sector, indicating that the savings glut is an important factor driving the construction boom that preceded the financial crisis. Our model generates small movements in the goods sector's employment share as compared to the data, however, indicating that other factors are more important in explaining the recent decline in the goods employment. In an extension of our model we draw from the literature on structural change and allow for productivity in the goods sector to grow faster than in services. This generates larger movements in the goods and services employment shares, suggesting that structural change issues play an important role.

When the savings glut ends, employment shifts back towards the goods sector as the U.S. stops borrowing and begins to service its debt. A sudden stop will hasten this reallocation towards goods and cause a large, temporary drop in construction employment due to a drop in

[1] Because we use the term "goods" to refer to manufacturing, agriculture and minerals, we use the term "commodities" to refer to the different types out output produced by our model's sectors. Typically, studies in the international macro literature refer to "traded goods" and "nontraded goods." This usage would be confusing for obvious reasons, so we use the terms "traded commodities" and "nontraded commodities" instead.

investment. In our model with structural change, however, the goods employment share falls in the long run, as fast goods productivity growth reduces the labor needed to produce enough goods to service the U.S. external debt. Reallocation towards the goods sector is also limited by the fact that services, which are relatively export-oriented, are a primary source of net exports used to service debt in the long run. In fact, our model predicts that the goods trade balance will remain below -2 percent of GDP forever, while the services trade balance will rise to more than +3 percent of GDP. To address Bernanke's point about the possibility that the reallocation caused by the end of the savings glut may cause real economic harm, we study an extension of our model with labor adjustment costs. We find that these costs are particularly important during a disorderly sudden stop, causing real GDP to fall on impact by an additional 2.5 percent.

The remainder of the paper proceeds as follows. Section 2 discusses our paper's relation to the literature. In section 3 we describe our model and our notion of equilibrium. Section 5 details our calibration and our data sources for exogenous processes like population. Section 6 presents the results of our first quantitative exercise, a comparison of our model with the data during the savings glut period. Section 7 presents the results from our second quantitative exercise, an analysis of three scenarios for the end of the savings glut. In section 8 we discuss three extensions of our baseline model: structural change, labor adjustment costs and a version without services trade. Section 9 provides concluding remarks.

2. Related literature

The persistent, large capital inflows into the United States shown in figure 1 have fueled a large body of research and debates among policymakers and academics. Many scholars view these "global imbalances" as unsustainable and intimately linked with financial crises[2], while others see them as sustainable equilibrium outcomes from financial integration among countries that differ in financial development, business cycle properties, demographic structure, etc.[3] Our study remains neutral in these debates. We take no position on the source of the increase in demand for saving in the rest of the world or on the likelihood of a sudden "unwinding" of these imbalances. Our focus is on the long-term effects of the capital inflows of the past two decades on the U.S.

[2] See Summers (2004), Roubini and Setzer (2005), Obstfeld and Rogoff (2007), Krugman (2007), Caballero and Krishnamurthy (2009), Obstfeld and Rogoff (2009).
[3] See Mendoza et al. (2009), Caballero et al. (2008), Folgi and Perri (2010).

economy, and the effects of a sudden stop in foreign lending as compared to a more gradual rebalancing process.

We model the savings glut as an exogenous drop in the real interest rate beginning in 1998; we do not explicitly model global demand for saving or its effect on interest rates. Recent research, however, indicates that foreign demand for saving is a significant driver of interest rate movements in the United States. Empirical studies show that purchases of U.S. Treasuries and similar securities by Foreign Official Institutions have significant effects on Treasury yields (Bernanke et al., 2004; Krishnamurthy and Vissing-Jorgensen, 2007; Warnock and Warnock, 2009; Bernanke et al., 2011). Favilukis et al. (2012) use a quantitative model calibrated to the U.S. economy to study the effect of foreign purchases of U.S. debt and find that these purchases have an economically important downward impact on the risk-free rate, consistent with the empirical literature. While our assumption that the United States takes the real interest rate as given may seem strong, we view it as reasonable in light of the evidence above. An alternative approach would be to treat foreign demand for U.S. debt as exogenous and determine the real interest rate endogenously by clearing the market for that debt as in Favilukis et al. (2012). We could then calibrate a time-series for foreign demand so that the model generates interest rates that match the data (and our assumptions about real interest rate dynamics in the future). This approach would greatly increase our computational burden and, we believe, would ultimately yield results that are very similar to our current ones.

Our paper is also related to the literature on historical sudden stop episodes such as those that occurred in Mexico in 1994-1995 and in several Southeast Asian countries in 1997-1998. Empirical studies document that these episodes are typically characterized by sudden trade balance increases, real exchange rate depreciations and TFP-driven output contractions painless (Calvo et al., 2004; Calvo et al., 2005; Meza and Quintin, 2007), although Calvo et al. (2004) identify several sudden stops that occurred in European countries in 1992—1993 as a result of the ERM crisis that were relatively painless. Models of sudden stops fall into two main groups. The first seeks to explain why sudden stops occur, modeling them as equilibrium outcomes that arise due to lack of commitment to repay sovereign debt (Calvo, 1988; Cole and Kehoe, 2000; Arellano, 2008) or financial friction-driven amplification effects (Mendoza, 2010). The second group takes sudden stops as exogenous, unanticipated events and studies their effects on other economic variables. Our approach is similar to that taken by Chari Kehoe and MacGrattan (2005), Cook and Devereux (2006), Meza and Quintin (2007), and especially Kehoe and Ruhl (2009), who use a related model to study the sudden stop that hit Mexico in 1994-1995. One challenge this group of studies faces is explaining the large observed drops in TFP that have accompanied most sudden stops (Chari, Kehoe and McGrattan, 2005; Meza and Quintin, 2007). In our model, a sudden stop does not endogenously generate a drop in TFP. We do, however, study a scenario in which a sudden stop is accompanied by an exogenous negative TFP shock of similar magnitude to historical episodes as reported by Meza and Quintin (2007). Other than causing a contraction in output, a TFP shock does not affect most of our results.

This paper emphasizes the effects of unexpected capital inflows (the savings glut) and outflows (the sudden stop) on the sectoral composition of the economy and relative prices. When the savings glut occurs, resources shift from services to construction and goods, while the sudden stop has the opposite effect. SAY SOMETHING ABOUT THE CONSTRUCTION DATA KIM GAVE ME HERE. These shifts are accompanied by large fluctuations in the real exchange rate: the savings glut causes an appreciation of 16 percent in the data (17 percent in our model, while a sudden stop in our model causes a depreciation of 15 percent. These findings are consistent with previous studies like Cordoba and Kehoe (1999), who study Spain's entry into the European Community, as well as Burstein et al., Mendoza (2005), Kehoe and Ruhl (2009), who study real exchange rate depreciation during sudden stops.

Given our emphasis on the effects of the savings glut and its end on long-run sectoral reallocation trends, our study also relates to the literature on structural change. In our baseline model, the goods sector's share of employment falls during the savings glut but rises in the long run once the United States begins to pay back its debt. This paints a rosy view of the future for goods sector employment. In section 8, however, we explore an extension motivated by the structural change literature in which labor productivity in the goods sector grows faster than services productivity. In our preferred calibration the elasticity of substitution between goods and services in final consumption is less than one. When combined with asymmetric productivity growth, this causes the goods sector's employment share to fall over time. This is the same mechanism studied by Ngai and Pissarides (2007). It is originally attributed to Baumol (1967), and was later supported empirically by Kravis et al. (1983) and Baumol et al. (1985). We stress that this occurs despite the fact that the composition of the U.S. economy must shift towards traded sectors in the long run as the United States begins to repay the debt incurred during the savings glut. This result is driven by our treatment of both goods and services sectors as traded. In the long-run in our model, the United States runs a trade deficit in goods and a surplus in services; the services sector provides the exports necessary to sustain the necessary capital outflows. Our treatment of structural change in an open economy complements recent work by Yi and Zhang (2011), who emphasize the importance of the fact that countries don't always consume the same goods and services they produce in explaining observed patterns of structural change across countries.

3. Baseline Model

We model the United States as a semi-small open economy with perfect foresight over the paths of world interest rates, population and government policy, with the exception of a limited period of uncertainty about interest rates between 1998 and 2010 which we describe below. The length of a period in our model is one year. The United States takes the world real interest rate r_t^* as exogenous and faces downward-sloping demand curves for its exports of goods and services. We begin the model in 1992, at which time the real interest rate was approximately 4% and United States' trade balance as a fraction of its GDP was close to zero. At this time, agents in the model expect the real interest rate to gradually revert to a long-run rate of 3% consistent with a balanced growth path.

In 1998 the savings starts begins unexpectedly. Once the savings glut begins, agents in our model are uncertain about the path the real interest rate will take. In each year between 1999 and 2008 there is a chance that the savings glut will end early and interest rates will quickly rise to our long-run rate of 3%. In 2009, if the savings glut is still in effect there is a chance of a temporary spike in the interest rate due to deflation caused by the financial crisis. All uncertainty is resolved by 2010 and the real interest rate rises to 3% over time thereafter. We provide a detailed explanation of the uncertainty in our model in section 5.

In 2017, the United States experiences another unexpected event: a sudden stop. Model agents are restricted from going further into debt for one year. Afterwards, the real interest rate rises temporarily and quickly converges to 3%, reflecting a sudden end to the external factors driving the savings glut. We study two types of sudden stops, which we term *orderly* and *disorderly*. In the former, the borrowing restriction and shift in the interest rate path are the only changes. In the latter, we add a shock to total factor productivity to capture a common element of sudden stops in the past.

In our baseline model capital and labor can be costlessly reallocated across sectors and productivity in the traded and nontraded sectors grows at the same rate. Later, we add factor adjustment frictions and allow for different rates of productivity growth across sectors to study the effects of these features on the model's performance relative to the data during the 1992-2010 period and on the model's dynamics following the sudden stop in 2017.

Production

There are 8 types of commodities in the model:

1. Domestically produced goods y_{gt}^D
2. Domestically produced services y_{st}^D
3. Construction y_{ct}
4. Imported goods m_{gt}
5. Imported services m_{st}
6. Composite traded goods y_{gt}
7. Composite traded services y_{st}
8. Investment y_t^I

All 8 commodities are sold in perfectly competitive markets. Sectors in the economy are linked to one another through an input-output production structure. Domestically produced goods and services are produced at home but used only as intermediate inputs to the production of composite goods and services. We use the superscript D to distinguish them from other commodities for this reason. Throughout this section we use the subscript $j \in \{g, s, c\}$ to index goods, services and construction. Construction is used an as intermediate input to production of all three domestic commodities as well as investment. Imported goods are used solely as inputs in composite goods production; imported services are used analogously. The composite traded commodities have both intermediate and final uses. They are used as inputs to production of domestic commodities and investment, for consumption by domestic households, and for exports. Composite goods are traded more heavily than composite services. Finally, investment is used by households to augment the economy's capital stock. In what follows we provide a detailed description of production of each type of commodity.

Domestic commodity j is produced using capital k_{jt} and labor ℓ_{jt}, along with intermediate inputs of composite traded goods z_{gjt}, composite services z_{sjt} and construction z_{cjt} according to the production technology

$$(1) \qquad y_{jt}^{D} = \min\left[z_{gjt} / a_{gj}, z_{sjt} / a_{sj}, z_{cjt} / a_{cj}, A_j k_{jt}^{\alpha_j} \left(\gamma^t \ell_{jt}\right)^{1-\alpha_j} \right], \quad j \in \{g, s\}.$$

Construction is produced using the same kind of technology. The Leontief structure of these production functions is consistent with SOME REFERENCE TO APPLIED GE LITERATURE. The parameters (a_{gj}, a_{sj}, a_{cj}) govern the share of intermediates in production of commodity j. Here, the first subscript denotes the input source sector and the second one the destination. We assume that the growth rate $\gamma - 1$ of labor-augmenting productivity is the same in all three sectors for now, although we relax this assumption in section 6. Producers of domestic commodity j choose inputs to minimize costs, which implies the following marginal product pricing conditions:

$$(2) \qquad \begin{aligned} r_{Kt} &= \left(p^{D}{}_{jt} - a_{gj} p_{gt} - a_{sj} p_{st} - a_{cj} p_{ct} \right) \alpha_j A_j k_{jt}^{\alpha_j - 1} \left(\gamma^t \ell_{jt} \right)^{1-\alpha_j} \\ w_t &= \left(p^{D}{}_{jt} - a_{gj} p_{gt}^{T} - a_{sj} p_{st}^{T} - a_{cj} p_{ct} \right) \gamma^t (1-\alpha_j) A_j k_{jt}^{\alpha_j} \left(\gamma^t \ell_{jt} \right)^{-\alpha_j} \end{aligned}$$

Perfect competition and constant returns to scale imply that domestic commodity producers earn zero profits in equilibrium:

$$(3) \qquad p_{jt}^{D} y_{jt}^{D} - r_{kt} k_{jt} - w_t \ell_{jt} - p_{gt} z_{ct} - p_{st} z_{st} - p_{ct} z_{ct} = 0 .$$

Again, similar conditions hold for construction producers without D superscripts.

Composite traded commodity j is made up of imports m_{jt} and of the domestically produced analogue x_{jt}^{D} (composite goods use domestic goods and similar for services) according to a standard Armington aggregator production function:

$$(4) \qquad y_{jt} = M_j \left(\mu_j (x_{jt}^{D})^{\zeta_j} + (1-\mu_j)(m_{jt})^{\zeta_j} \right)^{\frac{1}{\zeta_j}}, \quad j \in \{g, s\}.$$

The parameter μ_j governs the share of imports in production and $1/(1-\zeta_j)$ is the elasticity of substitution between domestically produced traded goods and imports. We allow for these elasticities to differ for goods and services to capture the above observation that the services trade balance is less volatile than the goods trade balance. The imported good is the numeraire in this model so without loss of generality we normalize its price to unity: $p_{gt}^{m} = 1$. We assume that the United States has no effect on the price of imported goods and services and takes the relative price of imported services p_{st}^{m} as exogenous. Perfect competition implies that composite traded producers earn zero profits, so the price of the composite j is given by

$$(5) \qquad p_{jt} = M_j^{-1} \left(\mu_j^{\frac{1}{1-\zeta_j}} \left(p_{jt}^{D} \right)^{\frac{-\zeta_j}{1-\zeta_j}} + \left(1-\mu_j\right)^{\frac{1}{1-\zeta_j}} \right)^{\frac{1-\zeta_j}{-\zeta_j}}, \quad j \in \{g, s\}.$$

In our calibration we allow the share parameters in the initial period, μ_{j1992}, to vary from our calibrated long-term shares in order to match the initial level of imports.

The investment good is produced using composite traded goods z_{gIt}, composite traded services z_{sIt}, and construction z_{cIt} using a Cobb-Douglas technology:

$$(6) \qquad y_t^{I} = G z_{gIt}^{\theta_g} z_{sIt}^{\theta_s} z_{cIt}^{\theta_c}, \quad \theta_g + \theta_s + \theta_c = 1.$$

The price of investment is denoted by q_t. Our choice of a Cobb-Douglas technology implies that the elasticity of substitution between inputs to investment production is one. This is consistent with empirical evidence reported by Bems (2008), who shows that expenditure shares on investment inputs are approximately constant over time across a range of countries.

The United States is a semi-small open economy in the sense that demand for its exports is not perfectly elastic. Foreign demand for composite traded commodity k is

(7) $$x_{jFt} = D_{jt} p_{jt}^{-\frac{1}{1-\zeta_j}}, \quad j \in \{g, s\}.$$

The scale factors D_{jt} grow over time as foreign demand for the United States' exports grows over time due to population growth and technological progress in the rest of the world. The real exchange rate is calculated as

(8) $$RER_t = NER_t \frac{p_{world,t}}{p_{us,t}} ,$$

where NER_t is the nominal exchange rate, and $p_{world,t}$ and $p_{us,t}$ are the aggregate consumer price indices for the world (details in section 4) and the United States respectively.

Households

The economy is populated by a continuum of identical households. We draw a distinction between the total and working age populations as these two groups grow at different rates. We denote the total population by $\tilde{n}_t$ and the working age population by $\overline{\ell}_t$. We evaluate consumption per capita on an adult-equivalent basis by defining the adult-equivalent population as

(9) $$n_t = \overline{\ell}_t + (\tilde{n}_t - \overline{\ell}_t)/2 .$$

We normalize the amount of time available for work and leisure by working age person to be one and denote the total labor supply by ℓ_t. Households choose labor supply, consumption of composite goods and services, c_{gt} and c_{st}, investment i_t, and bond holdings b_t, to maximize expected utility

(10) $$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\left(\varepsilon \left(\frac{c_{gt}}{n_t} \right)^{\rho} + (1-\varepsilon) \left(\frac{c_{st}}{n_t} \right)^{\rho} \right)^{\frac{\eta\psi}{\rho}} \left(\frac{\overline{\ell}_t - \ell_t}{\overline{\ell}_t} \right)^{(1-\eta)\psi} - 1 \right) / \psi \right]$$

subject to the budget constraints

(11) $$p_{gt}c_{gt} + p_{st}c_{st} + q_t i_t + b_{t+1} = w_t \ell_t + (1+r_t^*)b_t + (1-\tau_k)r_{kt}k_t - T_t ,$$

the law of motion for capital

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

the appropriate non-negativity constraints, initial conditions for the capital stock and bond holdings, $\bar{k}_{1992}$ and $\bar{b}_{1992}$, and a constraint on bond holdings that rules out Ponzi schemes but does not otherwise bind in equilibrium.

