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Does the US Current Account Show a Symmetric Behavior over the Business Cycle?*

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Abstract

Traditionally, the literature that attempts to explain the link between the current account and output finds a linear negative relationship (e.g., Backus et al., 1995). Using nonparametric regressions, we find a robust U-shaped relationship between the U.S. current account and the GDP cycle. When output is above (below) its trend the current account and detrended output are positively (negatively) correlated. We argue that this nonlinearity might be caused by persistent productivity shocks coupled with uncertainty shocks about future productivity.

JEL codes: E3, F3, F4

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1 Introduction

The U.S. current account deficit is by far the most important component of the so-called global imbalances. The concern about such a deficit is probably related to the fear that the effects of a sudden reversal could have on economic activity.[1] One of the several hypotheses about the U.S. external deficit is the one proposed by Fogli and Perri (2006, 2015). The authors argue that uncertainty about future productivity plays a significant role in the long-run accumulation of external imbalances. The mechanism of their model is based on the link between uncertainty and consumption. A persistent increase in productivity accompanied with a fall in uncertainty about future productivity (as in the case of the Great Moderation) can generate large positive effects on consumption (large fall in savings) for precautionary motives, causing a drastic reduction in the current account balance.

Motivated by these findings, we analyze the U.S. current account and the role of uncertainty, but from a short-run perspective. More precisely, we investigate the implications of uncertainty shocks of productivity on the cyclical behavior of the U.S. current account. The standard RBC literature only finds and explains linear relationships (correlations) between the current account surplus and the GDP cycle (e.g., Baxter and Crucini, 1993; Backus et al., 1995). Their conclusion is that the U.S. current account is (weakly) countercyclical. That is, it is negatively correlated with the cyclical component of GDP. In this paper we challenge this common wisdom. Interestingly, this correlation is slightly negative but, statistically speaking, nil.[2] Using nonparametric techniques, we find a robust U-shaped relationship between the U.S. current account and the cyclical component of real GDP. When output is below its long-run trend, the current account tends to be inversely related to the GDP cycle, as previous studies find. In contrast, when output is above its trend, the current account tends to be directly related to the GDP cycle.

We do not view this finding as a curious data feature, but as a relationship that deserves attention because of the underlying mechanism at play. In particular, we argue that this empirical fact is caused by a combination of first-moment and second-moment shocks of productivity.[3] Using a stylized model, we show that persistent productivity shocks coupled with uncertainty shocks about future productivity not only generate the typical negative link between the current account and output observed during recessions, but also the positive link we find during expansions. In our model, large positive productivity shocks that carry a component of higher uncertainty would increase output in an amount larger than the total increase in domestic absorption (consumption plus investment) because of the higher volatility that the economic agents face. A higher uncertainty about future productivity discourages investment because physical capital becomes riskier, and lowers consumption

[1] Some authors argue that trade-balance reversals imply non-negligible costs in terms of GDP growth (Croke et al., 2005).

[2] The correlation is -0.27 with a standard error of 0.18 during the period of our study. See also the slope estimates reported in Table A2 (column 1).

[3] In this paper we will use the terms "second-moment shock" or 'volatility shock" to refer to the same shock of uncertainty about, unless stated otherwise, future total factor productivity.

due to precautionary motives. These negative effects do not compensate the larger positive effect on domestic absorption caused by the persistent increase in productivity. Given that output grows more than absorption, the current account improves. This implies the positive comovement observed during expansionary periods in the U-curve we find. During recessions, with large negative shocks, the increase in uncertainty just reinforces the effect of the persistent productivity shocks.

It is worth highlighting that uncertainty shocks are neither new nor irrelevant. Since the study of the Great Moderation and, especially, the onset of the Great Recession, macroeconomists have paid more attention to such shocks (e.g., Bloom, 2009). More importantly, the presence of uncertainty shocks has implications in the design of macroeconomic policy. According to Bloom et al. (2012), increased uncertainty alters the relative impact of government policies, making them initially less effective. From a theoretical viewpoint, Basu and Bundick (2012) argue that monetary policy usually plays a key role in offsetting the negative impact of uncertainty shocks on output.

Our study also relates to an empirical literature in international finance that models the current account using univariate models. A number of researchers argue that there exist nonlinear dynamics in the form of thresholds. This literature includes works by Freund (2005), Clarida et al. (2005), and Christopoulos and León-Ledesma (2010). The former, for instance, concludes that a typical current account reversal begins when the (previous) current account deficit is approximately 5% of GDP. Clearly, their focus is on an asymmetry with respect to the current account itself, not over the business cycle.[4]

In the next section, we document the main finding of our study. Section 3 formulates a simple model to explain it. Section 4 adds some final remarks. The Appendix shows that this finding is robust to alternative measures of external imbalances and cyclical components, different period and country samples, and a number of econometric specifications.

2 The Asymmetric Link Between the US Current Account and the GDP Cycle

2.1 Nonparametric Estimator and Data

To explore the empirical relationship between the current account and the GDP cycle we use a nonparametric regression. The advantage of this type of estimator is that it is robust to departures from a parametric specification and it does not impose a specific functional form for the relationship of interest. Thus, the current account-to-GDP ratio (ca) is related to the cyclical component of GDP (y) as follows:

[4]Needless to say that our main intention is not to enlarge a well-known literature in international finance populated by empirical findings with alphabetical shapes. Some papers highlight the response of the current account in the form of a J-curve after a rise in the exchange rate (Junz and Rhomberg, 1973). Others find a tilted S-curve between the cross-correlation function for net export and terms of trade (Backus et al., 1994).

$$ca_t = m(y_t) + \varepsilon_t \tag{1}$$

$$E(\varepsilon_t|y_t) = 0$$

where $m(.)$ is the conditional mean of ca_t given y_t and ε_t is the error term. According to equation (1), the link between the current account, adequately scaled by the GDP, and the cycle of output could be nonlinear because $m(.)$ is a function that may take different forms and does not impose any specific mathematical relationship. To estimate $m(.)$ we use the local linear estimator, which is widely studied and employed in the nonparametric econometrics literature.[5] The problem consists of minimizing

$$\sum_{t=1}^{T} K\left(\frac{y_t - y}{h}\right)\left[ca_t - \alpha - \beta(y_t - y)\right]^2 \tag{2}$$

where $K(.)$ is the kernel density, h is the bandwidth, α and β are the parameters to be estimated locally for every value y.

We define ca as the (demeaned) sum of net exports and net primary income from abroad as a percentage of GDP, expressed in percentages. The cyclical component of real output, y_t, is obtained by detrending the log of real GDP using a Baxter-King approximation to the band pass filter ($BP_{12}(6, 32)$). We use quarterly seasonally-adjusted data during the 1973.1-2012.1 period.[6]

2.2 The U-shaped Relationship

Fig. 1 shows a scatter plot of both series and the kernel fit according to the solution to (2). For our baseline estimation, we use cross validation to select the bandwidth and a Gaussian density for the kernel. As seen, the relationship between the current account and the cycle of output is nonlinear.

When GDP is below its trend, the current account and detrended GDP tend to be negatively correlated. In contrast, when GDP is above its trend (approximately 1% above its trend),[7] the current account and detrended GDP tend to be positively correlated. The figure also shows 95% asymptotic confidence intervals. Table A1 in Appendix A reports the p-value of

[5] See, for instance, Li and Racine (2007).

[6] The initial period of the sample eases any comparison to other empirical studies and allows us to use available series of the effective real exchange rate in the multiple-regressor analysis (see Appendix A). Main findings hold if we use the 1957.1-2012.1 period and they are available upon request.

[7] More exactly, the turning point is 1.18% and it occurs when the kernel fit (blue line in Fig. 1) is equal to -1.34 points of GDP. From now on, to simplify the exposition, we refer to this as the turning point that is 1% above its trend.

a consistent test of statistical significance proposed by Racine et al. (2006) for this type of nonparametric estimations. We cannot reject the null that the cyclical measure of GDP is statistically related to the current account at standard levels of significance.

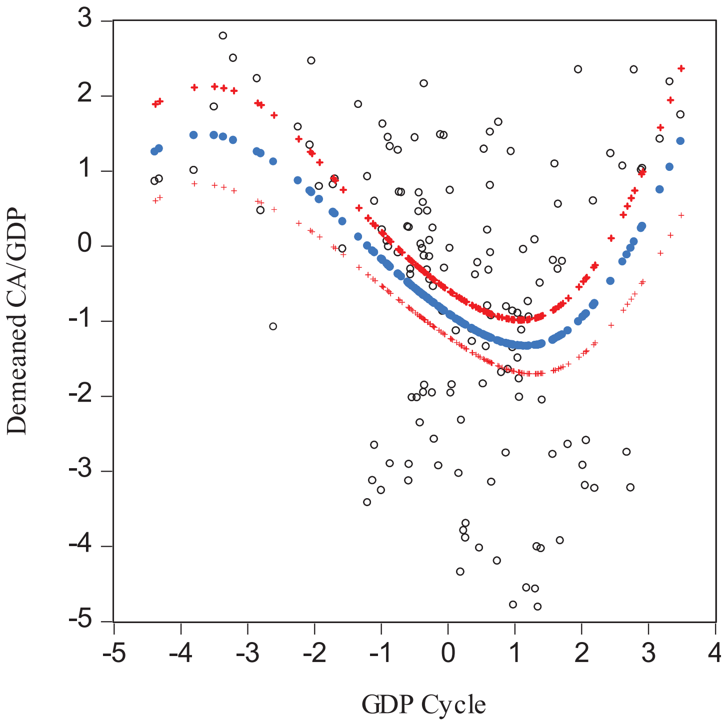

Fig. 1. Kernel Fit between Current Account/GDP and GDP Cycle and 95% Confidence Interval (US: 1973.1-2012.1)

How robust is this empirical finding? The nonparametric estimation presented earlier involves the construction of a measure of external imbalance (the current-account-to-GDP ratio), a measure of the GDP cycle, and a number of econometric issues related to nonparametric estimations (bandwidth selection, densities, etc.). In Appendix A, we perform a comprehensive analysis to find out whether the asymmetry of the U.S. current account over the business cycle is sensitive in such dimensions. We also evaluate whether this finding belongs to a certain period of time and whether it is observed in other G7 economies. Finally, we find out whether this phenomenon is due to the omission of some potential driver of the U.S. current account (the real exchange rate, the fiscal surplus, among others).