Bonds are denominated in units of imported goods, which implies that a real exchange rate depreciation makes them more expensive in units of consumption. Households pay constant proportional taxes τ_k on capital income and a lump-sum tax or transfer T_t. We use the capital income tax to obtain a sensible calibration for the initial capital stock and depreciation rate. In our calibration we also allow the tax rate on capital income in 1993, τ_{k1993}, to differ from the constant rate τ_k in order to match level of investment in 1992. The United States takes the world real interest rate r_t^* as given. As mentioned above, in the general model we allow for the real interest rate to be stochastic. The first-order conditions for b_t and k_t imply the no-arbitrage condition

(13) $$\mathbb{E}_t\left[1+r_{t+1}^*\right] = \mathbb{E}_t\left[\left((1-\tau_k)r_{kt+1} + q_{t+1}(1-\delta)\right)/\, q_t\right],$$

which says that the expected return on investing in bonds must equal the expected return on investing in an additional unit of capital. During the sudden stop episode that occurs in 2017 private bond holdings are fixed and the internal real interest rate is determined endogenously.

Government

The government of the United States in the model levies taxes and sells bonds in order to finance exogenously required government consumption of composite goods and services, G_{gt} and G_{st}. The government's budget constraint is

(14) $$p_{gt}G_{gt} + p_{st}G_{st} - r_t^* B_t = \tau_k r_{kt} k_t + T_t + B_t - B_{t+1}.$$

In the event that consumption expenditures $p_{gt}G_{gt} + p_{st}G_{st}$ and interest payments $r_t B_t$ exceed tax revenues $\tau_k r_{kt} k_t + T_t$, the government must sell bonds, i.e., $B_t - B_{t+1}$ must be positive.

Government consumption expenditures and debt are exogenous in our model. We specify parameters for the time paths for the government consumption expenditures and debt as fractions of GDP, matching the data for 1992-2010 and using projections from the Congressional Budget Office for the future, and allow the lump-sum tax T_t to vary as necessary to ensure that the government's budget constraint is satisfied. Formally, let $\{\nu_t, \upsilon_t\}_{t=0}^{\infty}$ denote the fractions of nominal GDP in each period t that government consumption expenditures and debt must equal respectively. Then, given prices $\{p_{gt}, p_{st}\}_{t=0}^{\infty}$, we require that

(15) $$p_{gt}G_{gt} + p_{st}G_{st} = \nu_t GDP_t$$

and

(16) $$B_t = \upsilon_t GDP_t.$$

In this setup we must specify the degree to which the government can substitute goods for services. We remain neutral and set the government's elasticity of substitution between goods and services to one. The government therefore chooses G_{gt} and G_{st} to maximize

(17) $$G_{gt}^{\varepsilon_G} G_{st}^{1-\varepsilon_G}$$

subject to (15). In our baseline model we assume that government spending does not enter the household's utility function (or equivalently, it enters in a separable fashion), nor does it enter any of the production functions.

The fact that the tax rate on capital income does not vary over time means that a version of Ricardian equivalence holds in our model. Formally, suppose that $\{X_t, b_t, G_{gt}, G_{st}, B_t, T_t\}_{t=0}^{\infty}$ is an equilibrium (defined explicitly below) in our model given a sequence of interest rates $\{r_t^*\}_{t=0}^{\infty}$, where X_t represents all non-government equilibrium objects other than private bond-holdings. Then for any $\{\tilde{B}_t\}_{t=0}^{\infty}$ there exists $\{\tilde{b}_t, \tilde{T}_t\}_{t=0}^{\infty}$ such that $\{X_t, \tilde{b}_t, G_{gt}, G_{st}, \tilde{B}_t, \tilde{T}_t\}_{t=0}^{\infty}$ is also an equilibrium. In other words, the decomposition of total debt into public and private components is indeterminate. This result would not hold if changes in government debt were accompanied by changes in distortionary taxes. We leave this kind of exercise for future work. Unlike government debt, government spending does have an impact on other model quantities. We assume that expectations about time path for government spending change when the savings glut starts. This change does not play a large quantitative role in our results, but we provide a sensitivity analysis in which we keep government expenditures fixed as a percentage of GDP throughout our scenarios in section 6.

Market clearing and equilibrium

In equilibrium, all production of domestic goods and services must be used by the producers of composite goods and services. Hence

(18) $$x_{jt}^D = y_{jt}^D, \quad j \in \{g, s\}$$

Construction is not traded or used for consumption by households or governments, so the market clearing condition for construction is

(19) $$z_{c1t} + z_{c2t} + z_{c3t} + z_{cIt} = y_{ct}.$$

Market clearing for investment is

(20) $$i_t = y_t^I.$$

The market clearing conditions for composite goods and services are

(21) $$c_{jt} + G_{jt} + x_{jFt} + z_{jgt} + z_{jst} + z_{jct} + z_{jIt} = y_{jt}, \quad j \in \{g, s\}$$

Factor markets must also clear:

(22) $$k_{gt} + k_{st} + k_{ct} = k_t$$

(23) $$\ell_{gt} + \ell_{st} + \ell_{ct} \, .$$

The balance of payments condition is

(24) $$m_{gt} + p_{st}^{m} m_{st} + b_{t+1} + B_{t+1} = p_{gt} x_{gFt} + p_{st} x_{sFt} + (1 + r_t)(b_t + B_t) \, .$$

Loosely, an equilibrium in our model for a given path of interest rates and policy parameters $\{r_t^*, \nu_t, \upsilon_t\}_{t=0}^{\infty}$ and initial conditions $\left(\bar{b}_0, \bar{B}_0, \bar{k}_0\right)$ consists of sequences of model variables such that households maximize their expected utility subject to their constraint set, prices and quantities satisfy marginal product pricing conditions for all 8 commodities, exports are given by export demand functions, all domestic commodity and factor markets clear, the government's objective and budget constraint are satisfied, and the balance of payments condition holds. Model agents usually have perfect foresight in our model, but we allow for uncertainty about interest rates in a finite number of periods during our savings glut scenario. While we are only interested in the results for a particular realized interest rate path, our notion of equilibrium is more precisely defined as sequences of model variables *for every possible history of interest rate realizations* such that all the relevant conditions are satisfied. Since there is a finite number of periods with uncertainty there is also a finite number of possible histories. We describe the nature of the uncertainty in our model in more detail on section 6 when we discuss our second quantitative exercise. We describe our computational approach in the appendix.

4. Outline of our quantitative strategy

Before we proceed with our calibration and quantitative exercises, we pause for a moment to briefly describe our overall quantitative strategy. We perform three main exercises: calibration, a comparison of the model's ability to capture the key facts about the savings glut listed above, and an analysis of the model's predictions about the short- and long-run dynamics of the U.S. economy following the end of the savings glut. These exercises build upon each other in an iterative process and we think it's appropriate to provide the reader with a broad view of how this process works before describing each of our exercises in detail.

Our first step is to calibrate the model's parameters and initial conditions so that the equilibrium in which neither the savings glut nor sudden stop occur replicates the benchmark input-output matrix and other relevant data for 1992. To be precise, we construct an equilibrium in which the real interest rate matches the data through 1997 and then falls gradually to our long-run rate of 3 percent over time. Figure 4 provides a graphical depiction of agents' expectations about the real interest rate in this exercise. Note that this is by definition a counterfactual exercise; the real interest rate did not actually take this path. We feel, however, that our assumption that agents did not foresee the savings glut in 1992 is entirely appropriate. LOOK AT CBO PROJECTIONS.

After calibrating the model we proceed to our second step, an assessment of the model's ability to capture the key facts discussed in the introduction. In this step we construct a second equilibrium. Our equilibrium in this step matches the one constructed in the previous step from 1992 through 1997. In 1998, the savings glut begins unexpectedly, and our model agents revise their expectations about the path the real interest rate will take in the future. They do not, however, have perfect foresight at this point. In each year between 1999 and 2009 there is uncertainty about the path the real interest rate will take. Between 1999 and 2008, there is a chance that the savings glut will end early, and the real interest rate will quickly rise to 3 percent. In 2009, if the savings glut is still in effect, there is a chance of a temporary spike in the real interest rate. By 2010 all uncertainty is resolved and agents have perfect foresight thereafter, and expect the savings glut to end gradually, with the real interest rate rising to 3 percent by 2050. The realized interest rate path matches the data through 2010. We provide more detail on the nature of the uncertainty in this exercise in section 6. At this point we wish to stress, however, that while the realized ex-post interest rate in our model matches the data, the ex-ante real interest rate in our model does not due to the presence of uncertainty.

Our third exercise is an analysis of the short-and long-run consequences of the end of the savings glut in three scenarios. We call this first scenario "gradual rebalancing." In this scenario the real interest rate rises gradually over time, just as agents expect after 2010 in the previous exercise. Our second scenario is an "orderly sudden stop" in which agents are restricted from borrowing for one period and the real interest rate moves quickly to 3 percent after rising temporarily. This is an entirely unanticipated event, but there are no other exogenous shocks. Our final scenario is a "disorderly sudden stop" in which total factor productivity falls by 10 percent when the sudden stop hits and recovers quickly thereafter. This scenario is intended to capture the fact that TFP typically has fallen during most sudden stops in the past, especially those that have occurred in emerging economies. Our model is not equipped to explain the relationship between sudden stops and TFP so we treat this as an additional unanticipated shock.

5. Calibration

In the spirit of multisector, static applied general equilibrium models like Kehoe and Kehoe (1994), we calibrate many of the model's parameters so that the equilibrium in 1992 of the model without a savings glut or sudden stop replicates the input-output matrix for that same year published by the Bureau of Economic Analysis. The dynamic nature of the model and the fact that the economy is open to capital flows introduce several other crucial elements to our calibration. The time paths for the real interest rate r_t and government policy (ν_t, υ_t) are central drivers of our results. The time paths for population demographics also play an important role, particularly the growth rate of the working age population $\overline{\ell}_t$ and adult equivalent population n_t in the United States relative to the growth rate of trade partners' populations captured by D_{kt}. We summarize the baseline model's calibration in table 2.

Production parameters

We compute the parameters in the production functions for the domestic commodities using data in the input-output matrix in table 1. We normalize quantity units so that GDP is equal to 100 and all prices in the model are equal to one in 1992. This means that all 1992 quantities are expressed as percentages of 1992 GDP.

We calibrate the parameters of the other production functions so that the quantities in the input-output matrix satisfy the relevant equilibrium conditions. For example, take the production for the investment good (6). The first-order conditions for cost minimization imply that

$$(25) \qquad \frac{p^T_{1,1992}}{p^T_{2,1992}} = \frac{\gamma_1 z^T_{2I,1992}}{\gamma_2 z^T_{1I,1992}}, \quad \frac{p^T_{1,1992}}{p^D_{3,1992}} = \frac{\gamma_1 z^D_{3I,1992}}{\gamma_3 z^T_{1I,1992}}$$

(commas inserted to make subscripts more readable in this case). Since we normalize all 1992 prices to one, we plug in the values $z_{gI,1992} = 7.03$, $z_{sI,1992} = 1.84$, and $z_{cI,1992} = 8.29$ to get $(\theta_g, \theta_s, \theta_c) = (0.410, 0.107, 0.483)$. We then calculate the scale factor G as

(26) $$G = \frac{y_{I1992}}{z_{gI1992}^{\theta_g} z_{cI1992}^{\theta_c} z_{cI1992}^{\theta_c}} = 2.60 .$$

To calibrate the Armington aggregators (5) we must choose the elasticities of substitution between imports and domestic traded goods and services, $1/(1-\zeta_j)$. There is some debate over this elasticity as business cycle models tend to imply low elasticities while analysis of trade policy changes often suggest much higher elasticities (see Ruhl (2008) for a detailed discussion). As in Kehoe and Ruhl (2009), we set the goods Armington elasticity to 2. We set the services Armington elascity to 1.5 to reflect the observation above that the services trade balance is less volatile. Both of these values, however, are within the range of values commonly used in the international business cycles literature. In order to simultaneously match the import data in our input-output table and the 1992 balance of payments, we allow the domestic shares in the Armington aggregators in 1992, μ_{j1992} , to differ from the values employed in the remaining periods, μ . The first-order conditions for profit maximization in 1992 imply that

(27) $$\frac{\mu_{j1992}}{1-\mu_{j1992}} = p_{j1992}^{D} \left(\frac{m_{j1992}}{x_{j1992}^{D}} \right)^{\zeta_j - 1} .$$

Since we normalize the all 1992 prices to one, we obtain μ_{j1992} using input-output data on imports m_{j1992} and domestic inputs of goods and services x_{j1992}^{D}. We choose the scale factors M_j so that output y_{j1992} of composite goods and services also match the input-output table using the same method employed in (26).

We choose the growth rate of labor-augmenting productivity $\gamma - 1$ to be two percent. This is the average growth rate of GDP per working age person in the United States during the twentieth century, and Kehoe and Prescott (2007) argue that this is the growth rate implied by technological progress. We set $r_{1992}^{*} = 0.04$, by subtracting the growth rate of the CPI from the yield on 20-year Treasury bonds. Depreciation was 11.7 percent of GDP in 1992, so given a tax rate on capital income τ_k we can then calibrate the initial capital stock as

(28) $$k_{1992} = \frac{(1-\tau_k) r_{k1992} k_{1992} - \delta k_{1992}}{r_{1992}} = \frac{(1-\tau_k)36.0 - 11.7}{0.04}.$$

We then calibrate the depreciation rate as

(29) $$\delta = \frac{11.7}{k_{1992}}.$$

We choose the tax rate τ_k so that $\delta = 0.05$, which implies an initial capital stock of $k_{1992} = 234.0$.

Household parameters

We set the elasticity of intertemporal substitution $1/(1-\psi) = 0.5$. We set the long-run world interest rate r_∞^* to be 3%. We require this rate to be consistent with balanced growth, which implies that the discount factor is $\beta = g^{1-\psi}/(1+r_\infty^*) = 0.996$. We set the elasticity of substitution between traded and nontraded goods in consumption as $1/(1-\rho)$ =0.5. The first-order conditions of the household's problem yield

(30) $$\frac{\varepsilon}{1-\varepsilon} = \frac{p_{g,1992}}{p_{s,1992}} \left(\frac{c_{g,1992}}{c_{s,1992}} \right)^{1-\rho},$$

which we use to calibrate $\varepsilon = 0.060$. We then calibrate $\eta = 0.292$ using data on hours worked.

The United States was open to international capital flows in 1992, and ran a capital account surplus of 0.81% of GDP. We calibrate the initial private stock of bonds $\bar{b}_{1992}$ so that the model replicates this statistic, taking as given the path of government debt implied by $\{\upsilon_t\}_{t=0}^{\infty}$. In order to match the level of investment in 1992 in the input-output table, we allow the tax rate on capital income in 1993 to vary from the constant rate τ_k obtained above. Because we need to calibrate these parameters dynamically while simultaneously solving for the model's equilibrium, we re-calibrate them when we perform numerical experiments that vary from our baseline model.

Exogenous processes

We take population growth rates of the United States' working age and total populations $\bar{\ell}_t$ and $\tilde{n}_t$ from the 2010 annual report of the board of trustees of the United States Social Security Administration, which provides historical data for 1992-2010 as well as projections about future growth rates. To obtain series for the export demand parameters D_{jt}, we obtain historical population data and projections for the United States' top 15 export partners from the United Nations Economics and Social Affairs division's World Population Prospects report. We then construct an average growth rate series using export shares as weights. We use a similar procedure to construct a series for the relative price of traded commodities in the rest of the world to calculate real exchange rates in the model. We take a weighted average of the PPI/CPI ratio[4] for the United States' top trade partners for the period 1992-2010 from the IMF's International Financial Statistics dataset, then extrapolate linearly to obtain future projections. Note that this series plays no role in the model; its only use is in comparison of the model's results with the data.

We construct our real interest rate series by subtracting the CPI growth rate from yields on 20-year Treasury bonds. This gives us data for 1992-2010. In 1992, the real interest rate was 4%. For our initial scenario in which neither the savings glut nor sudden stop not occur, we assume that the interest rate gradually reverts downward to the long-run rate of 3% over the following 15 years. In the model with the savings glut, we assume that the real interest rate matches the data for 1992-2010, after which it gradually reverts upward to 3%. In the third scenario with the sudden stop, we assume that the interest rate departs from the savings glut scenario when the sudden stop occurs in 2017 and rises to 5%, then quickly drop back down to 3%. Figure 3 plots the real interest rate in each of these three scenarios, along with the 1992-2010 data.

We take a similar approach to the government policy parameters $\{\nu_t, \upsilon_t\}_{t=0}^{\infty}$. In 1992, government expenditures were 19.31% of GDP and government debt was 48.06% of GDP. In the

[4] Ideally, we would use sectoral gross output deflators to construct tradable and overall price levels for each of our trade partners. We are unable to obtain the sector-level gross output data necessary to do so for China and Canada, two of our most important trade partners. Consumer and producer price indices are the next-best option. See Kehoe and Betts (2008) and Kehoe and Betts (2006) for detailed discussion.

initial scenario without savings glut or sudden stop, we assume that government spending will remain constant as a fraction of GDP, while government debt will rise slowly to 60% of GDP. We base our projections for government debt in this scenario on testimony by the director of the Congressional Budget Office to Congress in June, 1992. In the scenario in which the savings glut occurs but the sudden stop does not, we assume that both government debt and spending as fractions of GDP match the data for 1992-2010, after which they match projections published by the CBO in 2010. Finally, in the scenario with the sudden stop, government policy follows the savings glut scenario until 2017, after which we assume that government debt as a fraction of GDP quickly falls to 45% while spending remains constant. Figure 4 plots the paths of government debt as a fraction of GDP for these three scenarios.

6. Quantitative exercise: the savings glut

Having calibrated our model we move on to an assessment of our model's ability to capture the key facts about the savings glut discussed in section 1. Before presenting our results, however, we provide the details of the stochastic nature of our exercise.

Stochastic real interest rates

As stated above, our equilibrium with a savings glut matches the equilibrium constructed in our calibration between 1992 and 1997, after which time model agents expect the real interest rate to move smoothly towards 3 percent as in figure 4. In 1998, the savings glut begins unexpectedly. Initially, agents are uncertain about the path the real interest rate will take in the future. In 1998, there is a 10 percent chance that the savings glut will end in 1999 and the interest rate will quickly rise to 3 percent in a deterministic fashion afterwards. The other 90 percent of the time, the interest rate will continue to fall for at least one additional year, matching the ex-post real interest rate data in figure 1. If the savings glut is still in effect in 1999, there is a similar ten percent chance that the savings glut will end early in 2000. This same pattern repeats until 2008. If the savings glut is still in effect at that time, there is a 10 percent chance that the real interest rate will temporarily spike for one year due to deflation caused by a financial crisis. The other 90 percent of the time, agents expect that the interest rate will stay low. Regardless of whether the financial crisis occurs, the real interest rate will be low in 2010 and there is no more uncertainty; the real interest rate will rise slowly to 3 percent over the next few decades as the factors driving the savings glut peter out.

The realized interest rate path that we feed into the model matches the data, including the temporary spike during the savings glut. However, this isn't the most likely path from agents' perspective in 1998. Figure 5 illustrates this point. Each period during the savings glut until 2008 there is a 90 percent chance that the savings glut continues, but in 2008 agents think it more likely that the financial crisis will not occur. The temporary high ex-post real interest rate during the financial crisis is therefore viewed by model agents as an unlikely event, which implies that the model agents expect the real interest rate in 2009 to be much lower. The unconditionally most probably path from the perspective of model agents in 1998 is that the savings glut will continue through 2010 but the financial crisis will not occur. Figure 6 illustrates this point another way by plotting the realized path (i.e. the actual data) in green alongside all of the other possible paths the interest rate could take, which are plotted in grey.

The structure of the uncertainty in our model is crucial to retaining tractability. In particular, the fact that there is no remaining uncertainty following an early exit to the savings glut between 1999 and 2008 implies that while there are 11 years in which agents are uncertain about the future (1998—2008), there are only 12 possible paths the real interest rate could take. As a consequence, the curse of dimensionality is not an obstacle to solving our model. In the appendix we provide details of our computational approach.

Results: the key facts

Now that we've explained the details of our exercise we move on to our results. As mentioned in the introduction, the purpose of this exercise is to show that the model captures the important effects of the savings glut on the U.S. economy – distilled into the three key facts presented in section 1 – so that we can be confident in its predictions about what will happen when the savings glut ends. We begin with the trade balance. Figure 7 plots the trade balance in the model and the data between 1992 and 2010. The model closely matches the data throughout the period, including the recovery after the financial crisis. The trade deficit grows slightly faster in the model during the first part of the period, but this is counteracted by the fact that the peak trade deficit in the model, which occurs at almost exactly the same time as in the data, is slightly lower. As a consequence, we match the total amount of capital flowing into the United States during the period almost exactly. In our opinion this is the most important part of this exercise;

the amount of debt the United States must service in the long run directly affects the size of long-run trade surplus and the extent of sectoral reallocations.

Figure 8 plots the disaggregated trade balances for goods and services in the model and the data for the same 1992—2010 period. We match both balances closely, just as we do the aggregate trade balance. In both the model and the data, the goods trade balance drives the aggregate trade balance dynamics. The goods trade deficit rises to 7.5 percent of GDP in the data (6.75 percent of GDP in the model) by 2006, while the services trade surplus hovers around 2 percent of GDP in the model and data throughout the period. The fact that we match the key facts about sector-level trade balances as well as the aggregate trade balance means that our model is well-equipped to speak to the effects of the savings glut (and its eventual end) on the allocation of resources across sectors in the U.S. economy.

Figure 9 plots the real exchange rate in the model and data for the savings glut period. Our model matches exactly the maximum level of depreciation during the period, although it takes several years longer to reach it in the model as compared to the data. We also capture the fact that the real exchange rate starts to appreciate again in the latter part of the period.

Results: sectoral reallocation

We believe that the degree to which our model matches the three key facts above indicates that we have successfully explained the important direct effects of the savings glut on the U.S. economy. One of our main emphases in this paper is the effect of the savings glut on the allocation of resource across sectors. We do not believe that the savings glut alone is responsible for all sectoral reallocation we observe during this period. There are other prominent factors driving reallocation reallocation like structural change. While our model does not match the degree to which resources shifted across sectors during this period, it does match the qualitative patterns. We capture the boom in construction employment particularly well. In the data, construction employment rose more than 60 percent during the period before crashing after the financial crisis. In the model, construction employment rose by almost 40 percent by 2008 and fell following the crisis, just as in the data. The large increase in construction employment is driven by two main forces. First, construction is the only purely nontraded sector in our model. The fact that capital inflows cause reallocation towards nontraded sectors is well-known in the literature (see, for example, Fernández de Córdoba and Kehoe, 2000). Second, construction is used almost entirely for investment, and the low interest rates during the savings glut caused a surge in investment. We also capture the fact that services employment rose at roughly the same rate as total employment. While goods employment falls to a degree at the onset of the savings glut in our model, it does not fall nearly as much as in the data.

Our interpretation of these results is that our model captures the degree to which the savings glut effected the allocation of resources across sectors. In the next section we study how the end of the savings glut (and the way in which it ends) affects reallocation across sectors. In section 8 we explore an extension to our model in which we incorporate structural change by relaxing the assumption that labor productivity grows at the same rate in all three sectors. We find that this helps the model capture sectoral reallocation dynamics during the period and also has large consequences for reallocation following the end of the savings glut.

7. Quantitative exercise: scenarios for the end of the savings glut

Now that we've shown that our model is consistent with the key facts about the effects of the savings glut on the U.S. economy, we move on to analyze the model's predictions about the effects of the end of the savings glut. We consider three possible scenarios in which the savings glut ends. In the first, which we call "gradual rebalancing," the real interest rate rises slowly over time to 3 percent after 2010, following the same path that agents in our model expect at this point time as shown in figure 6. This scenario is intended to capture the possibility that the factors that drive the savings glut gradually die out over the next few decades, causing world demand for saving to fall and real interest rates to rise in a steady manner.

In the second scenario, which we call an "orderly sudden stop," two unexpected events occur in 2017: the U.S. is unexpectedly restricted from borrowing for one year, and the real interest rate path shifts upward. This scenario is intended to capture the possibility of a sudden halt in lending by foreigners that is not accompanied by a significant contraction in output. PUT IN AN EXAMPLE. ARE THE ERM SUDDEN STOPS THE BEST ONE?

The third scenario, which we call a "disorderly sudden stop," we add a temporary 10 percent TFP shock in addition to the borrowing constraint and change in the interest rate path. The purpose of this scenario is to capture the fact that sudden stops in the past were often accompanied by large TFP-driven contractions in output. For example, Meza and Quintin (2007) document that TFP fell by 10 percent on average during five recent sudden stop episodes in Latin America and Asia. It is well known that standard models are ill-equipped to generate endogenous TFP movements during sudden stops like those in the data (Chari at al., 2005), so we follow previous studies like Mendoza (2010) and Kehoe and Ruhl (2009) in imposing an exogenous TFP shock. The nature of the causal link between sudden stops and productivity is an interesting issue and is not yet settled in the literature, but this is beyond the scope of our study.

Results: key fact variables after the savings glut

Figure 10 shows the real interest rate paths in the three different scenarios, alongside the 1992—2011 data and agents' expectations in the counterfactual scenario in which the savings glut never occurs. We plot the interest rate paths out to 2050 to illustrate how long it takes to converge to the long-run rate of 3 percent in the gradual rebalancing scenario. In the two sudden stop scenarios the real interest rate spikes temporarily, to 10 percent and 17 percent in orderly and disorderly sudden stops, respectively, before quickly settling to 3 percent. These spikes are endogenous outcomes of the model; when the United States is restricted from borrowing in 2017, the arbitrage condition (13) no longer holds and the 2018 real interest rate is pinned down by the domestic marginal product of capital. That the real interest rate rises more during the disorderly sudden stop reflects the fact that households have a stronger desire to borrow against future income to smooth consumption.

Figure 11 shows the aggregate trade balances in the three scenarios. In the absence of a sudden stop, our model predicts that the trade balance will turn positive in 2021, and will continue to rise, settling around 1.5 percent of GDP by 2035. We want to emphasize that our model predicts that the United States will run a trade surplus in the long-run. Once capital stops flowing into the United States it must run a trade surplus to service the large external debt it has accumulated. If a sudden stop occurs, the trade balance will reverse on impact, rising from -1.13 percent of GDP to 3.3 percent or 5.17 percent, depending on whether the sudden stop is accompanied by a fall in TFP. The larger reversal in the disorderly sudden stop is due to the fact that imports fall more due to the drop in domestic income. By 2035, the trade balance reaches a similar level regardless of whether the sudden stop occurs. In other words, a sudden stop has a small long-run impact on aggregate trade balance dynamics.

Figure 12 shows the disaggregated trade balances for goods and services in the three scenarios. In the long run, both goods and services trade balances rise relative to both their bottoms during the savings glut and their 1992 starting points. The goods trade balance, however, remains negative, at around -2 percent of GDP in 2035. The services trade balance grows to about +3 percent of GDP. This implies that the services sector, not the goods sector, is the primary source of the net exports used to service debt in the long run. This result suggests that it is important to take services' tradability seriously, especially for countries like the United States in which services are more export-oriented than goods. In section 8 we study the importance of this feature of our model for long-run reallocation of resources across sectors.

Figure 13 shows the real exchange rate in the savings glut exit scenarios. Our model predicts that by 2035, the real exchange rate will depreciate by almost 40 percent relative to its bottom during the savings glut. The increase in exports needed to service the U.S. external debt in the long run pushes down export prices due to foreigners' downward-sloping demand for U.S. exports. General equilibrium effects push the overall price U.S. price level down, causing the real exchange rate to rise. If a sudden stop occurs, there will be a sharp depreciation on impact: 17.6 percent in an orderly sudden stop and 18.8 percent in a disorderly one. Figure 14 shows real GDP in the three scenarios between 2016 and 2025. We include this figure to make the simple point that while a disorderly sudden stop will cause a significant contraction in output in the short term, these effects dissipate quickly. This result depends, however, on our assumption that TFP will recover quickly. This assumption is consistent with the experiences of countries that have had sudden stops accompanied by large TFP drops as documented by Meza and Quintin (2007) and Calvo et al. (2006), but a longer-lasting TFP shock would cause longer-lasting economic pain.

Results: sectoral reallocation

Our model indicates that the low real interest rates during the past two decade explain part of the changes in resource allocation across sectors during this period. The end of the savings glut also has implications for sectoral reallocation, since the United States must shift production towards traded commodities in order to service its debt in the long run, which implies a shift away from nontraded sectors. Our model's realistic production structure makes it well-suited to study these effects.

Figures 15 through 17 plot the shares of total employment in the goods, services and construction sectors between 1992 and 2035 in our three savings glut exit scenarios. Employment in the goods sector rises in the long run, consistent with the fact that the goods trade balance rises as well. From its low of 20 percent of total employment, the model predicts that the goods sector's employment share will rise to 22 percent by 2035. The services employment share falls by around 2 percent over the period, while the construction employment share falls from its peak during the savings glut and returns to its 1992 level of around 5 percent. SOME MORE COMMENTARY.

If a sudden stop occurs, the shift in employment towards the goods sector will occur much more rapidly. This reallocation towards goods is a typical feature of past sudden stops as documented by Kehoe and Ruhl (2009). A disorderly sudden stop lowers the level of immediate reallocation due to the fact that goods are used disproportionately as intermediate inputs; a TFP shock lowers demand for intermediates in all three sectors The construction sector is hit hard by a sudden stop, and more so by a disorderly one. This is due primarily to the fact that construction is used almost entirely to produce investment goods, and the spike in real interest rates that accompanies a sudden stop causes investment to crash. Once the real interest rate falls, construction employment immediately recovers. An orderly sudden stop has little effect on the services sector, while a disorderly one causes a temporary jump in the services employment share. The services sector is not hit as hard by the drop in intermediate demand caused by a TFP shock as the goods sector, so most of the displaced construction employment shifts to services. The sudden and large shifts in employment across sectors triggered by a sudden stop in our model result from our assumption that reallocation is costless. In section 8 we explore an extension of our model with costly labor adjustment.

8. Extensions

In this section we present three extensions of our model. First, we allow for labor productivity growth rates to differ across sectors to study how this affects the model's ability to capture employment share dynamics during the savings glut and the implications for reallocation in the long run. Second, we study a version of the model with labor adjustment frictions to assess their impact on the reallocation effects of a sudden stop. Finally, we construct a version of our model in which services are not traded to illustrate the importance of our accurate treatment of the services sector for long-run reallocation across sectors.

Structural change

Our model predicts that when the savings glut occurs, the employment share in the goods sector will fall by around one percent, and then rise gradually once the savings glut ends. This paints a rosy picture for the future of employment in the goods-producing industries like manufacturing. In the model, the logic behind this result is clear: the U.S. must export more in the long run to pay off the debt incurred during the savings glut, and since goods are the most traded sector, goods production as a share of GDP must rise in the long run. This only implies an upward trend in the goods employment share under our assumption that labor productivity grows in all sectors at the same rate. Drawing from the literature on structural change, we now ask: how do our model's results change when we allow for labor productivity in the goods sector to grow faster than in the services sector?

In this specification, the production functions are now

(31) $$y_{jt}^{D} = \min\left[z_{gjt} / a_{gj}, z_{sjt} / a_{sj}, z_{cjt} / a_{cj}, A_j k_{jt}^{\alpha_j} \left(\tilde{\gamma}_{jt} \ell_{jt} \right)^{1-\alpha_j} \right]$$

We assume that $\tilde{\gamma}_{g,1993} / \tilde{\gamma}_{g,1992} = 1.03$ and $\tilde{\gamma}_{s,1993} / \tilde{\gamma}_{s,1992} = 1.01$, and that

(32) $$\lim_{t\to\infty} \tilde{\gamma}_{gt+1} / \tilde{\gamma}_{gt} = \lim_{t\to\infty} \tilde{\gamma}_{st+1} / \tilde{\gamma}_{st} = 1.02$$

This means that the goods sector grows faster than the services sector at the beginning of the simulation, but that the two sectors grow at the same rate in the limit. For $t > 1992$, we set $\tilde{\gamma}_{jt+1} / \tilde{\gamma}_{jt} = 0.9(\tilde{\gamma}_{jt} / \tilde{\gamma}_{jt-1}) + 0.1(1.02)$ so that both sectors' growth rates converge to a tolerance of 10^{-8} after 75 years. We assume that construction productivity grows at a constant 2% rate. Because construction employs a small share of the total workforce, this last assumption has little effect on reallocation to and from goods and services. These assumptions ensure that our model still has a balanced growth path consistent with a long-term real interest rate of 3% and the discount factor calibrated above. We lengthen the simulation, allowing the model to converge to a balanced growth path after 150 years. We make these assumptions purely for tractability, and it is important to state that a perpetual difference in labor productivity growth rates across sectors would cause larger changes in results relative to our baseline model.

Figures 18 through 20 show the goods, services and construction employment shares in the baseline model and our extension with structural change. Adding structural change causes the goods employment share to fall much more during the savings glut in our model, and in the long run the goods employment share now falls relative to its initial 1992 level instead of rising. The reverse is true for services. Due to our assumption that the construction employment share grows at the average rate of 2 percent per year, structural change has very little effect on employment share dynamics in the construction sector. We also see that structural change has no effect on the consequences of a sudden stop on sectoral employment shares as compared to the gradual rebalancing scenario. Figure 21 shows that incorporating structural change has no effect on the model's ability to match the trade balance dynamics during the savings glut period, nor does it have any effect on the model's prediction about trade balance dynamics for the future. The same holds true for the dynamics of other key variables.

The goal of this exercise is to illustrate the qualitative interaction between the reallocative forces of the savings glut (and its end) and those of structural change. Our results indicate that while debt service that must follow the savings glut causes employment to shift towards the goods sector, this effect is likely to be negated by other structural change factors that will push employment away from goods. We hope this exercise motivates further research into the interactions between structural change and international payments.

Labor adjustment costs

Our baseline model makes stark predictions about the effects of a sudden stop on the allocation of labor across sectors in the United States. These results depend on our assumption that labor can be costlessly shifted across sectors, so we find it natural to ask how our results change when we relax this assumption. To model labor adjustment costs, we assume that firms lose some output if they change their employment. We employ the quadratic specification used by Sargent (1978) and Kehoe and Ruhl (2009). The production functions for domestic commodities are now

$$(33)\ y_{jt}^{D} = \min\left[z_{gjt} / a_{gj}, z_{sjt} / a_{cj}, z_{cjt} / a_{cj}, A_j k_{jt}^{\alpha_j} \left(g^t \ell_{jt} \right)^{1-\alpha_j} \right] - \gamma^t \phi \left(\frac{\ell_{jt}}{\ell_{jt-1}} - 1 \right)^2 \ell_{jt-1}, \quad j \in \{g, s, c\}.$$

To ensure that the adjustment cost plays a non-trivial role in both early and later parts of our simulations we assume that it grows at the same rate as labor productivity, $\gamma - 1$. We set $\phi = 5$. Note that this value is only two-thirds that used in Kehoe and Ruhl (2009). We choose this value to show that, as we will see below, while even a small adjustment cost has a large effect on sectoral employment dynamics, it has virtually no effect on the trade balance or international prices. This holds true for larger values of ϕ as well.

Figures 22 through 24 show the goods, services and construction shares in the baseline model and in the model with labor adjustment costs. We plot the results for the disorderly sudden stop scenario to highlight the effect of adjustment costs on the sharp reallocations the combination of a sudden stop and TFP shock causes. The figures show that adjustment costs dampen and smooth these reallocations a great deal, as well as the reallocations that occur during the savings glut. The large spike in the services sector's employment share during the disorderly sudden stop almost disappears entirely, and the crash in construction's employment share is much smaller. Adding adjustment costs to our model also has significant implications for the amount of pain that a disorderly sudden stop will cause. Figure 25 plots real GDP dynamics around a disorderly sudden stop with and without adjustment costs. In the baseline model, real GDP falls by about 5 percent. In the model with adjustment costs it falls by 7.5 percent. This result speaks directly to Bernanke's fear that reallocations induced by the end of the savings glut may impose real costs on firms and workers affected by the adjustment process.