In general, our exercises suggest that the main results do not change qualitatively. Appendix A shows the outcomes of these exercises (see Fig. A1-A5). Table A1 reports p-values related to the test of statistical significance of the cyclical measure of GDP for each sensitivity exercise. The main message from this table is that the nonlinear relationship between the current account surplus and the GDP cycle is not given by chance, but it is statistically significant. The U-curve relationship is relatively stable over time and not highly sensitive to the bandwidth selection or density functions. Also, with the possible exceptions of Japan and United Kingdom, it does not seem to be a common pattern across the G7 economies.

3 A Possible Explanation

3.1 Intuition about the Mechanism

One way to understand this asymmetry is by drawing a feature of the model proposed by Fogli and Perri (2015).[8] The authors assume that productivity shocks follow a GARCH process. Assume that $\epsilon_t \sim WN(0,1)$ represents the innovation of total factor productivity (TFP), which follows a GARCH(1,1) specification:

$$TFP_t = \beta_0 + \beta_1 TFP_{t-1} + \sigma_t \epsilon_t \tag{3}$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \alpha_2 \sigma_{t-1}^2 \tag{4}$$

where σ_t^2 is the time-dependent standard deviation of the error term in period t. After shocks are realized, agents use observations on ϵ_t to form an idea of the TFP level and ϵ_t^2 to forecast its variance. This implies that each realization of the shock contains two types of news: one on the level of TFP and another on the TFP variance.[9] During a recession, a large negative shock contains both bad news on the level because ϵ_t is negative and on the variance because ϵ_t^2 is large. That is, a large negative shock will be amplified. During an expansion, in contrast, a large positive shock will carry two news with opposite effects: one on the level because ϵ_t is positive and the other negative because the variance ϵ_t^2 is large. A large positive shock generates a boom that will be attenuated by the higher volatility of the TFP shocks. Hence, agents' responses to large positive shocks and large negative shocks will be asymmetric.[10,11] An implication is that agents' joint forecasting of first and second moments might convert a process with symmetric variance into decision variables that display asymmetric dynamics.

This asymmetric dynamics can help understand the U-curve behavior of the current account over the business cycle. Suppose that risk-averse agents populate an economy whose initial GDP is at its steady-state level (the GDP cyclical component is zero). The economy is hit by a large negative, persistent TFP shock that reduces the level of TFP but, at the same time, raises its variance. Such a shock will reduce not only output, but especially consumption and investment, causing an increase in the current account surplus. This effect would lead to a negative comovement between the current account and GDP cycle similar to the one

[8] Ebell (2001) also proposes a similar idea and time-series process to explain why asset returns are more volatile during a recession. We draw some key intuition from this work too.

[9] Put differently, TFP innovations are non-variance-preserving shocks.

[10] This idea is consistent with a fact –well studied in the literature of business cycle asymmetries– called deepness. This business cycle feature is observed when troughs are further below trend than peaks are above. See Sichel (1993) for the definition and empirical evidence on deepness for the U.S. business cycle.

[11] Note also that only small –either positive or negative– values of ϵ_t determine small values of ϵ_t^2 and, thus, uncertainty.

shown on the left side, first half, of Fig. 1. Now, suppose the economy is at its steady-state level and we observe a large positive, persistent TFP shock that raises both the level of TFP and its future variance. This shock would increase output in an amount larger than the total increase in domestic absorption (consumption plus investment) because of the higher volatility that agents face. A higher TFP volatility discourages investment because the physical asset becomes riskier, and causes a reduction in consumption due to precautionary motives. These negative effects only partially offset the positive (and larger) effects from the persistent increase in TFP. Given that output grows more than domestic absorption, the current account improves. This would be consistent with the positive comovement between the current account and GDP cycle shown on the right side –especially beyond the 1% turning point– of Fig. 1.

3.2 A Simple Model

We can verify that this intuition is qualitatively consistent with a simple standard model. Risk-averse agents form expectations about future TFP in a simpler fashion than the one proposed by Fogli and Perri (2015). However, the basic ingredient (namely, TFP shocks in levels and uncertainty shocks of future TFP) is captured in our setup. Consider a small-open economy[12] populated by a consumer that lives two periods ($\tau = t, t+1$) and chooses streams of consumption and amounts of financial and physical assets to maximize

$$U = E_t \sum_{\tau=t,t+1} \beta^{\tau-t} \frac{c_\tau^{1-\sigma}}{1-\sigma}$$

subject to the first-period budget constraint

$$b_{t+1} = (1+r)b_t + y_t - c_t - k_{t+1} \tag{5}$$

and the second-period budget constraints

$$0 = (1+r)b_{t+1} + y_{t+1}^H - c_{t+1}^H \tag{6}$$
$$0 = (1+r)b_{t+1} + y_{t+1}^L - c_{t+1}^L \tag{7}$$

where E_t is the expectation operator given period t information, β is the subjective discount factor, c_τ denotes consumption, σ is the coefficient of relative risk aversion, b_τ denotes the stock of net foreign assets, r is the risk-free real interest rate, k_τ is the stock of physical capital, y_τ denotes output, A_τ stands for current TFP. Note that, for simplicity, we assume that capital fully depreciates at the end of each period. First-period output is given by the production function

[12] We closely follow Végh (2013, chapter 13), but the nature of the exercises and their purposes are different.

$$y_t = A_t k_t$$

Second-period TFP depends on two states of the nature, high and low productivity:

$$A_{t+1} = \begin{cases} A^H \text{ with probability } p \\ A^L \text{ with probability } 1-p \end{cases}$$

where $A^H > A^L > 0$. Thus, second-period output can take two values, $y^H_{t+1} = A^H k_{t+1}$ and $y^L_{t+1} = A^L k_{t+1}$. The expected future TFP and the variance of future TFP are:

$$E(A_{t+1}) = pA^H + (1-p)A^L \tag{8}$$

$$V(A_{t+1}) = (A^H - A^L)^2 p(1-p) \tag{9}$$

Even though we do not have a GARCH process here, this setup allows us to generate the desired persistent shocks in levels and uncertainty. An increase in A^H raises both the expected future TFP level and the variance of future TFP. Whereas, a fall in A^L lowers the expected future TFP level but raises the variance of future TFP. We will see later that a proper combination of changes in parameters A_t, A^H, and A^L will allow us to implement a persistent TFP shock coupled with an uncertainty shock about future TFP.

Let λ_t, λ^H_{t+1}, and λ^L_{t+1} be the corresponding Lagrange multipliers. The first-order conditions (FOCs) with respect to c_t, c^H_{t+1}, c^L_{t+1}, k_{t+1}, and b_{t+1} are

$$c_t^{-\sigma} = \lambda_t$$

$$\beta p \left(c^H_{t+1}\right)^{-\sigma} = \lambda^H_{t+1}$$

$$\beta(1-p) \left(c^L_{t+1}\right)^{-\sigma} = \lambda^L_{t+1}$$

$$\lambda_t = \lambda^H_{t+1} A^H + \lambda^L_{t+1} A^L$$

$$\lambda_t = (1+r)\left(\lambda^H_{t+1} + \lambda^L_{t+1}\right)$$

Combining these FOCs we have the usual Euler equation

$$c_t^{-\sigma} = \beta(1+r)[p\left(c^H_{t+1}\right)^{-\sigma} + (1-p)\left(c^L_{t+1}\right)^{-\sigma}] \tag{10}$$

and the condition for the investment decision

$$c_t^{-\sigma} = \beta[p \left(c_{t+1}^H\right)^{-\sigma} A^H + (1-p) \left(c_{t+1}^L A^L\right)^{-\sigma}] \tag{11}$$

The expressions (5)-(7) and (10)-(11) constitute a system of five nonlinear equations that characterize the solution for c_t, c_{t+1}^H, c_{t+1}^L, k_{t+1}, and b_{t+1}. Finally, we assume that (i) b_t and k_t are exogenously given, and (ii) $A^H > 1 + r > A^L$ and $E_t(A_{t+1}) > 1 + r$ to guarantee an interior solution for the stocks.

3.3 Persistent TFP Shock and Uncertainty Shock of Future TFP

This type of shock can be generated in the model by an adequate variation in the parameters A_t, A^H, and A^L that govern equations (8)-(9). Given the difficulty to obtain a simple analytical solution we parameterize the model and solve it numerically. The parameter values are the following: $b_t = 0$, $k_t = 1$, $r = 0.06$, $\beta = (1+r)^{-1}$, $\sigma = 2$, $p = 0.5$.