In the long run, though, adjustment costs have very little effect on employment shares or GDP dynamics. By 2035, sectoral employment shares are almost exactly the same in the baseline model and the model with adjustment costs. To get some intuition for this result, we plot the aggregate trade balance dynamics in the baseline model and the model with adjustment costs in figure 26. We see that adjustment costs have very little effect on the trade balance during the savings glut. In other words, adding adjustment costs does not change the amount of capital that flows into the U.S. economy during this period. Adjustment costs affect trade balance dynamics during the sudden stop only moderately, as well. By 2035, the trade balance is almost exactly the same in both models. In other words, adjustment costs do not affect the amount of net exports the U.S. uses to service debt in the long run. As a consequence, the long-run effects of debt repayment on sectoral employment shares are about the same regardless of whether we model adjustment costs.

Nontraded services

In our finale extension we study how our results change if we assume that services are not tradable. We adjust our input-output table so that all imports and exports are attributed to the goods sector, then re-calibrate the model and perform the same experiments.

Figures 27 through 29 show the goods, services and construction employment shares in our baseline model and the nontraded services model. To highlight the effects of this change on long-run dynamics we plot the results for the gradual rebalancing scenario. Both the goods and services employment shares are more volatile when services are nontraded. During the savings glut, the goods employment share falls more in the nontraded services model, while the services employment share rises more. The reverse happens in the long run. When services are nontraded, the goods employment share rises more since the goods sector must produce all net exports used to service debt, while the services employment share falls more in the long run. The construction sector's employment share dynamics are largely unaffected by removing services trade. Figure 30 shows that while accounting for services trade affects goods and services employment share dynamics it does not play a large role in the model's ability to match the key facts about the savings glut. The figure shows the aggregate trade balance dynamics in the nontraded services model are similar to those of the baseline model, indicating that accounting for services trade does not have a large effect on the amount of capital that flows into the United States during the savings glut or the amount of capital that flows out once the savings glut ends.

9. Concluding remarks

This paper studies the effects of long-term increase in interest rates to pre-1992 levels on the U.S. economy. We build a model of the U.S. economy and show that it accounts for key features of the U.S. trade balance and real exchange rate during the "savings glut" period characterized by low real interest rates that began in the early 1990s. We then use our model to study the impact of the end of this savings glut on the U.S. economy. We study three possible scenarios: a gradual rebalancing in which interest rates rise slowly to their long-run level, an orderly sudden stop in which lending ceases and the interest rate path shifts upwards, and a disorderly sudden stop in which total factor productivity falls temporarily when the lending halts. We show that the U.S. will run a trade surplus in the long run to service the debt it incurred during the savings glut. The goods sector will continue to run a trade deficit, however, while the services sector's trade surplus will grow even larger. The real exchange rate will depreciate by almost 40 percent from its low in the 2000s. When the savings glut ends, employment will shift out of construction and into the goods sector, reversing the employment share dynamics that characterize the savings glut. If the savings glut ends suddenly in an unanticipated sudden stop, the trade balance reversal, real exchange rate depreciation and sectoral employment shifts will occur immediately. If the sudden stop is accompanied by a drop in total factor productivity like many sudden stop episodes in the past, the short-term trade balance and employment dynamics will be even sharper and more painful.

Our study emphasizes the importance of accurately modeling the disaggregate structure of the U.S. economy. In the data, both goods (manufacturing, agriculture and minerals) and services engage in international trade. This fact is qualitatively and quantitatively important for understanding the effects of the savings glut, the long-run rebalancing it requires, and a future sudden stop. While the U.S. has run a large trade deficit over the last two decades, its trade balance in services has been consistently positive. We find that, regardless of whether or not a sudden stop occurs, this pattern will continue during the rebalancing process: the services trade surplus will rise while the goods trade balance will remain negative. In other words, the service sector will be the primary source of net exports used to finance the capital outflows required to service the U.S. external debt. This limits the extent to which employment in the goods sector will rise in the long run. In an extension to our model, we show that if labor productivity grows faster in the goods sector as in structural change studies like Ngai and Pissarides (2007), the goods sector's employment share will fall in the long run, despite the fact that the composition of the U.S. economy must shift towards traded sectors. Modeling the construction sector accurately is important as well. It is our only purely nontraded sector and is used almost entirely to produce investment goods, consistent with the U.S. input-output data. This structure allows our model to account for the construction boom that occurred during the savings glut, and is crucial in our prediction that a sudden stop will trigger a construction crash.

A consistent theme throughout all of our results is that the manner in which the savings glut ends – whether it is gradual or sudden, orderly or disorderly – will not have much impact on the long-run dynamics of the U.S. economy. We wish to leave the reader with one final point: the fact that the savings glut happened *does* have large implications for the future of the U.S. economy. The long-run growth path on which the United States is now headed is very different than the one it would have taken had the savings glut never happened. Figure 31 illustrates the point by plotting the aggregate trade balance in our gradual rebalancing scenario against a counterfactual in which the savings glut never happened and interest rates took the path agents expected in 1992. In the counterfactual, U.S. trade is approximately balanced in the long run since the U.S. has little external debt to service. Because the savings glut did happen, however, our model predicts that the U.S. must run a trade surplus of more than 1.5 percent of GDP in the long run. So while the manner in which the savings glut is not likely to affect the long-run trajectory of the U.S. economy, the low real interest rates of the past two decades will have significant, lasting effects.

Appendix A. Computational approach

Our computational approach is similar to that taken in Kehoe and Ruhl (2009) and Conesa, Kehoe and Ruhl (2007) so we describe it only briefly here. We impose the restriction that an equilibrium in our model must converge to a balanced growth path in a finite number of periods T. In an equilibrium without uncertainty (our no-savings glut counterfactual, for example) there are K equilibrium conditions and K variables associated with each period of the simulation. We define a function $F:\mathbb{R}^{KT}\rightarrow\mathbb{R}^{KT}$ by stacking all equilibrium conditions for periods 0 through T. An equilibrium is then expressed as a vector $X\in\mathbb{R}^{KT}$ such that $F(X)=0$. We use a standard multi-dimensional root-finding algorithm to solve the system.

The presence of uncertainty complicates the procedure because we must solve for model variables along every possible history of realizations. Let

$$\tilde{T}\subset\left\{1,\ldots,T\right\}=\{\tilde{t}_1,\ldots,\tilde{t}_N\}=\{1999,\ldots,2009\}$$

denote the set of years with uncertainty in the stochastic version of our model. There are $N=11$ of these years. Recall that with probability $\pi=0.1$ the savings glut ends early (or the financial crisis happens in the case of 2009), and with probability $1-\pi = 0.9$ the savings glut continues for an additional period (or the financial crisis doesn't happen in the case of 2009). Let $s_n \in \{0,1\}$ denote which event occurs in each period $\tilde{t}_n \in \tilde{T}$, with $s_n = 0$ if the probability π event occurs and 1 if the other event occurs. Let $s^n = (s_1, \ldots, s_n)$ denote the history of realizations up to and including s_n.

The structure of our model implies that there are $N+1 = 12$ possible histories, since drawing a realization of s_n implies that $s_m = 1$ for all $m < n$. Abusing terminology a bit, let n index these histories as well. History 1 is $s_1 = 0$. For $1 < n < N+1$, history n is $(s_1 = 1, \ldots, s_{n-1} = 1, s_n = 0)$. History $N+1$ is $(s_1 = 1, \ldots, s_{N-1} = 1, s_N = 1)$. Note that history n and history $n+1$ are indistinguishable until s_n is revealed in period $\tilde{t}_n$. For example, histories 1 and 2 are the same until period $\tilde{t}_1$, when model agents discover whether $s_1 = 1$ or $s_1 = 0$. We can therefore treat history $n+1$ as "beginning" in period $\tilde{t}_n$. Formally, define $\tilde{X}_n \in \mathbb{R}^{KT}$ as the set of model variables on history n. It must be that $\tilde{X}_{n+1,t} = \tilde{X}_{n,t}$ for all $t < \tilde{t}_n$, so we can ignore $\tilde{X}_{n+1,t}$ for such t entirely. Put differently, the relevant part of $\tilde{X}_{n+1}$ is an element of $\mathbb{R}^{K(T-\tilde{t}_n)}$. This reduces the dimensionality of the problem slightly, implying that there is a total of

$$KT + K\sum_{n=1}^{N}(T - \tilde{t}_n)$$

variables we need to solve for. Let $\tilde{X} = (\tilde{X}_1, \ldots, \tilde{X}_{n+1})$ denote the entire vector of them put together.

Let $\tilde{F}_n$ denote the set of equilibrium conditions for each history $n \in \{1, \ldots, N+1\}$. The equilibrium conditions in a given history depend only on the model variables in that same history, except for intertemporal conditions in the periods before the uncertain event in which the next history branches off is realized. These equations take the form

$$\tilde{F}_{n,\tilde{t}_{n-1}}(\tilde{X}_{n,\tilde{t}_n - 1}, \tilde{X}_{n,\tilde{t}_n}, \tilde{X}_{n+1,\tilde{t}_n})$$

In other words, they are functions of model variables in history n in period $\tilde{t}_n - 1$, the year before s_n is realized, and the model variables in histories n and $n+1$ in period $\tilde{t}_n$. This reflects the fact that in period $\tilde{t}_n - 1$, there is a probability π that we stay on the current history with no remaining uncertainty, and the remaining probability that we move to the next history and face additional uncertainty in period $\tilde{t}_{n+1}$. In practice, we let the functions technically be of the form

$$\tilde{F}_n : \mathbb{R}^{KT + K\sum_{n=1}^{N}(T - \tilde{t}_n)} :\to \mathbb{R}^{K(T-\tilde{t}_n)}$$

so that they all have the same domain and we can stack them as $\tilde{F} = (\tilde{F}_1, \ldots, \tilde{F}_{N+1})$, then solve for $\tilde{F}(\tilde{X}) = 0$.

References

Arellano, C. (2008), "Default Risk and Income Fluctuations in Emerging Economies," *American Economic Review*, 98(3), 690–712.

Baumol, W.J. (1967), "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis." *American Economic Review*, 57(3), 415–26.

Baumol, W.J., S.A.B. Blackman, and E.N. Wolff (1985), "Unbalanced Growth Revisited: Asymptotic Stagnancy and New Evidence," American Economic Review, 75(4), 806 –17.

Bernanke, B. S. (2005), "The Global Saving Glut and the U.S. Current Account Deficit." Speech at the Sandridge Lecture, Virginia Assoc. Economists, Richmond, VA, March 10.

Bernanke, B.S., C. Bertaut, L.P. DeMarco, and S. Kamin (2011), "International Capital Flows and the Returns to Safe Assets in the United States, 2003-2007," Board of Governors of the Federal Reserve System International Finance Discussion Paper 1014

Burstein, A., M. Eichenbaum, and S. Rebelo (2005), "Large Devaluations and the Real Exchange Rate," *Journal of Political Economy*, 113(4), 742–84.

Caballero, R.J., Farhi, E., and Pierre-Olivier, G. (2008), "An Equilibrium Model of 'Global Imbalances' and Low Interest Rates." *American Economic Review*, 98 (1), 358–93.

Caballero, R.J. and A. Krishnamurthy (2009), "Global Imbalances and Financial Fragility," American Economic Review, 99(2), pp. 584-88

Calvo, G.A. (1988), "Servicing the Public Debt: The Role of Expectations," *American Economic Review*, 78(4), 647-61.

Calvo, G.A. (1998), "Capital Flows and Capital-Market Crises: The Simple Economics of Sudden Stops," *Journal of Applied Economics*, 1(1), 35-54.

Calvo, G.A., A. Izquierda, and L.F. Mejía (2004), "On the Empirics of Sudden Stops: The Relevance of Balance-Sheet Effects," NBER Working Paper 10520.

Calvo, G.A., A. Izquierdo, and E. Talvi (2006), "Phoenix Miracles in Emerging Markets: Recovering without Credit from Systemic Financial Crises," IADB Working Paper 570.

Calvo, G.A. and E. Talvi (2005), "Sudden Stops, Financial Factors and Economic Collapse in Latin America: Learning from Agentina and Chile," NBER Working Paper 11153.

Chari, V.V., P.J. Kehoe, and E.R. McGrattan (2005), "Sudden Stops and Output Drops," *American Economic Review*, 95(2), 381-87.

Cole, H.L. and T.J. Kehoe (2000), "Self-Fulfilling Debt Crises," *Review of Economic Studies*, 67(1), 91-116.

Conesa, J. C., T. J. Kehoe, and K. J. Ruhl (2007), "Modeling Great Depressions: The Depression in Finland in the 1990s," *Federal Reserve Bank of Minneapolis Quarterly Review*, 31(1), 16–44.

Cook, D. E. and M. B. Devereux (2006), "External Currency Pricing and the East Asian Crisis," *Journal of International Economics*, 69(1), 37–63.

Favilukis, J., S.C. Ludvigson, and S. Van Niewerburgh (2012), "Foreign Ownership of U.S. Safe Assets: Good or Bad?" Unpublished manuscript, LSE, NYU, NBER, and CEPR.

Fernández de Córdoba, G. and T. J. Kehoe (2000), "Capital Flows and Real Exchange Rate Fluctuations Following Spain's Entry into the European Community," *Journal of International Economics*, 51(1), 49–78.

Kaminsky, G. L. and C. M. Reinhart (1999), "The Twin Crises: The Causes of Banking and Balance-of-Payments Problems," *American Economic Review*, 89(3), 473–500.

Kehoe, P. J. and T. J. Kehoe (1994), "A Primer on Static Applied General Equilibrium Models," *Federal Reserve Bank of Minneapolis Quarterly Review*, 18(2), 2–16.

Kehoe, T.J. and K.J. Ruhl (2009), "Sudden Stops, Sectoral Reallocations and the Real Exchange Rate," Federal Reserve Bank of Minneapolis Research Department Staff Report 414.

Kravis, I.B., A.W. Heston, and R. Summers (1983), "The Share of Services in Economic Growth," In Global Econometrics: Essays in Honor of Lawrence R. Klein, edited by F.G. Adams and B.G. Hickman, 188 – 218. Cambridge, MA, and London: MIT Press

Krishnamurthy, A. and A. Vissing-Jorgensen (2007), "The Demand for Treasury Debt," NBER Working Paper 12881

Krugman, P.R. (2007), "Will there be a dollar crisis?" *Economic Policy*, 22, 435—467.

Mendoza, E. G. (2005), "Real Exchange Rate Volatility and the Price of Nontradables in Sudden-Stop-Prone Economies," *Journal of LACEA Economia*, 6(1), 103—148.

Mendoza, E.G. (2010). "Sudden Stops, Financial Crises, and Leverage." *American Economic Review*, 100(5), 1941–66.

Mendoza, E.G., V. Quadrini, and Rios-Rull, J.V. (2009), “Financial Integration, Financial Development, and Global Imbalances,” *Journal of Political Economy*, 117(3), 371—416

Meza, F. and E. Quintin (2007), “Factor Utilization and the Real Impact of Financial Crises,” *B. E. Journal of Macroeconomics (Advances)*, 7(1), article 33.

Ngai, L.R. and Pissarides, C.A. (2007), "Structural Change in a Multisector Model of Growth." *American Economic Review*, 97(1), 429–443.

Obstfeld, M. and Rogoff, K.S. (2007), “The Unsustainable U.S. Current Account Position Revisited,” In *G7 Current Account Imbalances: Sustainability and Adjustment*, edited by Richard H. Clarida, 339—376, Chicago: Univ. Chicago Press.

Obstfeld, M. and K. Rogoff (2009), “Global Imbalances and the Financial Crisis: Products of Common Causes,” Unpublished paper, Harvard University

Pierre-Olivier, G. and Rey, H. (2007), “From World Banker to World Venture Capitalist: US External Adjustment and the Exorbitant Privilege.” In *G7 Current Account Imbalances: Sustainability and Adjustment*, edited by Richard H. Clarida, 11–66, Chicago: Univ. Chicago Press.

Roubini, N. and Setser, B. (2005), “Will the Bretton Woods 2 Regime Unreavel Soon? The Risk of a Hard Landing in 2005—2006,” Manuscript, New York Univ. and Oxford Univ.

Sargent, T. J. (1978), “Estimation of Dynamic Labor Demand Schedules under Rational Expectations,” *Journal of Political Economy*, 86(6), 1009–44.

Summers, L.H. (2004), “The United States and the Global Adjustment Process,” Speech at the third annual Stavros S. Niarchos Lecture, Inst. Internat. Econ., Washington DC, March 23.

Warnock, F. E., and V. C. Warnock (2009), “International Capital Flows and U.S. Interest Rates,””Journal of International Money and Finance, 28, pp. 903—919

Yi, K. and Zhang, J. (2011), “Structural Change in an Open Economy,” Manuscript, Federal Reserve Bank if Minneapolis and Univ. of Michigan.