How would the economy's equilibrium change if there is a persistent change in TFP jointly with a change in TFP uncertainty? The results of the main exercise are shown in Fig. 2. The first column of the figure shows an increase in current and expected productivity jointly with a decrease in the variance of future productivity. Specifically, it assumes values for $A_t = [0.9 \;\; 1.0]$, $A^L = [0.89 \;\; 0.99]$, keeping A^H constant and equal to 1.22. The second column of the figure shows an increase in current and future productivity and also an increase in the variance of future productivity. It assumes values for $A_t = [1.0 \;\; 1.1]$, $A^H = [1.22 \;\; 1.34]$, keeping A^L constant and equal to 1.0.

In the first row of Fig. 2, we can observe the plot of the current-account-to-output ratio (ca_t) for every value of the combined shock. That graph measures ca_t on the vertical axis and, for comparison to the scatter plot of Fig. 1, current output (y_t) is always measured on the horizontal axis. The second, third, and fourth rows measure y_t, domestic absorption ($c_t + i_t$), and our measure of uncertainty (the standard deviation of future productivity, $SD(A_{t+1})$), respectively, on the vertical axis.

We can simplify the analysis if we assume that the economy's initial equilibrium is equal to 1. That holds when $y_t = A_t k_t = (1)(1) = 1$. Let us look at the left side of Fig. 2 first. It could be useful to assume that the economy is at its initial equilibrium ($y_t = 1$), look at the extreme right of the horizontal axis, and think about a negative persistent TFP shock that raises the future TFP variance. This can be understood if we read the graphs from right to left. We can see that this shock lowers output and domestic absorption. Given the persistence of the shock and the rise in TFP volatility, consumption and investment jointly decrease in a magnitude larger than the fall in output ($|\Delta c_t + \Delta i_t| > |\Delta y_t|$). As a result, the current account surplus improves ($\Delta ca_t = \Delta(y_t - c_t - i_t) > 0$). Given that output decreases but the current account increases, we observe a negative comovement. This is the conventional negative link that appears in the left side of Fig. 1 (see Section 2). In this case, the increase in TFP volatility just reinforces the effects of the persistent TFP shock.

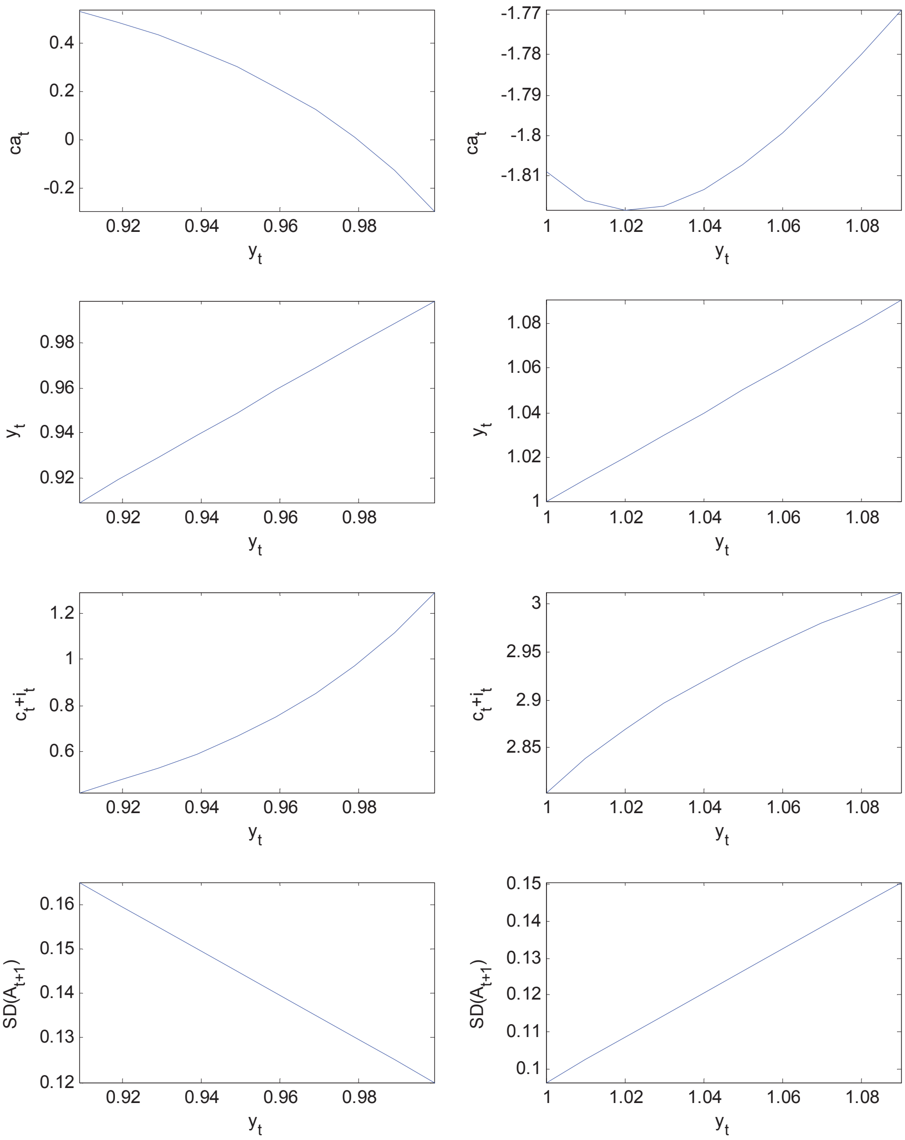

Fig. 2. Persistent TFP Shock and Uncertainty TFP Shock ($\sigma = 2$). Left side: increase in A_t and A^L ($\Delta A_t > 0$, $\Delta E(A_{t+1}) > 0$, $\Delta V(A_{t+1}) < 0$). Right side: increase in A_t and A^H ($\Delta A_t > 0$, $\Delta E(A_{t+1}) > 0$, $\Delta V(A_{t+1}) > 0$). Notation: $ca \equiv$ current-account-to-GDP ratio, $y \equiv$ output, $c+i \equiv$ consumption plus investment (absorption), $SD(A_{t+1}) \equiv$ standard deviation of future TFP.

Let us look at the right side of Fig. 2 now. Assume again that the economy is at its initial equilibrium ($y_t = 1$), at the extreme left of the horizontal axis. This time, there is a positive persistent shock in the TFP level that also increases the variance of future TFP. We observe the opposite effect on the current account due to one important difference; output increases more than the jointly rise in consumption and investment ($\Delta y_t > \Delta c_t + \Delta i_t$). The larger volatility that the risk-averse agent faces discourages investment (because physical capital becomes riskier) and consumption (due to precautionary motives), counteracting only partially the increase in such variables caused by the higher productivity. The result is an improvement of the current account surplus ($\Delta ca_t = \Delta(y_t - c_t - i_t) > 0$). In this case, the expansion of output is accompanied with an improvement in the current account, showing a positive comovement. This link would correspond to the right side of Fig. 1 (see Section 2).[13]

Some comments are worth pointing out. First, given equation (8), the effects of the changes in A^H or A^L on the expected future productivity ($E(A_{t+1})$) are linear. Both current and expected TFP change linearly when we observe such shocks.[14] Second, our explanation is consistent with the procyclicality of both consumption and investment. Third, there is evidence that uncertainty is higher during recessions as our simple model predicts (see Fig. 2, first column, last row) and on the existence of time-varying uncertainty shocks (see Section 3.4 below). Likewise, Fogli and Perri (2006, 2015) link the so-called Great Moderation to the deterioration of the U.S. external position and current account as a sort of structural break in the early 1980s. That said, a fully satisfactory explanation requires the formulation of a complete DSGE model, quantitatively capable of replicating the U-curve, including its turning point, and the other well-known features of the U.S. business cycle. Finally, as a robustness check, Fig. 3 shows a similar exercise assuming $\sigma = 4$ to verify that the results are even neater when risk aversion is higher.[15]

[13]In our view, the exogeneity of the world interest rate adopted to simplify the analysis does not constitute a strong assumption. The relaxation of that assumption might help the replication of the U-curve. When the economy is hit by a persistent negative TFP shock, the subsequent fall in the interest rate would attenuate the drop in domestic absorption and, therefore, the link between the current account and output. In contrast, when the economy is hit by a persistent positive TFP shock, a higher interest rate will discourage absorption, which reinforces the effect of a higher TFP volatility on the current account surplus.

[14]Altug et al. (1999) argue that Solow residuals –a usual measure of TFP shocks– are linear and do not show asymmetric behavior. However, Barro (2006) conjectures that TFP shocks show negative asymmetries caused by rare events such as financial crises. Daniel et al. (2012) find that a model with negative asymmetries in the Solow residual is a better fit for eight of eleven OECD countries than a model which imposes symmetry. They add large oil price increases to Barro's list of extreme events. For the explanations on and evidence of the asymmetric relationship between oil prices and GDP, see Balke et al. (2002) and the references therein. This is also relevant because negative TFP shocks can be interpreted in the model as rising oil prices, rather than technological regress.

[15]The intertemporal approach of the current account views the current account surplus as the result of forward-looking dynamic decisions of saving and investment based on expectations of, for example, future TFP growth (Obstfeld and Rogoff, 1995). Now, the U-shaped relationship is teaching us something new about this approach in the short run: That the reaction of the current account surplus to certain TFP shocks depends on the state of the economy and uncertainty. When there is a persistent increase in TFP (coupled with an uncertainty rise), analysts should not necessarily expect a negative response as the conventional view argues. In other words, the current account can improve during expansionary periods.