Table 1: 1992 Input-Output Matrix for the United States

	Inputs				Final demand					
Industry	**Goods**	**Services**	**Construction**	**Total intermediate**	**Private consumption**	**Government consumption**	**Investment**	**Exports**	**Total final demand**	**Total demand**
Goods	22.04	7.41	3.41	32.86	13.34	3.09	7.03	5.93	29.38	**62.25**
Services	10.15	25.27	2.46		52.75	14.14	1.84	3.71	72.44	**72.44**
Construction	0.38	2.20	0.01	37.89	-	-	8.29	-	8.29	**46.18**
Total intermediate consumption	32.57	34.89	5.89	73.34	66.10	17.22	17.15	9.64	110.11	**183.45**
Labor compensation	13.45	47.35	3.20	64.00	-	-	-	-	-	**64.00**
Returns to capital	7.57	26.64	1.80	36.00	-	-	-	-	-	**36.00**
Value added	21.02	73.99	4.99	100.00	-	-	-	-	-	**100.00**
Imports	8.66	1.45	-	10.11	-	-	-	-	-	**10.11**
Total gross output	**62.25**	**110.32**	**10.88**	**183.45**	**66.10**	**17.22**	**17.15**	**9.64**	**110.11**	**293.57**

Table 2: Baseline Calibration

Parameter	Value	Statistic	Target
Producer parameters			
(A_g, A_s, A_c)	(2.45,1.44,2.14)	Domestic gross output in 1992	(53.6,109,10.9)
(a_{gg}, a_{sg}, a_{cg})	(0.41,0.19,0.01)	Share of intermediates in domestic goods in 1992	(0.41,0.19,0.01)
(a_{gs}, a_{ss}, a_{cs})	(0.07,0.23,0.02)	Share of intermediates in domestic services in 1992	(0.07,0.23,0.02)
(a_{gc}, a_{sc}, a_{cc})	(0.31,0.23,0.001)	Share of intermediates in construction in 1992	(0.31,0.23,0.001)
$(\alpha_g, \alpha_s, \alpha_c)$	(0.36,0.36,0.36)	Capital's share of domestic value added in goods/svcs/constr. in 1992	(0.36,0.36,0.36)
$(\theta_g, \theta_s, \theta_c)$	(0.41,0.11,0.48)	Share of intermediates in investment good production in 1992	(0.41,0.11,0.48)
G	2.60	Investment in 1992	17.2
γ	1.02	Growth rate of U.S. GDP per working age person, in percent	2.00
Consumer parameters			
$\bar{b}_{1992}$	39.6	Capital account balance in 1992, in percent of GDP	0.08
$\bar{k}_{1992}$	234	Real interest rate in 1992, in percent	4.00
β	0.996	Long-term real interest rate, in percent	3.00
ε	0.06	Goods share of private consumption in 1992	25.3
ρ	-1.00	Elasticity of substitution, traded to nontraded	0.50
η	0.29	Ratio of hours worked to available hours in 1992	0.29
ψ	-1.00	Intertemporal elasticity of substitution	0.50
δ	0.05	Depreciation to GDP in 1992, in percent	11.7
Trade parameters			
(M_1, M_2)	(1.69,1.15)	Total traded goods in 1992	(62.2,110.3)
(μ_1, μ_2)	(0.70,0.95)	Imports in 1992	(8.66,1.45)
$(\mu_{1,1992}, \mu_{2,1992})$	(0.71,0.95)	Ratio of imports to domestic goods/services in 1992	(0.16,0.013)
(ζ_g, ζ_s)	(0.500,0.33)	Elasticity of substitution, domestic traded to imports	(2.00, 1.50)
$(D_{1,1992}, D_{2,1992})$	(5.93,3.71)	Exports in 1992	(5.93,3.71)
Government parameters			
τ_k	0.415	Depreciation rate	0.05
τ_{k1993}	0.478	Investment in 1992	17.2
ε_G	0.179	Traded good share of government consumption, in percent	0.18
Time series parameters			
$\{\bar{\ell}_t, n_t\}_{t=0}^{\infty}$		Social Security Admin. data and projections for U.S. working age and total populations	
$\{D_t\}_{t=0}^{\infty}$		Population data and projections for top export partners from World Bank	
$\{r_t\}_{t=0}^{\infty}$		20-year U.S. Treasury yields and CPI growth rates	
$\{\nu_t, \upsilon_t\}_{t=0}^{\infty}$		CBO historical data and projections	

Figure 1: Ex-post real interest rates vs. trade and current account balances, 1992 --2010

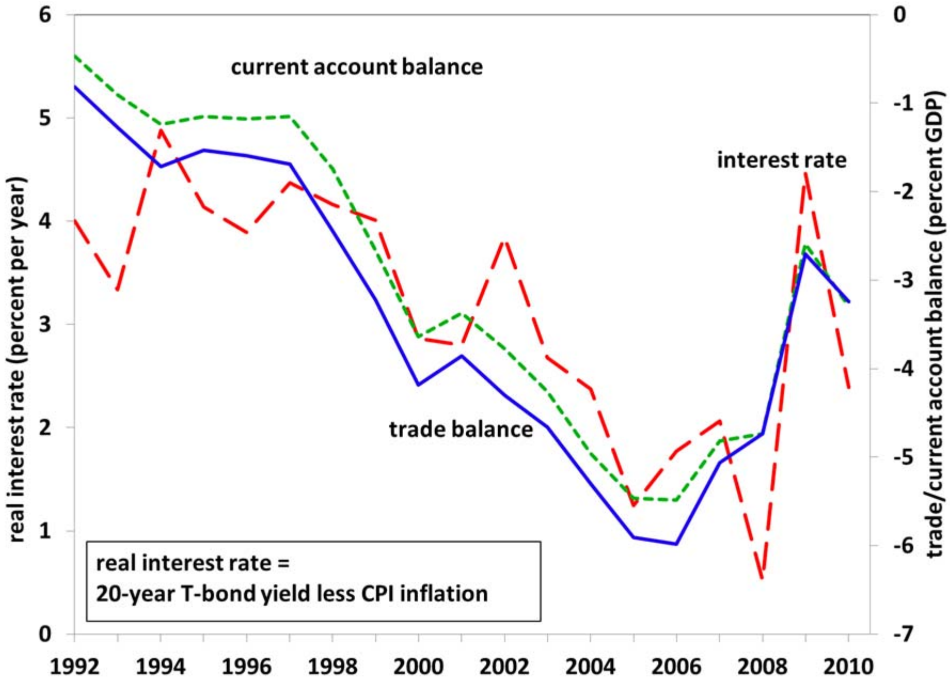

Figure 2: Disaggregated trade balances for goods and services, 1992--2010

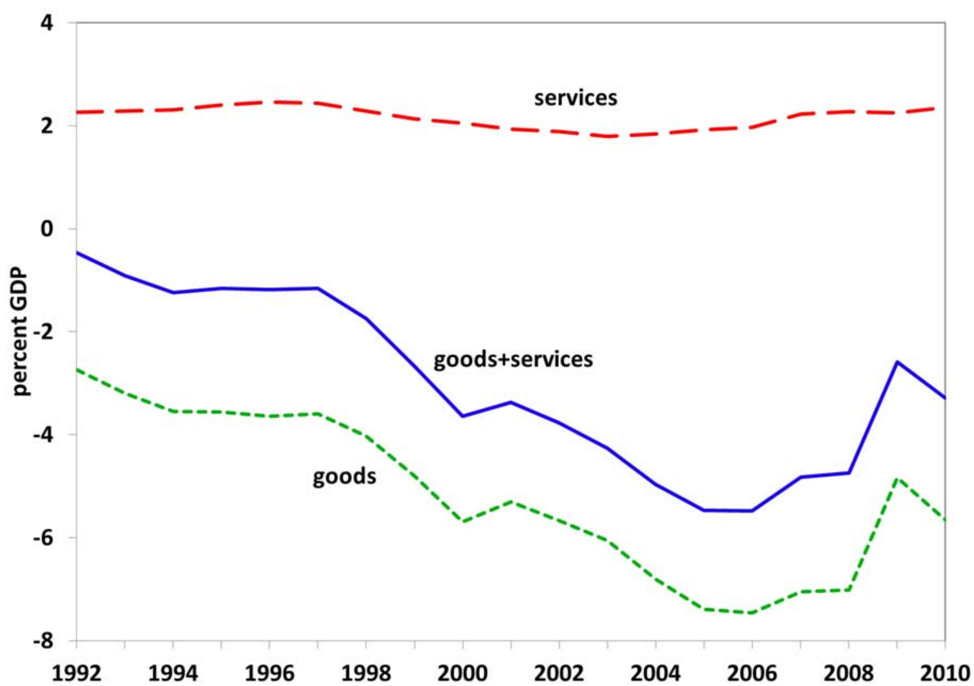

Figure 3: Real exchange rate, 1992—2010

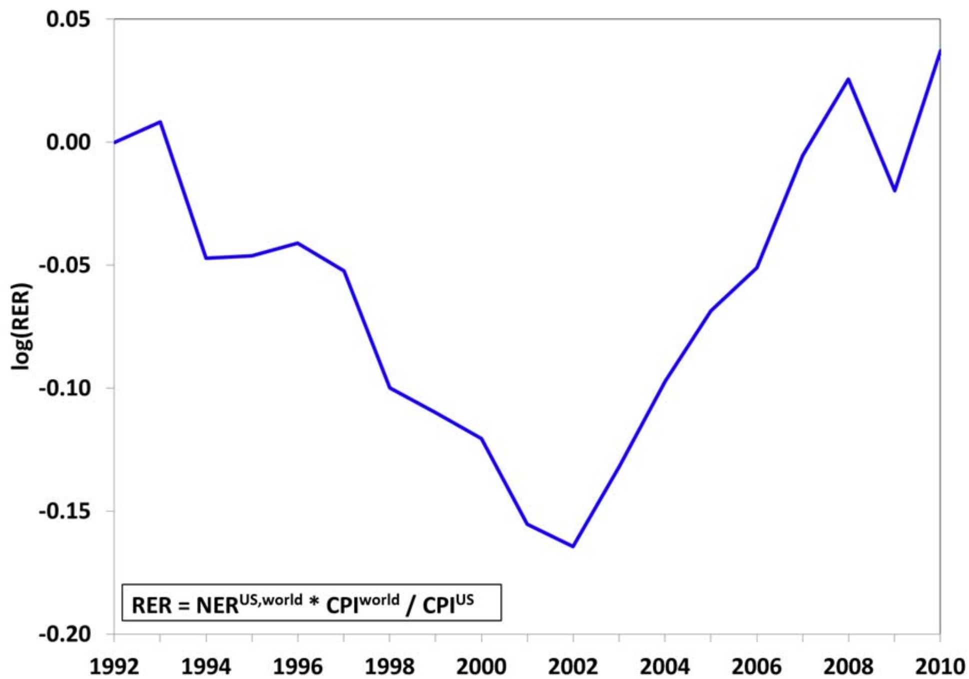

Figure 4: Real interest rate expectations in 1992

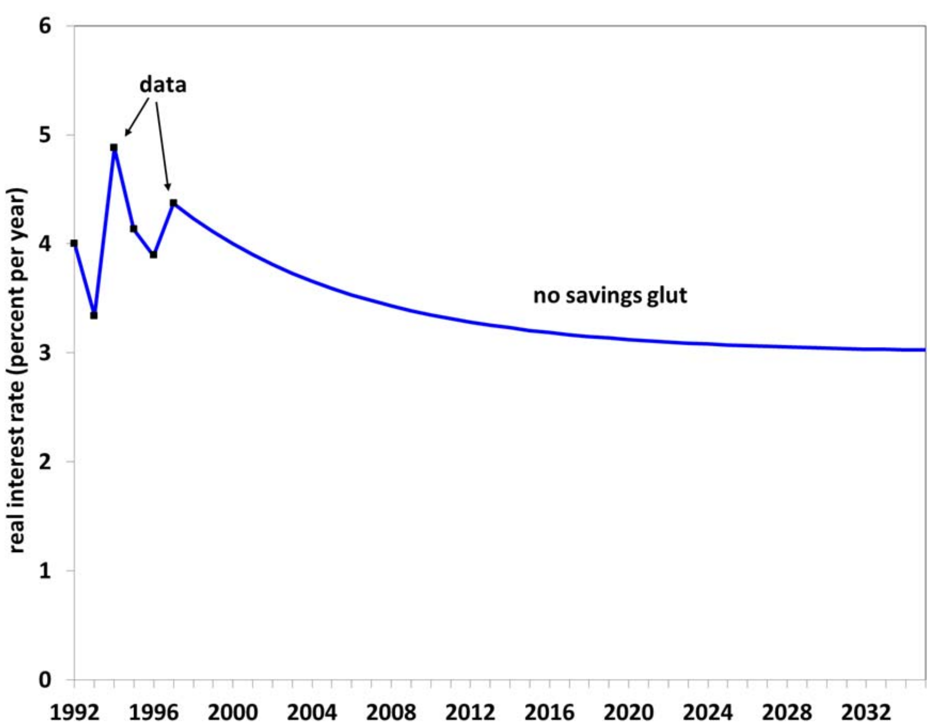

Figure 5: Graphical depiction of savings glut uncertainty tree

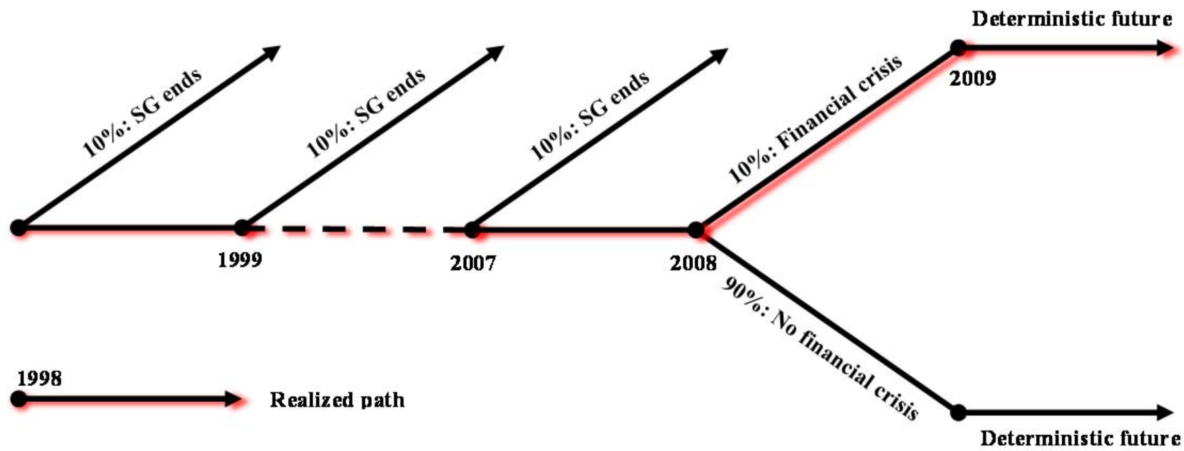

Figure 6: Real interest rate expectations in 1998 and realized ex-post interest rates