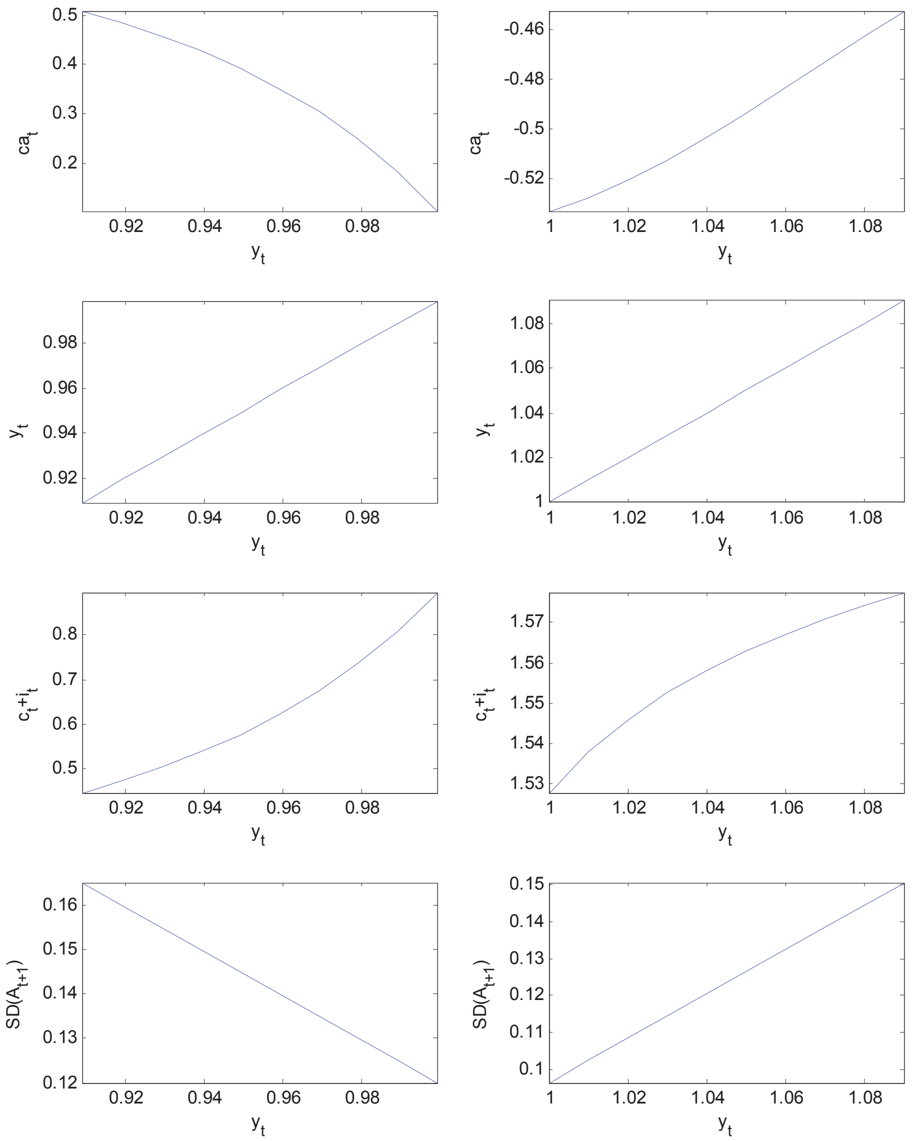

Fig. 3. Persistent TFP Shock and Uncertainty TFP Shock ($\sigma = 4$). Left side: increase in A_t and A^L ($\Delta A_t > 0$, $\Delta E(A_{t+1}) > 0$, $\Delta V(A_{t+1}) < 0$). Right side: increase in A_t and A^H ($\Delta A_t > 0$, $\Delta E(A_{t+1}) > 0$, $\Delta V(A_{t+1}) > 0$). Notation: $ca \equiv$ current-account-to-GDP ratio, $y \equiv$ output, $c+i \equiv$ consumption plus investment (absorption), $SD(A_{t+1}) \equiv$ standard deviation of future TFP.

3.4 Empirical Evidence on TFP Volatility Shocks

One way that the literature has used to model this type of shock is via GARCH models. Empirical evidence of this type of shocks in the U.S. economy is provided by works such as Bloom et al. (2012) and Fogli and Perri (2015). We also found evidence that the cyclical component of TFP follows a GARCH-type model as the one given by equations (3) and (4) during the baseline period of analysis:

$$TFP_t = \underset{(0.01)}{0.035} + \underset{(0.019)}{0.89}\, TFP_{t-1} + \sigma_t \epsilon_t$$

$$\sigma_t^2 = \underset{(0.002)}{0.008} + \underset{(0.14)}{0.886}\epsilon_{t-1}^2 + \underset{(0.058)}{0.225}\sigma_{t-1}^2, \qquad R^2 = 0.81,\ N = 145$$

Robust standard errors are reported in parentheses. All of the coefficients, especially those of the variance equation, are statistically significant at 1%. Note that a change in ϵ_t modifies not only the current level of TFP but also its future variance (σ_{t+1}^2). The construction of the TFP series is explained in Appendix B.2. Further details about these results are available upon request.

As indirect evidence of these shocks in the U.S. economy, it is worth mentioning that GARCH-type models of GDP growth have been estimated by Lee (1999), McConnell and Perez-Quiros (2000), DeJong et al. (2005), among many others.[16]

3.5 Other Possibility to Explore

Although we argue that TFP volatility shocks can play an important role, it is also plausible to think on a transmission mechanism that could be behind the asymmetry we find and reinforcing the effects of those shocks. Hansen and Prescott (2005) provide a mechanism that could be helpful to reproduce the U-shaped curve. They show that occasionally binding capacity constraints, introduced to an otherwise standard RBC model, can generate deepness in GDP cycles (troughs that are deeper on average than peaks are tall). Their economy has two types of capital which they call "equipment" and "location". The latter is identified with long-run capacity. The economy can operate at full capacity in that all locations are operated, or it can operate at less than full capacity if an insufficient amount of labor is employed to operate all locations. This feature allows them to replicate the degree of deepness that investment and hours worked show in the U.S. data.

Suppose this economy is open and at its steady-state equilibrium. A negative persistent TFP shock, either small or large, can cause the usual negative linkage between the current account and output. If the positive shock is large enough, though, the capacity constraint can bind and total investment would not change as much as in the case of a negative shock of the same magnitude. That is, domestic absorption might increase but less than the increase in output, causing an improvement of the current account. Note that this positive link will show up only when the positive shock is sufficiently large such that the capacity constraint binds. The potentially interesting aspect here is that this could explain why the positive relationship is observed when the economy is 1% above its long-run trend. Thus, rather than being a competitive conjecture, this mechanism could complement our prior explanation.

[16] Van Nieuwerburgh and Veldkamp (2006) propose a theoretical model that can generate endogenously such a GARCH-type behavior if agents can use Bayesian learning.

4 Concluding Remarks

In this paper we report an empirical regularity previously ignored in the literature. We find that fluctuations of the U.S. current account over the business cycle resemble a stylized U shape. When output is below its long-run trend, the U.S. current account and the GDP cycle tend to move in opposite directions as the literature traditionally finds. However, when output is above its long-run trend (approximately 1% above its trend), the U.S. current account and the GDP cycle tend to show a positive comovement. This empirical relationship is relatively stable over time and robust to a number of alternative measures of the external imbalance and cyclical components of GDP, as well as econometric specifications.

Some final remarks to summarize our contribution and findings are in order. First, to the best of our knowledge, this is the first paper in the literature that studies the cyclicality of the U.S. current account using a battery of nonparametric estimators and tests. We hope to motivate researchers to use this approach to analyze external imbalances in advanced countries, and avoid the misspecification problems that parametric models can entail. Second, we challenge the conventional view of the standard RBC literature that only seeks to explain a linear relationship (correlations) between the current account surplus and the GDP cycle. Correlations and linear models are simplifications that are useful as a first approximation to study a phenomenon. However, reality is usually more complex. We show that the U.S. current account and the business cycle are related in a nonlinear way. Ignoring this nonlinearity can lead to two undesired outcomes. One the one hand, the linear approximation can be nonsignificant. Actually, the correlation between the U.S. current account and the GDP cycle is slightly negative but not statistically significant (see also the slope estimate in Table A2, column 1). Based on this result, the observer could jump to the conclusion that the U.S. current account is acyclical (or, at most, weakly countercyclical). On the other hand, at trying to match such a correlation, the researcher will be induced to formulate a misspecified model (omission of, for example, uncertainty shocks). A more precise estimate of the relevant facts allows us to construct a more robust model, which can be potentially used to design better policies. Third, we argue that this nonlinearity has a explanation based on uncertainty shocks. Persistent TFP shocks are useful to explain a linear (negative) link between the current account and the GDP cycle, but not the nonlinearity reported in this paper. We argue that if we want to understand the U-curve, we also need shocks of uncertainty about future TFP. In this sense, our paper also contributes to the literature that highlights the importance of changes in the variance of TFP shocks to understand the dynamics of the U.S. current account (Fogli and Perri, 2006; 2015). We extend this branch of the literature by providing a short-run perspective that analyzes the current account dynamics over the business cycle.

Appendix

A Sensitivity Analysis

A.1 Alternative Definitions of the External Imbalance

Is this finding associated with a particular definition of external imbalance? Our results do not change significantly when we use net exports-to-GDP ratio, the current account-to-potential GDP ratio, the detrended current-account-to-GDP ratio, and the current account-to-net output ratio (see Fig. A1). For instance, the U-shaped curve remains almost invariant if we use potential GDP to rescale the current account surplus. This leads us to conclude that the denominator of the ratio is not generating the nonlinearity. In addition, the use of the net exports-to-GDP ratio –perhaps, not surprisingly– does not alter our main result.

It is interesting to note that the asymmetry remains even if we adopt the detrended current-account-to-GDP ratio under the assumption that the series contains a stochastic trend. A motivation to detrend the U.S. current account is the fact that we are not able to reject an apparent unit root using standard tests for the period of analysis.[17] We continue, however, using the dependent variable as constructed in the previous section because of several reasons. First, it is well known that univariate unit-root tests tend to not reject the unit-root hypothesis because the sample is not sufficiently large. Taylor (2002) rejects the presence of a unit root in the current account of the U.S. and other 14 countries in a long-span study whose sample starts in 1850. Second, there are works that provide evidence against unit roots using panel data studies (see Wu et al. 2001). Moreover, from a theoretical viewpoint, the stationarity of the current account surplus is consistent with the representative consumer's long-run budget constraint in a standard equilibrium model (see Trehan and Walsh, 1991).

[17] The statistic of the Elliot-Rothenberg-Stock DF-GLS test is -0.27 and we cannot reject the null of a unit root at conventional significance levels.

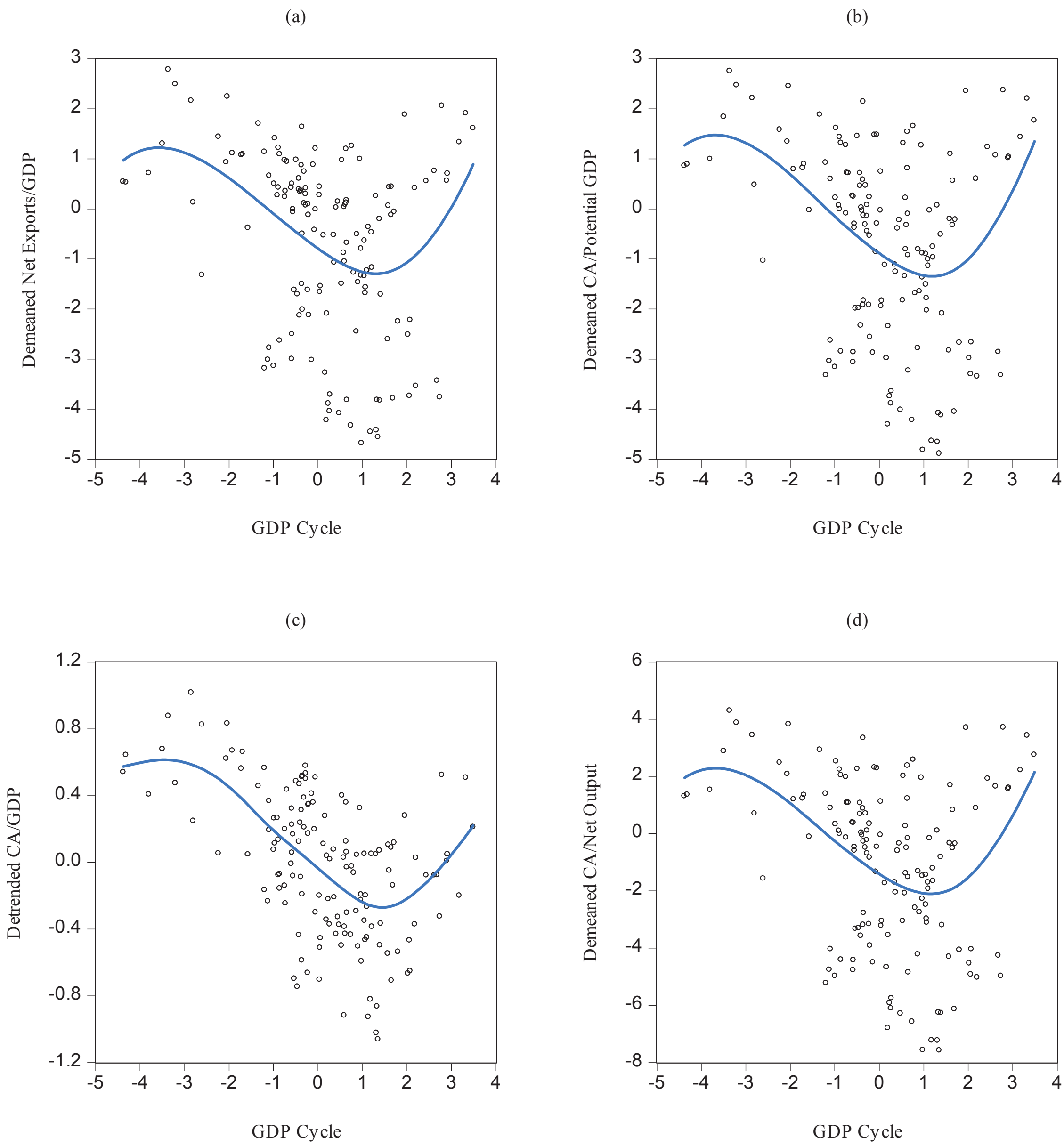

Fig. A1. Kernel Fit between Alternative Definitions of the External Imbalance and GDP Cycle (US: 1973.1-2012.1). (a) Net Exports/GDP. (b) Current Account/Potential GDP. (c) Detrended Current Account/GDP. (d) Current Account/Net Output.

A.2 Alternative Measures of the GDP Cycle

Is this finding related to the choice of the GDP cycle measure? The asymmetric link reported earlier is basically preserved if we change the number of lags of the Baxter-King approximation or use other detrending techniques (see Fig. A2). The use of the traditional filter proposed by Hodrick and Prescott (1997) and the band-pass filter proposed by Christiano and Fitzgerald (2003), tend to leave the results basically unchanged. The exception is perhaps the first-difference filter that shows a slight U-shaped curve with some deviations at the extreme values of the economic cycle (see Fig. A2 (c)). However, the first-difference filter is infrequently used in the literature probably because its relatively low success in isolating the cyclical component from the trend.[18]

[18] We also estimate the U-curve reducing the range for the cyclical component of output to +/− 2% using the $BP_{12}(6,32)$. This implies a reduction in the sample size of approximately 24% (from 157 to 127 observations). Even though the shape of the curve is affected, the U-curve link is still present. This result is available upon request.

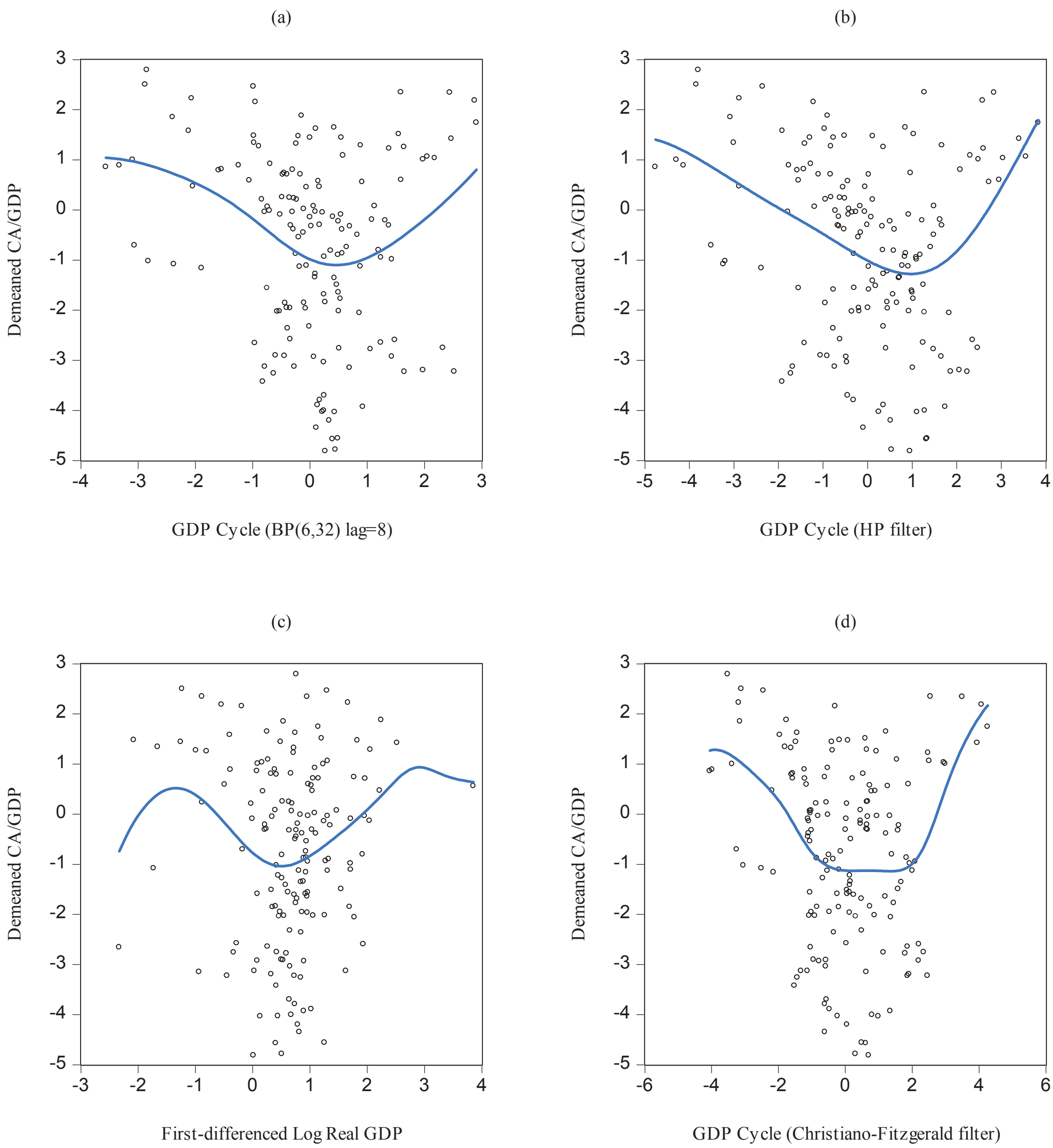

Fig. A2. Kernel Fit between Demeaned Current Account/GDP and Alternative Measures of the GDP Cycle (US: 1973.1-2012.1), using (a) BP Filter and 8 lags. (b) HP filter. (c) GDP Growth. (d) Christiano-Fitzgerald Filter.