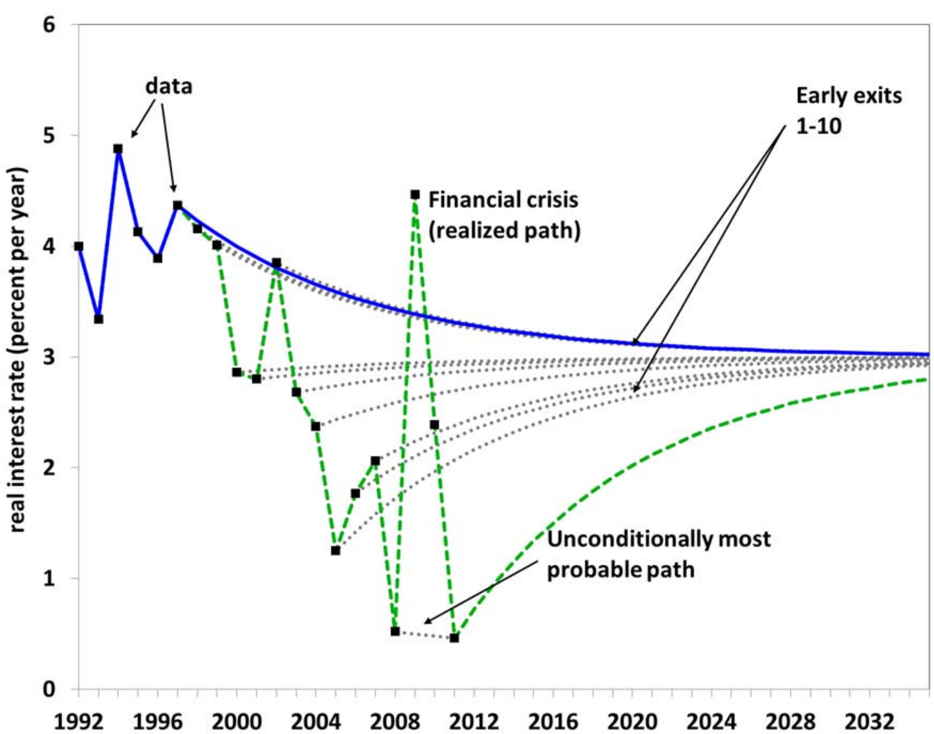

Figure 7: Trade balance in the model vs. data, 1992—2010

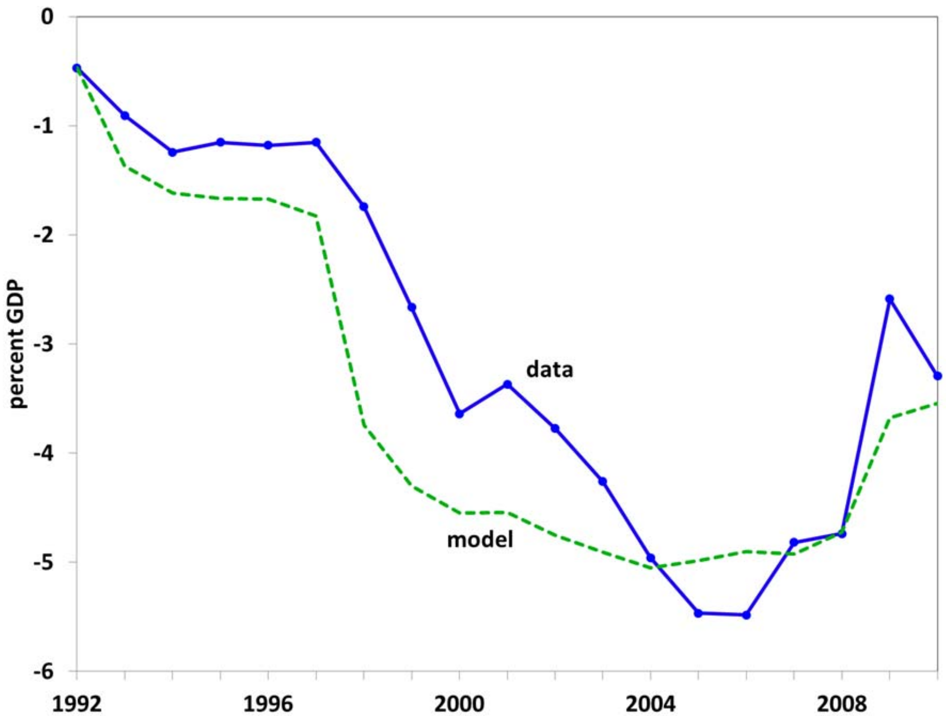

Figure 8: Disaggregated trade balances in the model vs. data, 1992—2010

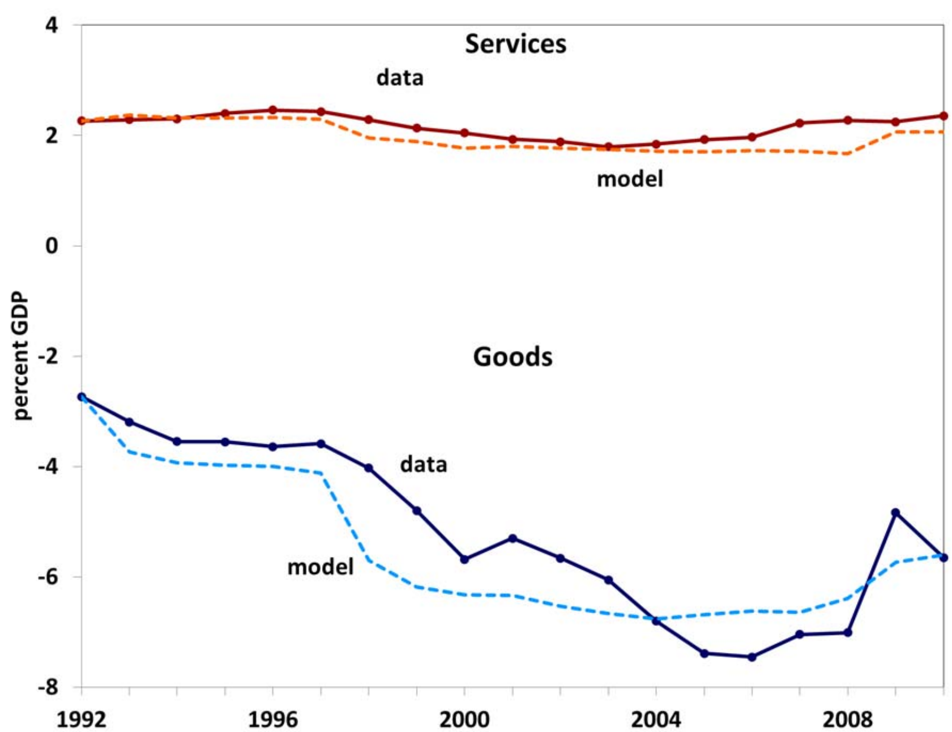

Figure 9: Real exchange rate in the model vs. data, 1992—2010

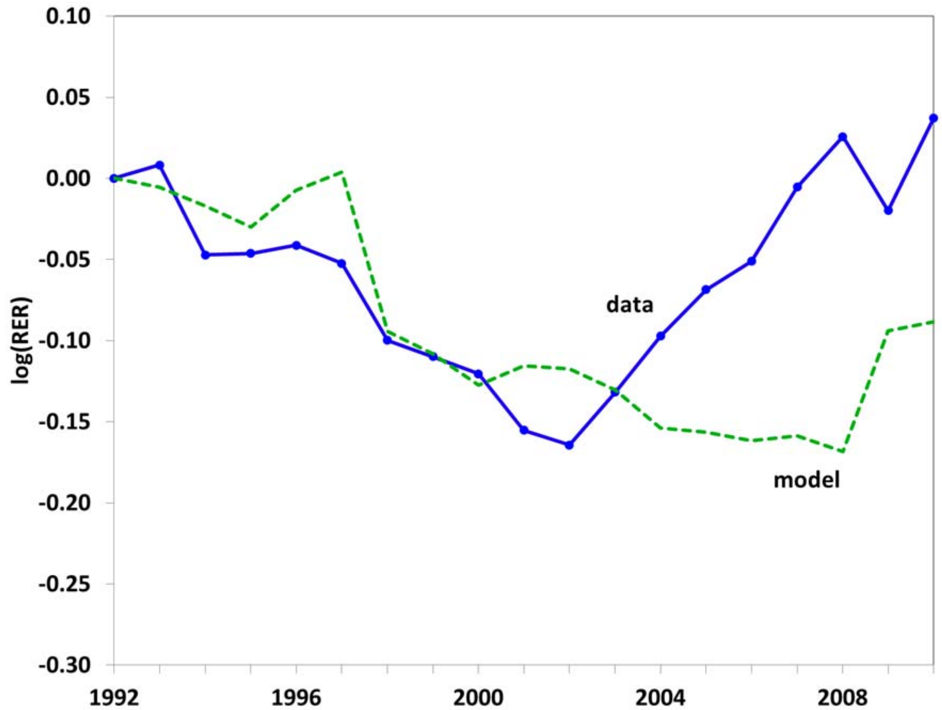

Figure 10: Real interest rates in savings glut exit scenarios, 1992—2050

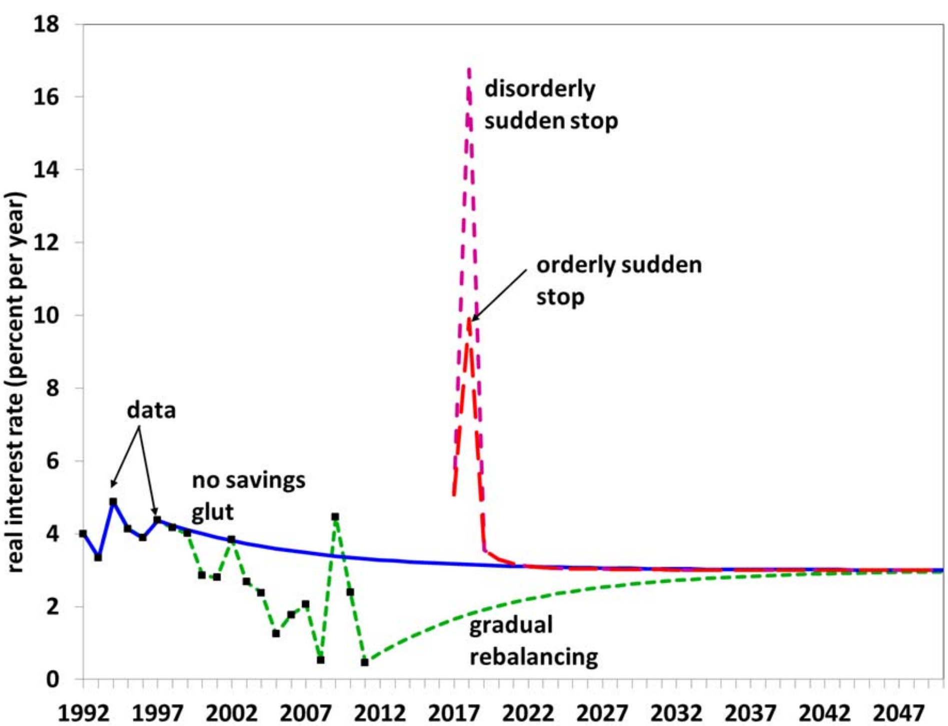

Figure 11: Aggregate trade balance in savings glut exit scenarios, 1992—2035

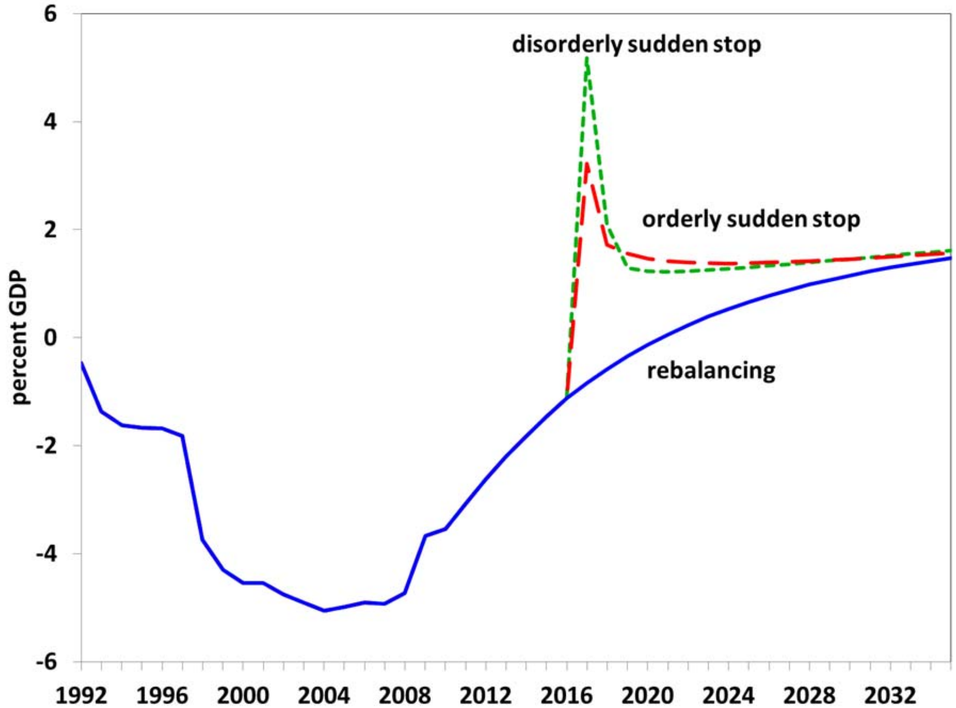

Figure 12: Disaggregated trade balances in savings glut exit scenarios, 1992—2035