A.3 Sample Periods

Is this finding present in a particular period of time or caused by the latest sample points? Our main result also survives for different subsamples (see Fig. A3). If we estimate the nonparametric model for the periods 1957-1970, 1973-1982, 1986-1997, and 1999-2012, the U-shaped curves tend to appear with slight modifications.

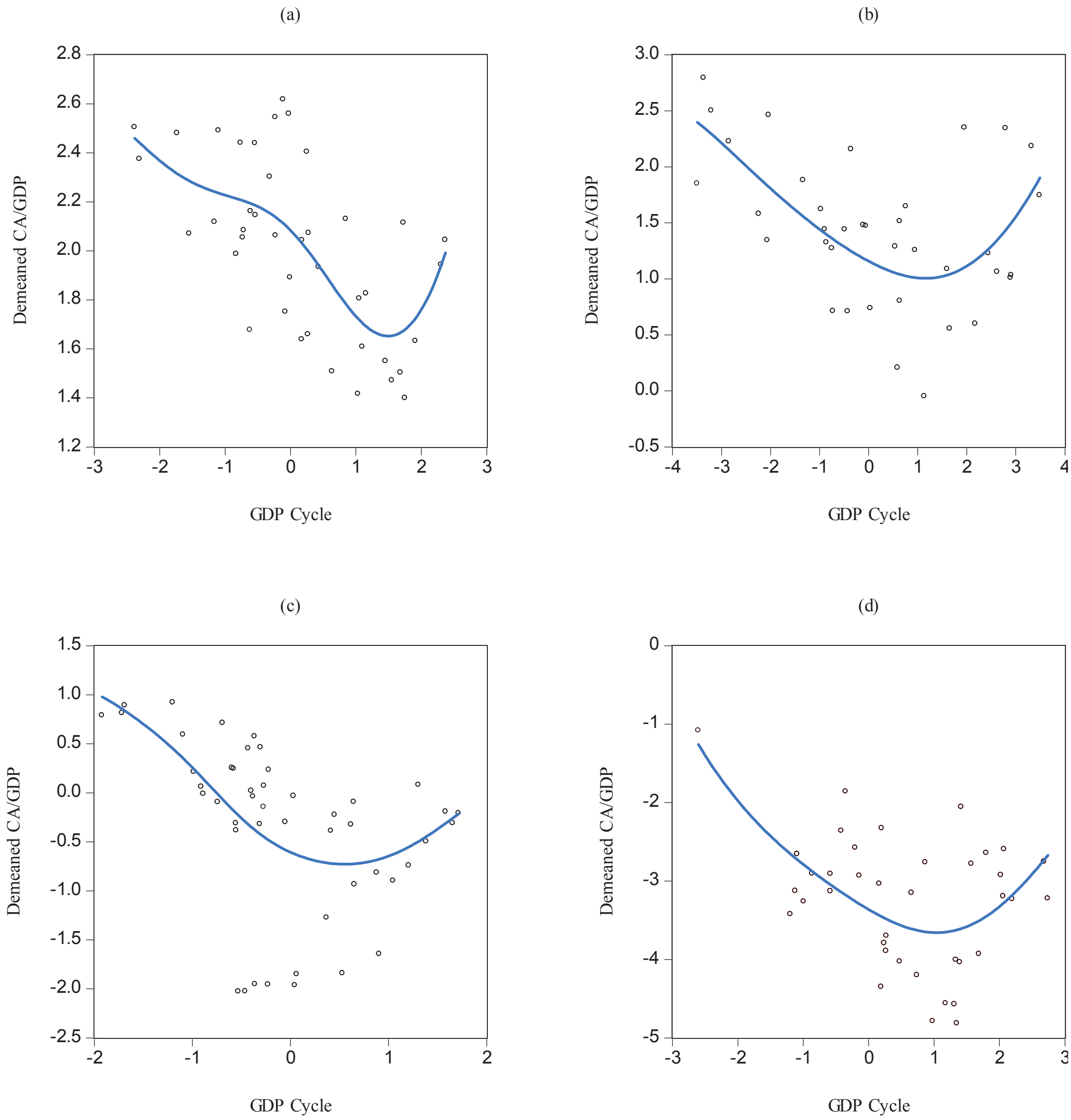

Fig. A3. Kernel Fit between Demeaned Current Account/GDP and the GDP Cycle, Different Sample Periods. (a) 1957-1970. (b) 1973-1982. (c) 1986-1997. (d) 1999-2012.

The idea in this case is to check our estimates after dropping a few observations closely related to periods of large shocks or sharp transitions such as the oil shock and the end of the Bretton-Woods era during the early 1970s, the beginning of the Great Moderation in the early 1980s,[19] and the aftermath of the Asian Financial Crisis during the late 1990s.[20] Interestingly, the curves tend to appear during periods of external surpluses (1957-1982) and external deficits (1986-2012).[21]

A.4 Econometric Issues

Is this finding caused by the particular selection of the bandwidth or the density function? It is widely known in the nonparametric econometrics literature that kernel estimates are sensitive to the choice of the bandwidth.[22] Hence, we investigate the sensitivity of our results to variations in the bandwidth estimate h. Fig. A4(a) and A4(b) plot the kernel regression fits using bandwidths 50% below and 50% above, respectively, of our estimated bandwidth in the baseline regression (see Fig. 1). In addition, Fig. A4(c) displays the fit with an Epanechnikov density function, while Fig. A4(d) checks if our estimates are sensitive to the adoption of the commonly used Nadaraya-Watson estimator.[23]

[19] Fogli and Perri (2006) argue that the so-called Great Moderation implied a sharp deterioration of the U.S. current account in the early 1980s.

[20] A drift in the deterministic intercept in current account regressions is reported in panel data studies. Gruber and Kamin (2007) find that an intercept dummy that controls for the Asian financial crisis is statistically significant in explaining medium-term fluctuations in the current accounts of 61 countries. Chinn et al. (2013) suggest that there is some sign of a structural break in the 1996-2000 period for a group of industrialized countries.

[21] The careful reader will notice that the curve estimated for the 1999-2012 period (Fig. A3 (d)) starts at a point on the upper-left side of the scatter plot, close to an observation that seems far from the rest of the data. To check sensitivity again, we drop such observation and find that the U-curve remains basically unaltered.

[22] See Fan and Yao (2003), Hardle et al. (2004).

[23] Our results are also not highly sensitive to the use of (i) the triangular and uniform densities, (ii) higher polynomial degrees of the local estimator (2 or 3), and (iii) the nearest neighbor estimator with similar polynomial degrees. This set of results is not reported but available upon request.

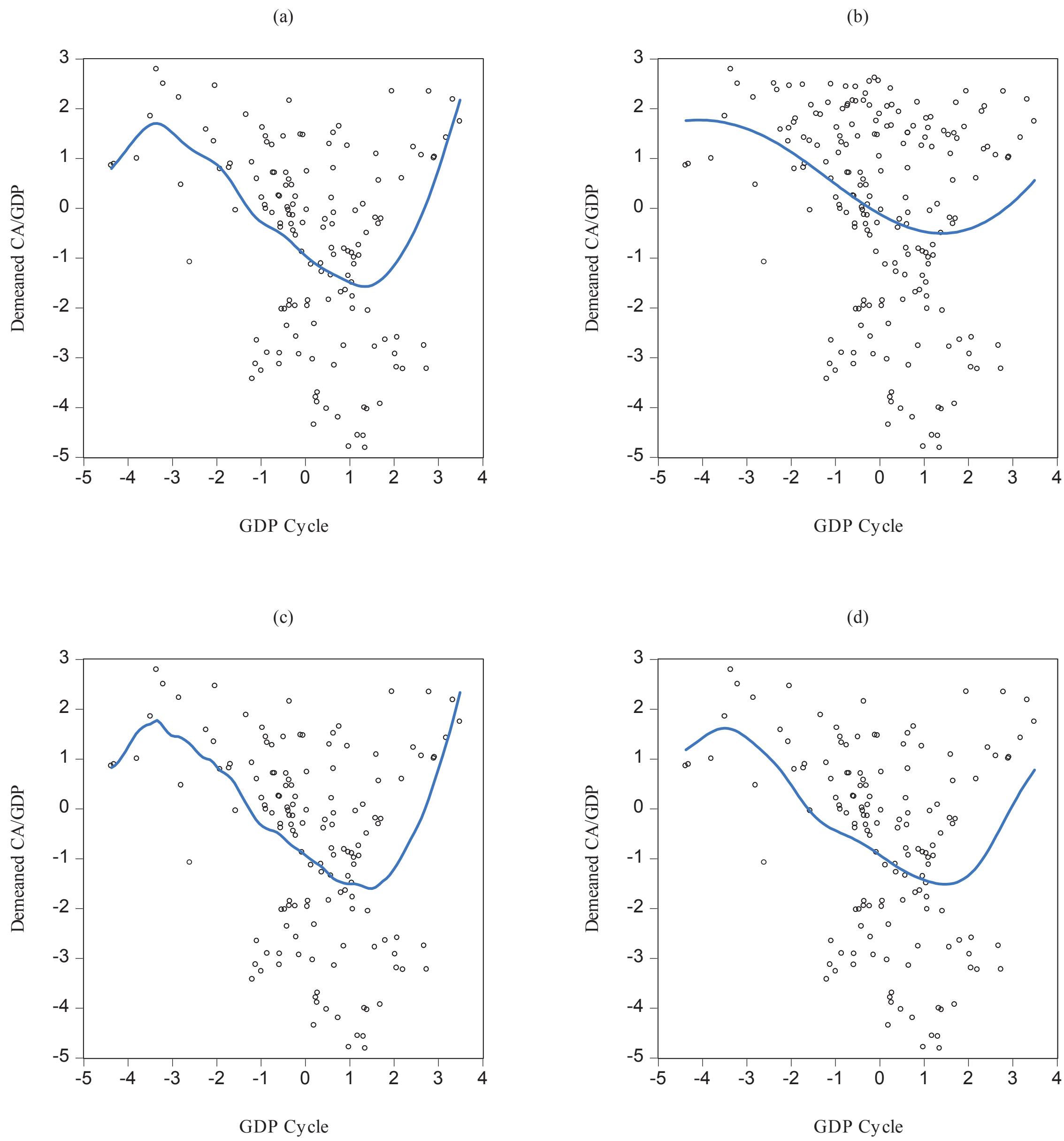

Fig. A4. Kernel Fit between Demeaned Current Account/GDP and the GDP Cycle, Different Sample Periods. (a) Low Bandwidth (h=0.5). (b) High Bandwidth (h=1.5). (c) Epanechnikov Density. (d) Nadaraya-Watson estimator.

A.5 Other Industrialized Economies

Is this finding observed in other similar economies? We verify whether this asymmetry is also present in other G7 industrialized economies. Based on a visual inspection of Fig. A5 (a) through (f), we are inclined to claim that the U-shaped curve is not observed in most of the G7 countries for the same or similar sample period.

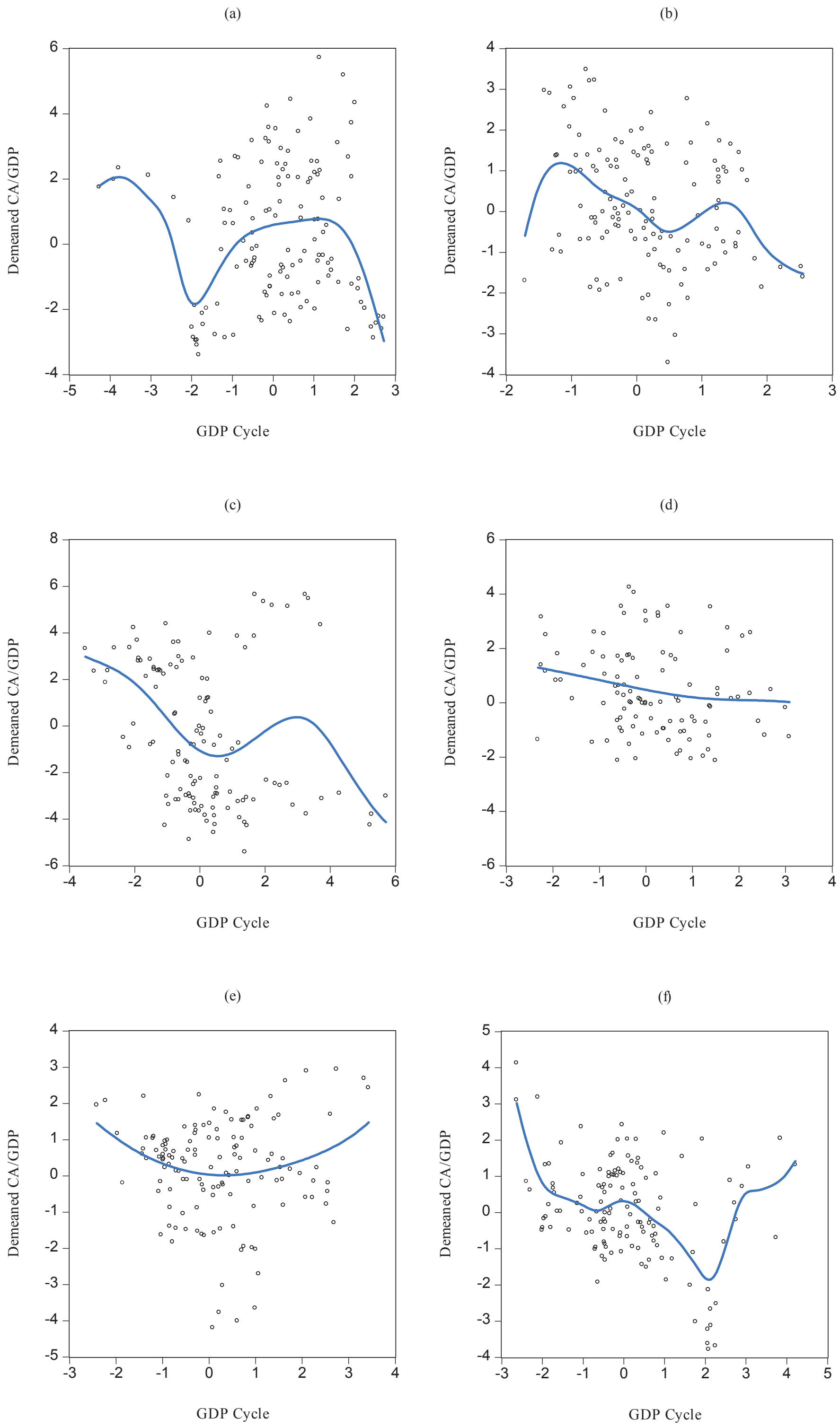

Fig. A5. Kernel Fit between Demeaned Current Account/GDP and the GDP Cycle. (a) Canada: 1973.1-2012.1. (b) France: 1973.1-2012.1. (c) Germany: 1978.1-2012.1. (d) Italy: 1983.1-2012.1. (e) Japan: 1973.1-2012.1. (f) United Kingdom: 1973.1-2012.1.

The exceptions are Japan and the United Kingdom. In the first case we observe a relatively flat U-shaped curve (Fig. A5(e)). In the latter case, the UK curve seems to be U-shaped but with some irregularities especially on the range of negative values of the GDP cycle (Fig. A5(f)).

A.6 Omission of Potentially Relevant Variables

Could the omission of a relevant driver of the current account surplus be artificially generating this result? We address this question by using a multiple-regressor nonparametric and a parametric analysis. In general, the U-shaped link survives even if we condition to other regressors. It is important to mention that this section does not attempt to provide a model that *explains* the current account behavior. The only purpose is to check whether the U-curve is caused by an omission of possibly relevant variables.

A.6.1 Statistical Significance in a Multiple-Regressor Nonparametric Model

In order to test whether the statistical significance of the GDP cycle remains unaltered in the presence of other regressors, we use a similar nonparametric regression by which the current account-to-GDP ratio is related to the cyclical component of GDP as well as other determinants:

$$ca_t = m(y_t, \mathbf{x_t}) + \varepsilon_t \tag{12}$$

where $\mathbf{x_t}$ contains (i) the real exchange rate, (ii) the fiscal surplus-to-GDP ratio, (iii) the relative price of oil, and (iv) the real interest rate. The choice of these variables is motivated by the literature which attempts to explain the dynamics of the U.S. current account.[24] Appendix B describes the construction of each variable. As Table A1 shows, the p-value associated with the GDP cycle is 0.016, thus we can reject the null of statistical irrelevance at 5% (see last row of Table A1). That is, the current account surplus and the GDP cycle are still statistically associated if we control for potential drivers.

[24] For example, a number of works based on DSGE models suggest that the U.S. current account is driven by fiscal shocks (Bussière et al., 2010) and oil prices (Bodenstein et al., 2011). Others highlight the role of the real exchange rate (Chinn and Prasad, 2003). The real interest is included to capture the possibility of a world saving glut, which affects the current account via a lower international cost of borrowing (see Bernanke, 2005). In addition, Kim (2001) emphasizes the role of monetary policy and interest rates in explaining movements of the U.S. current account.

TABLE A1
Tests of significance for non-parametric regressions.

	P-value of GDP cycle measure	Residual standard error	R-squared	Number of observations
Single-regressor specifications				
Figure				
1	0.000	1.664	0.230	145
A1(a)	0.000	1.605	0.217	145
A1(b)	0.001	1.668	0.232	145
A1(c)	0.000	0.337	0.389	145
A1(d)	0.000	2.584	0.236	145
A2(a)	0.002	1.722	0.153	149
A2(b)	0.000	1.687	0.207	145
A2(c)	0.026	1.734	0.106	157
A2(d)	0.009	1.669	0.222	145
A3(a)	0.058	0.261	0.456	41
A3(b)	0.014	0.527	0.357	37
A3(c)	0.005	0.714	0.299	47
A3(d)	0.053	0.713	0.273	38
A4(a)	0.093	1.642	0.245	145
A4(b)	0.000	1.692	0.205	145
A4(c)	0.000	1.666	0.227	145
A4(d)	0.016	1.663	0.232	145
A5(a)	0.031	1.852	0.241	133
A5(b)	0.063	1.331	0.194	133
A5(c)	0.000	2.650	0.222	123
A5(d)	0.042	1.578	0.043	105
A5(e)	0.024	1.324	0.089	132
A5(f)	0.081	1.072	0.407	133
Multiple-regressor specification				
	0.016	0.638	0.891	145

Notes: P-values correspond to the consistent test of significance proposed by Racine *et al.* (2006). The null hypothesis is related to whether the cyclical measure of GDP is statistically irrelevant. The test uses cross validation for bandwidth selection and wild bootstrap with 1000 replications. The only regressor in the bivariate specification is GDP cycle. In the multiple-regressor specification, we additionally include real exchange rate, fiscal surplus-to-GDP ratio, relative price of oil, and real interest rate. See Appendix B for the definition of the dependent variable and the regressors in each case. The coefficient of determination ("R-squared") is the one proposed by Doksum and Samarov (1995).