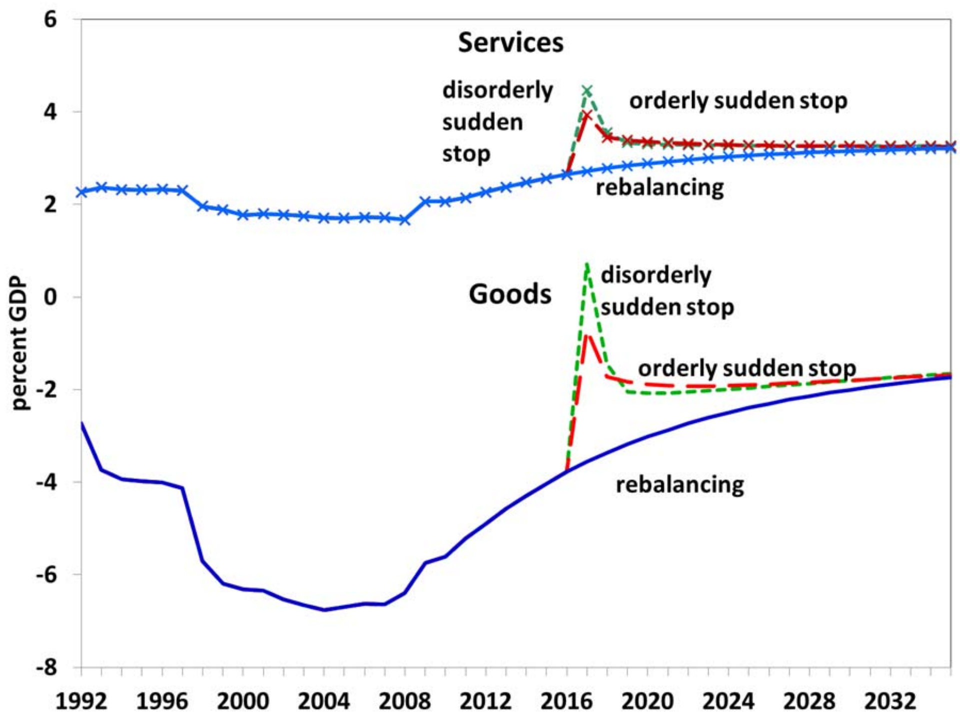

Figure 13: Real exchange rate in savings glut exit scenarios, 1992—2035

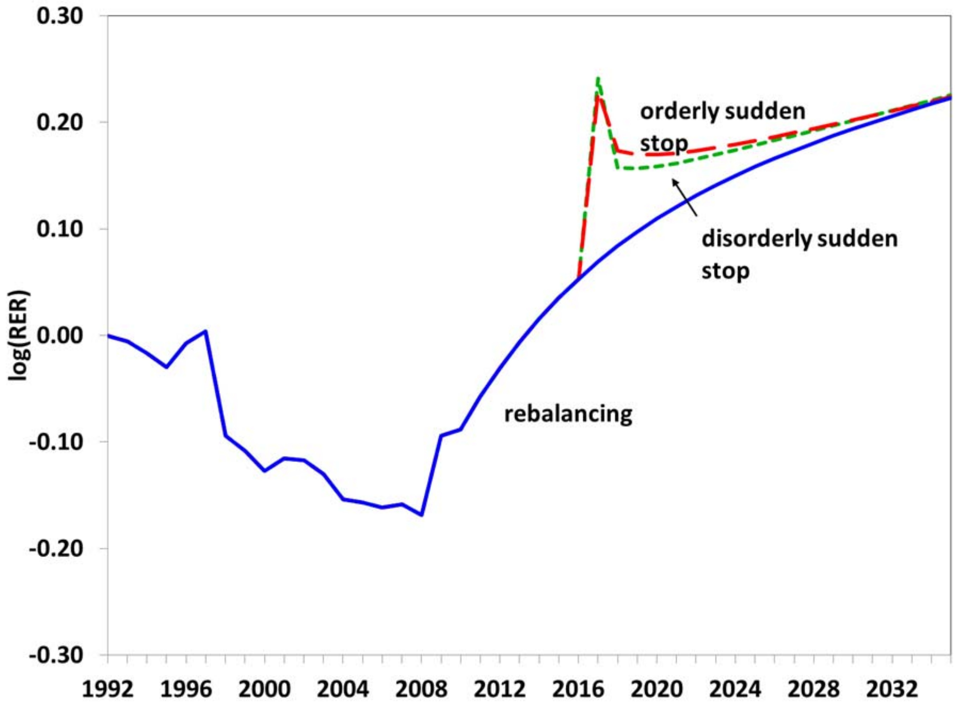

Figure 14: Real GDP in savings glut exit scenarios, 1992—2035

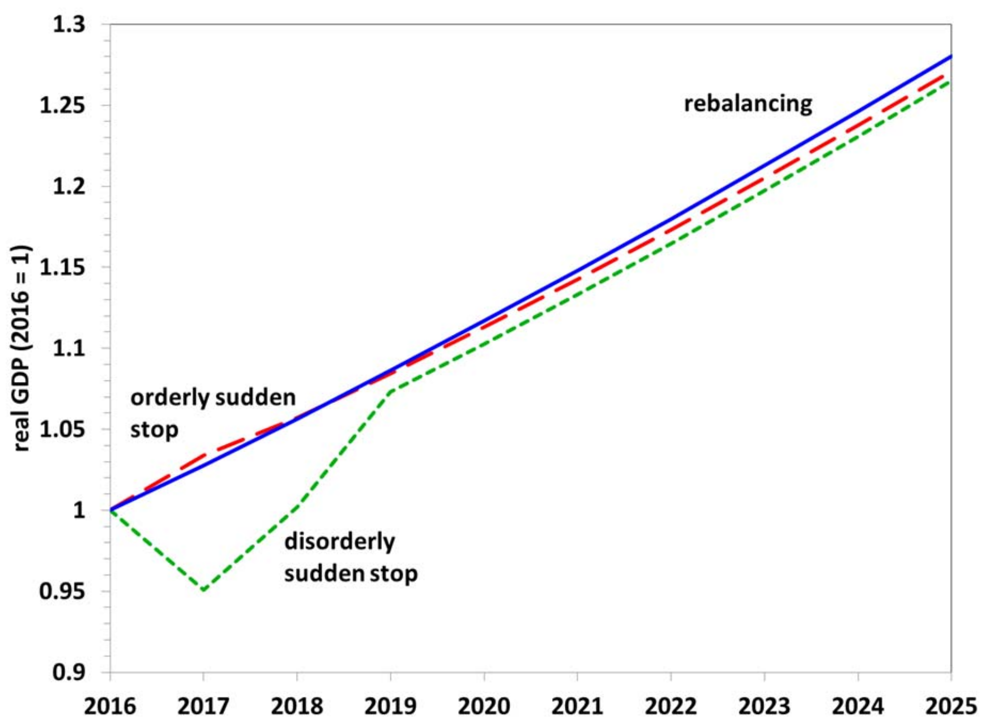

Figure 15: Goods employment share in savings glut exit scenarios, 1992—2035

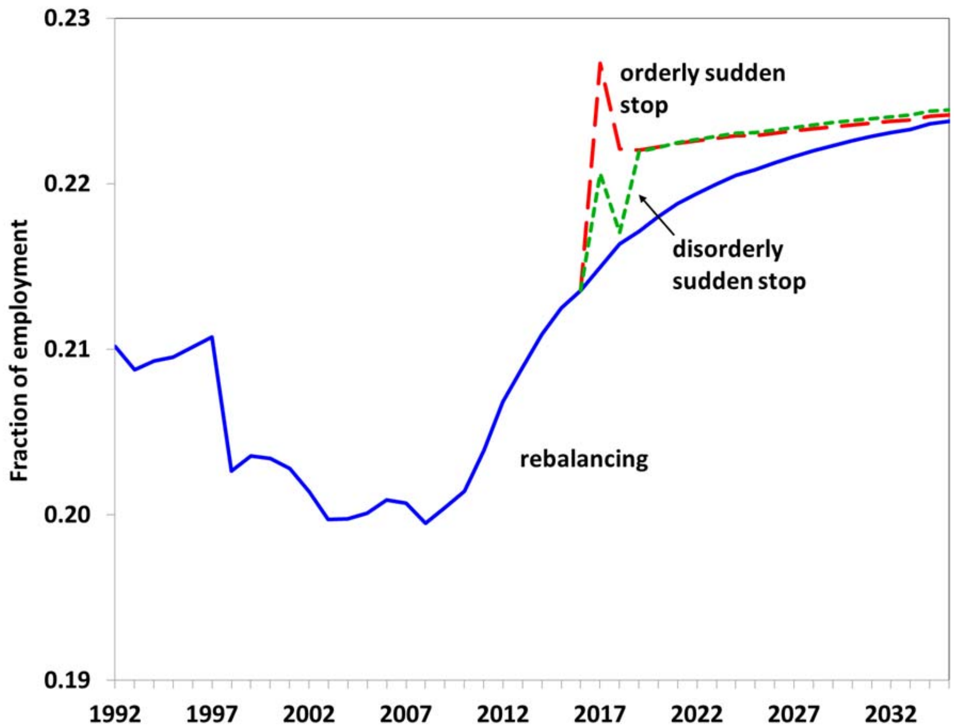

Figure 16: Services employment share in savings glut exit scenarios, 1992—2035

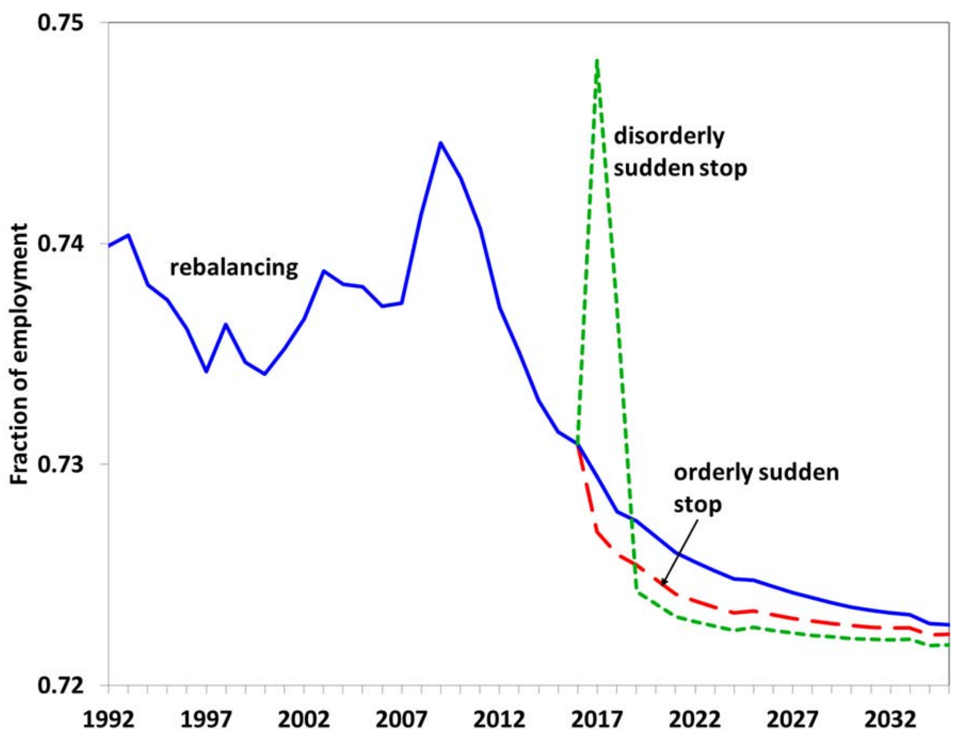

Figure 17: Construction employment share in savings glut exit scenarios, 1992—2035