A.6.2 A Parametric Approximation

As Li and Racine (2007) argue, nonparametric techniques adopt fewer assumptions about the object being estimated than do parametric techniques. Consequently, nonparametric estimators show slower converge rates to the population objects than parametric estimators when these are correctly specified. The convergence rate of nonparametric estimators is usually inversely related to the number of regressors included. This issue is sometimes called the "curse of dimensionality". Under the assumption of a correct specification, one possibility to overcome the slower convergence rates is to use a parametric estimator.

Given the U-shaped link between the current account surplus and the GDP cycle, we can reasonably approximate this relationship using a quadratic polynomial of y_t. This strategy allows to verify if the omission of a potentially relevant variable determines such a relationship and have another estimate of the turning point of the curve without the need of choosing a nonparametric estimator, a kernel density, or a bandwidth. Thus, we estimate

$$ca_t = \beta_0 + \beta_1 y_t + \beta_2 y_t^2 + \mathbf{x_t}\gamma + \varepsilon_t \tag{13}$$

where $\mathbf{x_t}$ is the row vector of regressors previously defined and γ is the corresponding column vector of coefficients. We are particularly interested in β_1 and β_2. A statistically significant $\beta_2 > 0$ should be consistent with the U-shaped link reported before. Table A2 reports the slopes estimates and their HAC standard errors. The first column of the table shows that the simple linear approximation, which omits the quadratic term of the GDP cycle (and other regressors), might mislead to the conclusion that the current account is not statistically associated with the GDP cycle. One would conclude that the current account is acyclical. Column 2 adds the quadratic term. Finally, column 3, includes all of the regressors.[25] As we can see, the coefficient estimate of the quadratic term, β_2, is positive and its statistical significance remains at conventional levels even in this parametric approximation. Table A2 also shows an estimate of the turning point, the lowest value of the U-curve relationship and its corresponding 95% confidence interval. The estimated turning points are 0.88% and 1.19% (see columns 2 and 3 in Table A2).

[25] We obtain theoretically plausible coefficient signs of the additional regressors but only the real exchange rate is statistically significant. Regarding the sign of the relative oil price, Kilian et al. (2009) argue that the effect of oil price changes can be different depending whether the source of the change is a supply or demand shock.

TABLE A2

Parametric regressions. Dependent Variable: Current account surplus / GDP.

	[1]		[2]		[3]	
GDP cycle	-0.335		-0.274		-0.403	*
s.e.	0.214		0.194		0.224	
Squared GDP cycle	…		**0.156**	**	**0.169**	**
s.e.			0.076		0.072	
Real exchange rate	…		…		-0.075	**
s.e.					0.030	
Fiscal surplus	…		…		0.158	
s.e.					0.157	
Relative price of oil	…		…		0.002	
s.e.					0.013	
Real interest rate	…		…		0.053	
s.e.					0.135	
Statistics						
R-squared	0.070		0.155		0.276	
Adjusted R-squared	0.064		0.143		0.245	
AIC	4.065		3.984		3.883	
BIC	4.106		4.045		4.027	
Turning point	…		0.88		1.19	
95% confidence interval	…		[0.84 0.91]		[1.15 1.23]	
No. of observations	145		145		145	

Notes: HAC standard errors are reported in parentheses. A symbol * denotes p-value lower than 10%, ** p-value lower than 5%, *** p-value lower than 1%. Intercepts are not reported. In column (3) we also include as regressors the real exchange rate, fiscal surplus-to-GDP ratio, relative price of oil, and real interest rate. See Appendix B for the definition of the dependent variable and the regressors in each case.

B Definitions and Data Sources

Current account surplus/GDP (ca): defined as (Exports -Imports + Net Primary Income from Abroad)/nominal GDP, expressed in percentages. Both numerator and denominator variables are expressed in current U.S. dollars.

GDP cycle (y): cyclical component of logged real GDP, expressed in percent deviations from its trend component obtained using the approximation by Baxter and King (1999) to the $BP_{12}(6, 32)$ filter.

Source: Authors' calculations using data from the Bureau of Economic Analysis (BEA).

B.1 Variables used in the sensitivity analysis

Net exports/GDP in Fig. A1(a): defined as (Exports-Imports)/nominal GDP, expressed in percentages. Both numerator and denominator variables are expressed in current U.S. dollars.

Current account surplus/potential GDP in Fig. A1(b): ca scaled by potential GDP. The latter is the trend component of nominal GDP obtained using a BK filter.

Detrended current account surplus/GDP in Fig. A1(c): cyclical component of ca/y, expressed in percent deviations from its trend component obtained using a BK filter.

Current account surplus/net output in Fig. A1(d): ca scaled by net output defined as (GDP-Gross Fixed Capital Formation-Public Final Consumption Expenditure).

GDP cycle in Fig. A2(a): cyclical component of logged real GDP, expressed in percent deviations from its trend component obtained using the Baxter-King (1999) approximation to the $BP_8(6, 32)$ filter.

GDP cycle in Fig. A2(b): cyclical component of logged real GDP, expressed in percent deviations from its trend component obtained using the Hodrick and Prescott (1997) filter.

GDP cycle in Fig. A2(c): first difference of logged real GDP, expressed in percentages.

GDP cycle in Fig. A2(d): cyclical component of logged real GDP, expressed in percent deviations from its trend component obtained using the Christiano-Fitzgerald (2003) full-sample asymmetric filter.

Figs. A3(a)-(d): Dependent variable and regressor used in the baseline regression of Fig. 1 but for the periods 1957.1-1970.1, 1973.1-1982.2, 1986.1-1997.3, 1999.4-2012.1, respectively.

Figs. A4(a)-(d): Dependent variable and regressor used in the baseline regression of Fig. 1 but with $h = .5$ (a), $h = 1.5$ (b), Epanechnikov density (c), and Nadaraya-Watson estimator (d).

Figs. A5(a)-(d): Dependent variable and regressor used in the baseline regression of Fig. 1 but for Canada (1973.1-2012.1), France (1973.1-2012.1), Germany (1978.1-2012.1), Italy (1983.1-2012.1), Japan (1973.1-2012.1), and United Kingdom (1973.1-2012.1).

Source: Authors' calculations using data from the BEA (U.S. time series) and the International Financial Statistics (IFS) of the International Monetary Fund (other countries' time series).

B.2 Other Regressors

Real exchange rate: Log of the real trade weighted U.S. dollar index, expressed in percentage. The index is the price-adjusted weighted average of the foreign exchange value of the U.S. dollar against the currencies of a broad group of major U.S. trading partners (Euro Area, Canada, Japan, Mexico, China, United Kingdom, Taiwan, Korea, Singapore, Hong Kong, Malaysia, Brazil, Switzerland, Thailand, Philippines, Australia, Indonesia, India, Israel, Saudi Arabia, Russia, Sweden, Argentina, Venezuela, Chile and Colombia). An increase of this variable indicates a real appreciation of the U.S. dollar. Source: Federal Reserve Economic Data (FRED).

Fiscal surplus-to-GDP ratio: Ratio of the primary fiscal surplus (government current receipts minus government current expenditures) to GDP, expressed in percentages. Both numerator and denominator variables are expressed in current U.S. dollars. Source: Authors' calculations using data from the BEA.

Relative price of oil: BP detrended log of the ratio of the WTI oil price index to the Consumer Price Index, expressed in percentage. Source: Authors' calculations using data from FRED for the WTI oil price, and the IFS for the export price index.

Real interest rate: $100 \times log((1+i)/(1+\pi))$, where i is the 10-Year Treasury Constant Maturity Rate, and π denotes the ex-post CPI inflation rate. Source: Authors' calculations using data from FRED.

When necessary, the variables described above were seasonally adjusted.

B.3 Series of Total Factor Productivity

Total factor productivity is calculated as the BP detrended logged Solow residual, expressed in percent change. The Solow residual as a proxy of total factor productivity (TFP) is defined as $TFP_t = Y_t/(K_t^{\alpha} N_t^{1-\alpha})$, where Y denotes real GDP (source: BEA), K is the stock of capital, N stands for total hours worked, and $0 < \alpha < 1$ is the capital share. The capital stock is constructed using the perpetual inventory method using investment (gross fixed capital formation plus change in inventories; BEA) adjusted by the GDP price deflator (BEA), a depreciation rate $\delta = 0.025$ per quarter, and an initial level of $K_0 = I_0/(\delta + g_I)$, where I_0 denotes real investment in period 0 (assumed to be equal to the actual level observed in 1957.I), and g_I is the growth rate of real investment obtained from estimating $log(I_t) = g_0 + g_I t + \epsilon_t$ for $t = 1957.I, ..., 1966.IV$. We assume that $\alpha = 0.36$. Total hours worked are the product of weekly hours per quarter and number of persons at work (BEA).

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