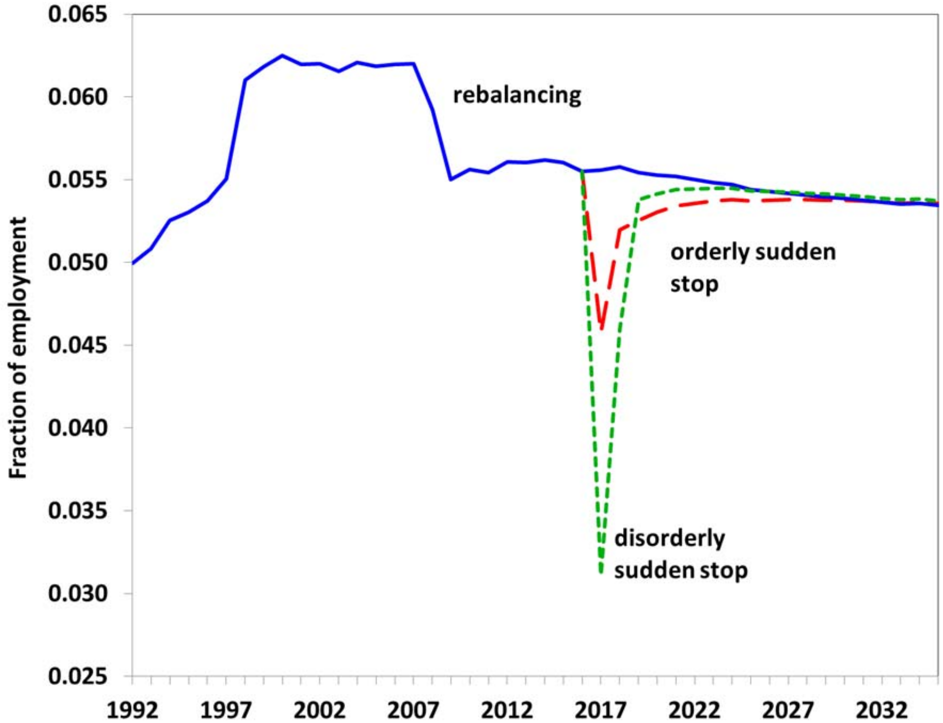

Figure 18: Goods employment share with and without structural change

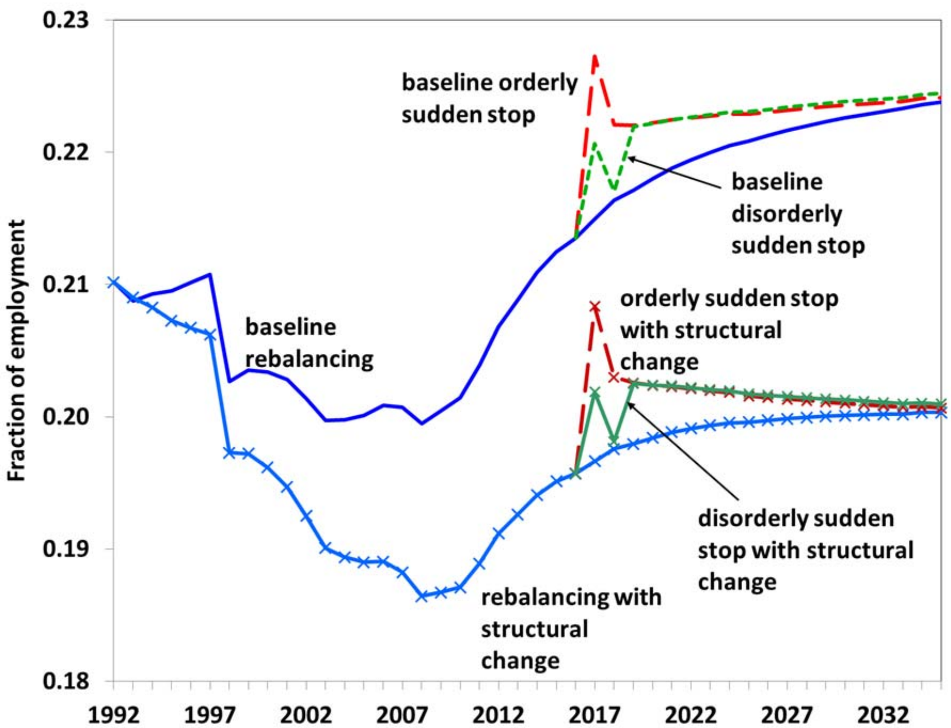

Figure 19: Services employment with and without structural change

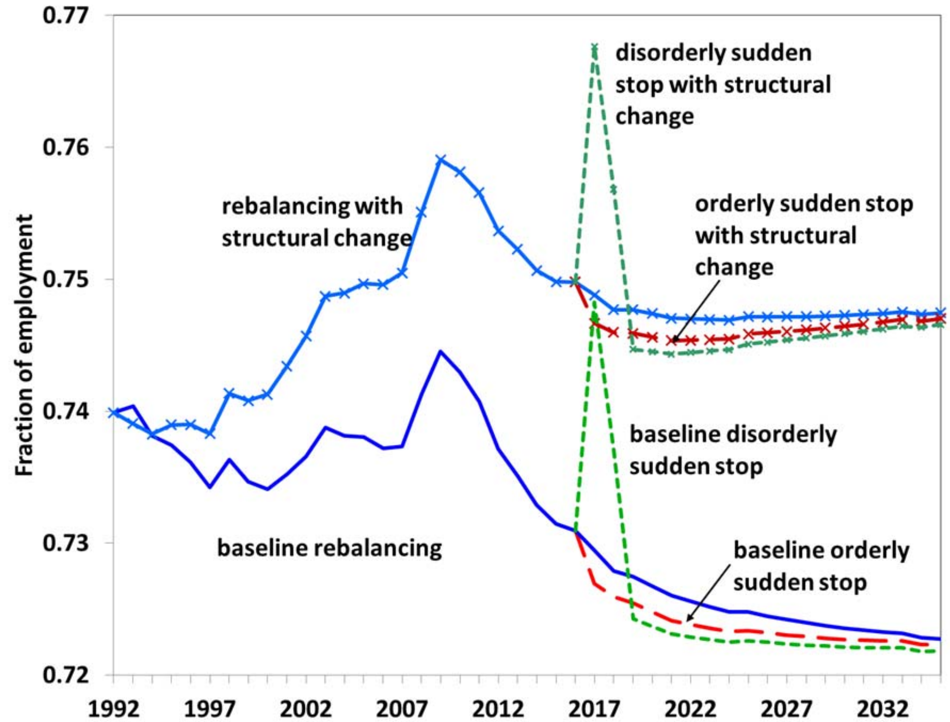

Figure 20: Construction employment with and without structural change

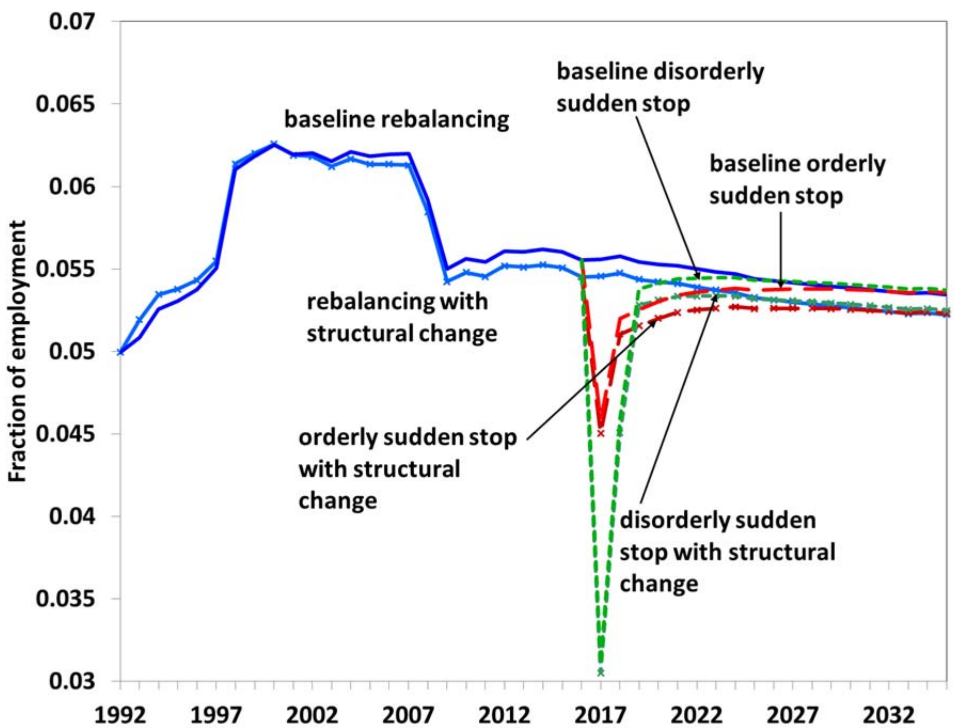

Figure 21: Aggregate trade balance with and without structural change

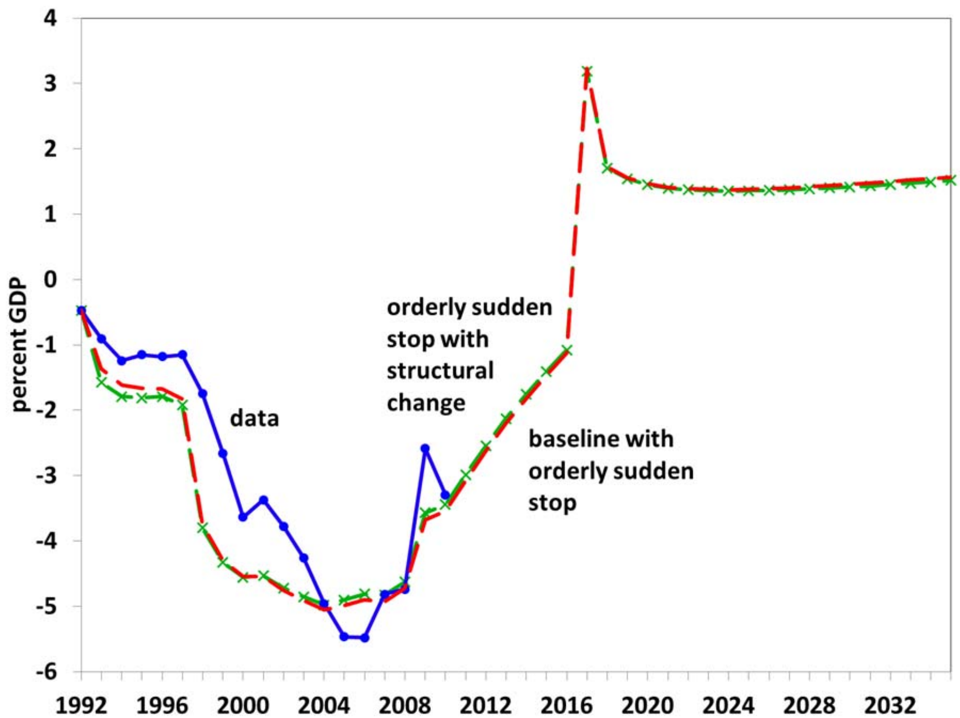

Figure 22: Goods employment share with adjustment costs

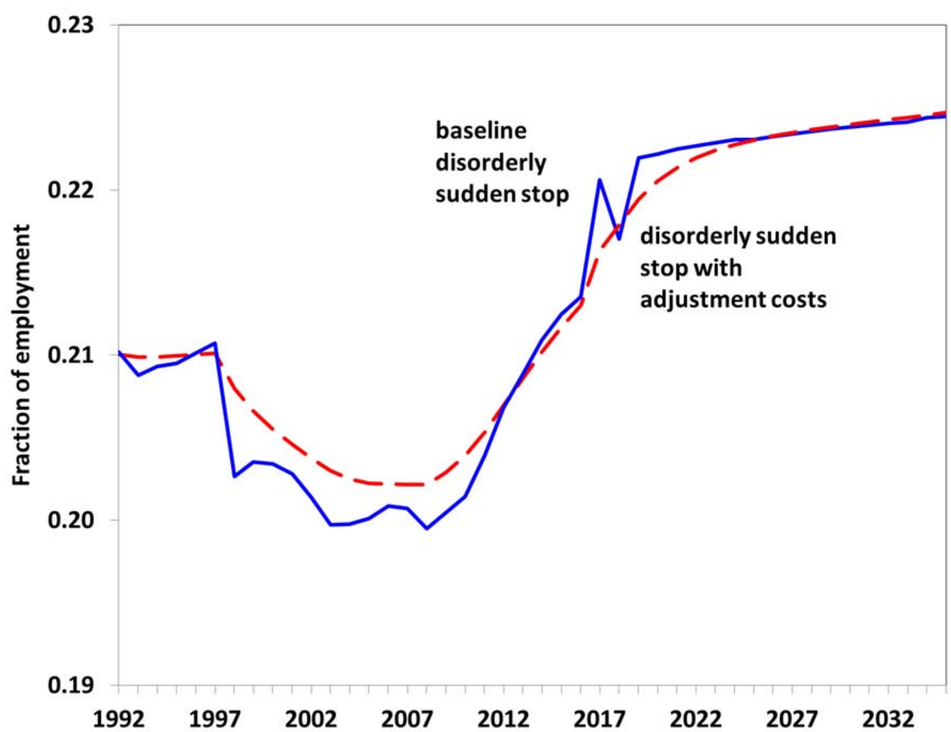

Figure 23: Services employment share with adjustment costs

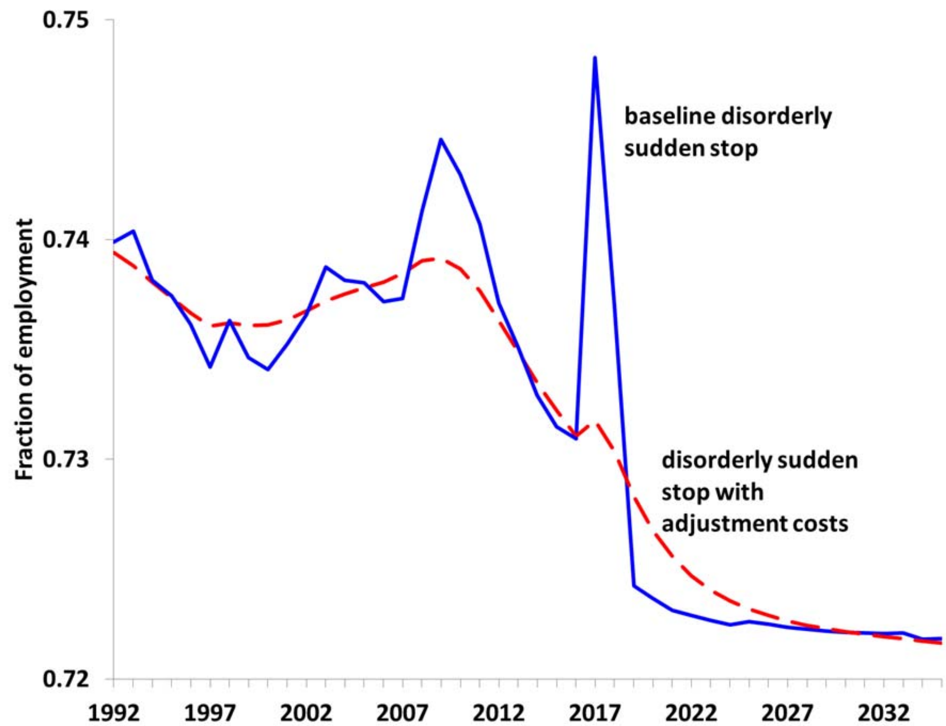

Figure 24: Construction employment share with adjustment costs

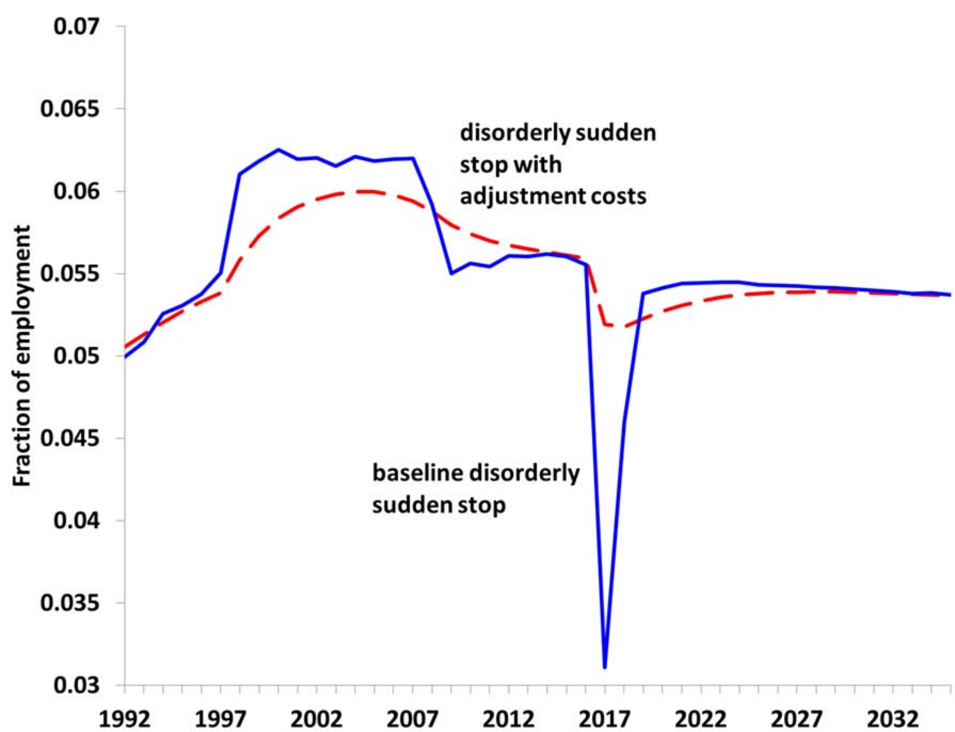

Figure 25: Real GDP with adjustment costs

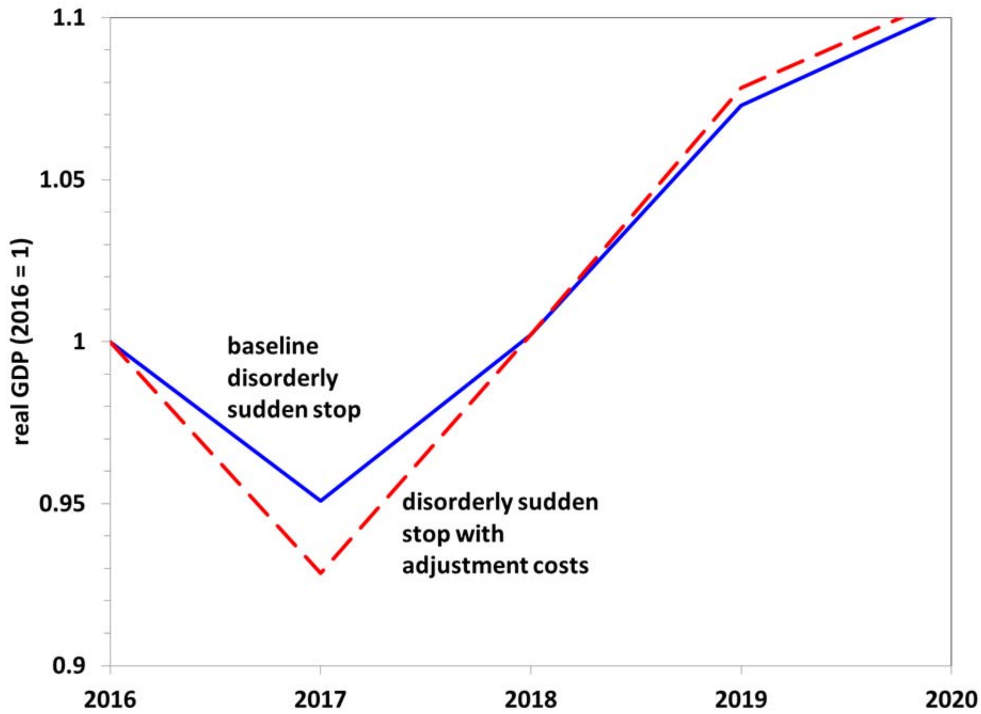

Figure 26: Aggregate trade balance with adjustment costs

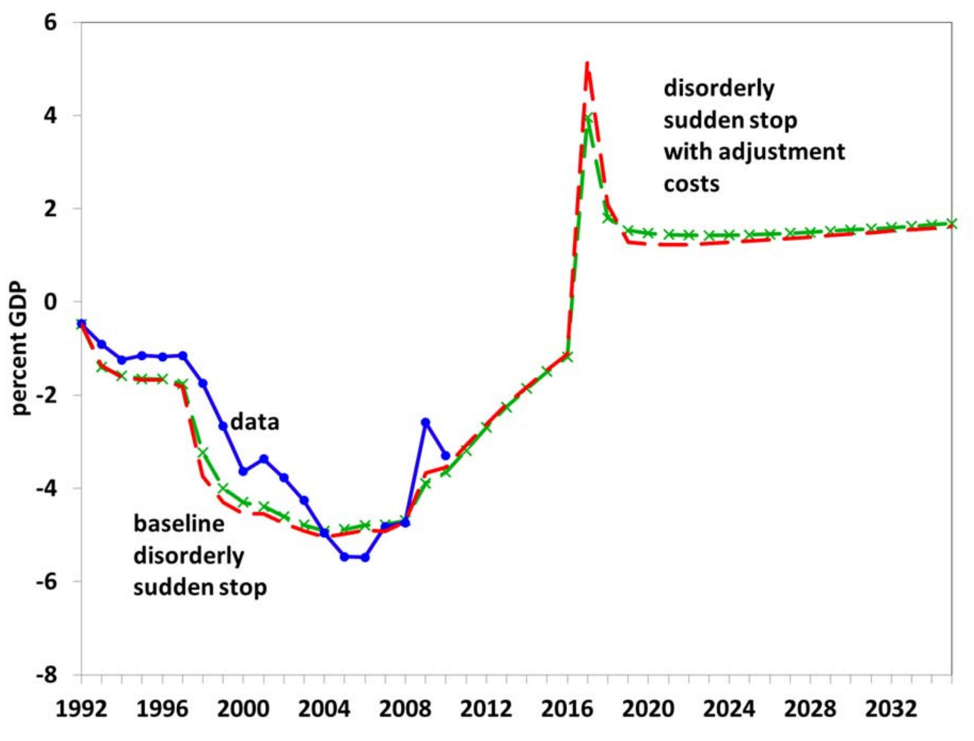

Figure 27: Goods employment share with nontraded services

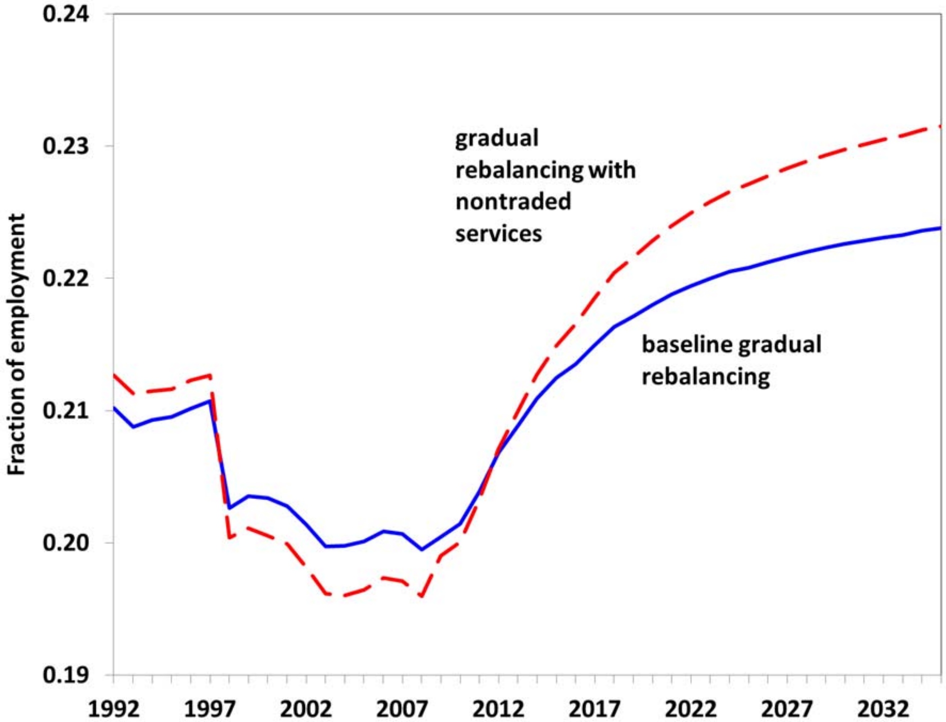

Figure 28: Services employment share with nontraded services

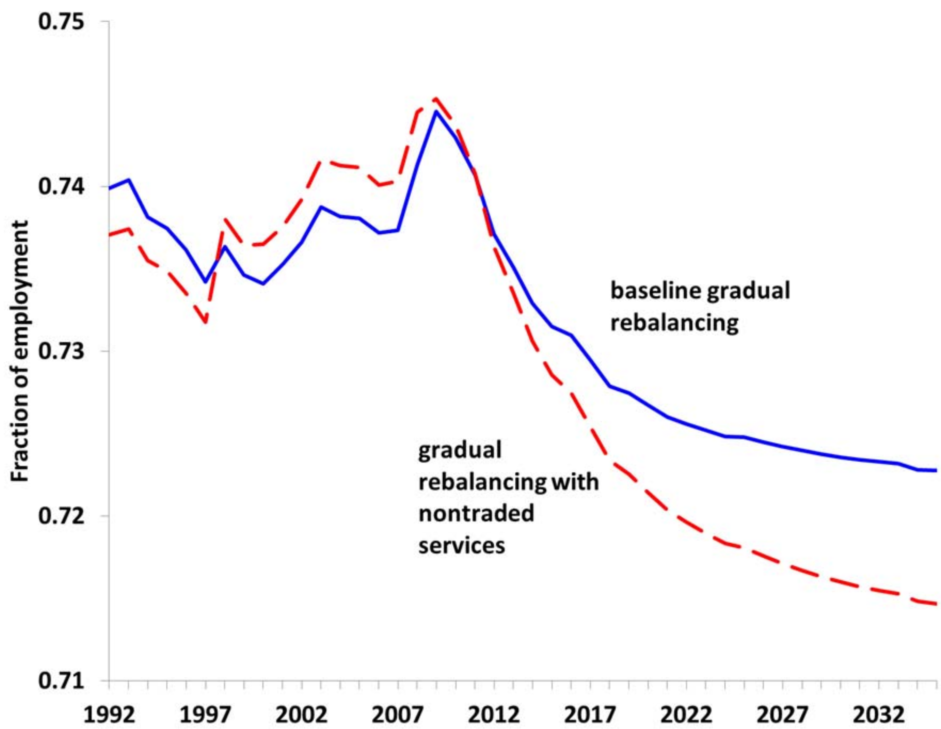

Figure 29: Construction employment share with nontraded services

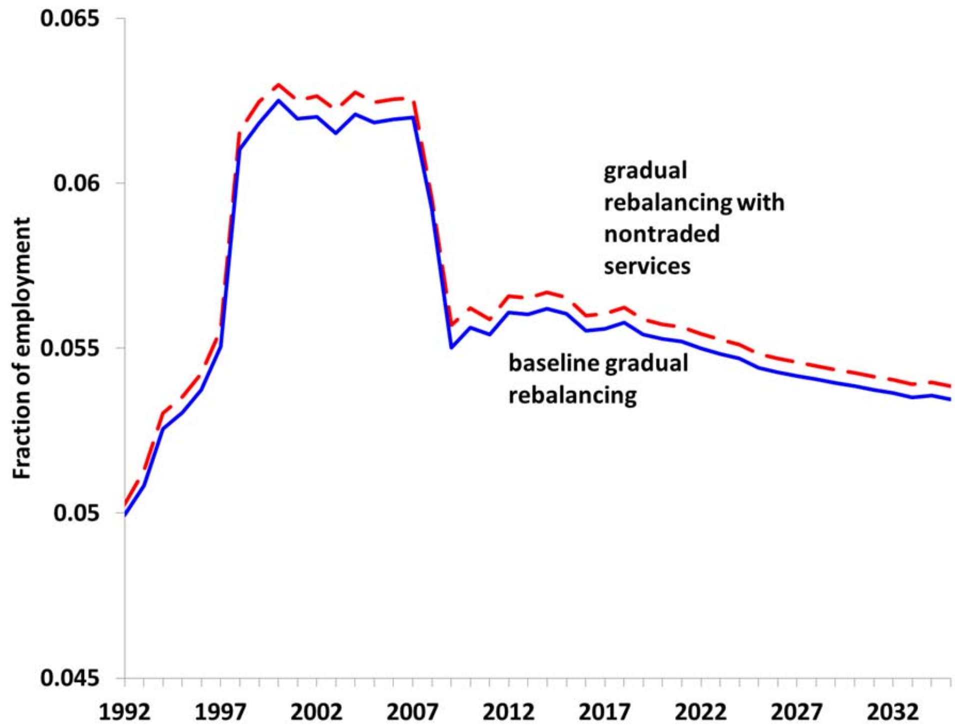

Figure 30: Aggregate trade balance with nontraded services

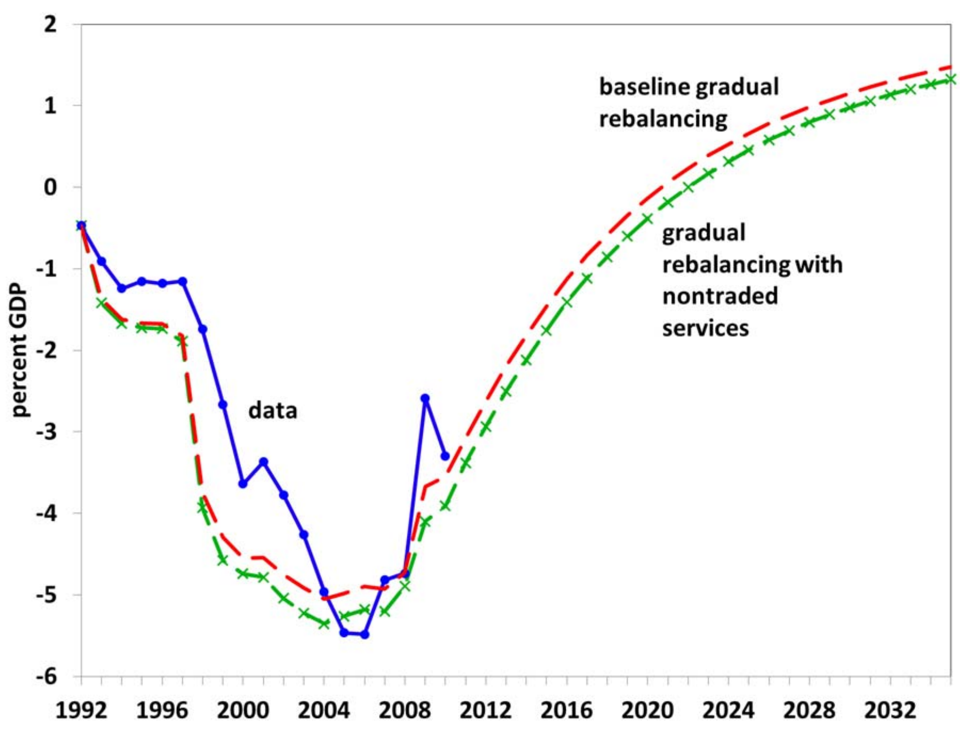

Figure 31: Aggregate trade balance in no-savings glut counterfactual