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Empirical and Thematic Perspectives

Stall Speeds and Spillovers: Some New Evidence for the Global Economy

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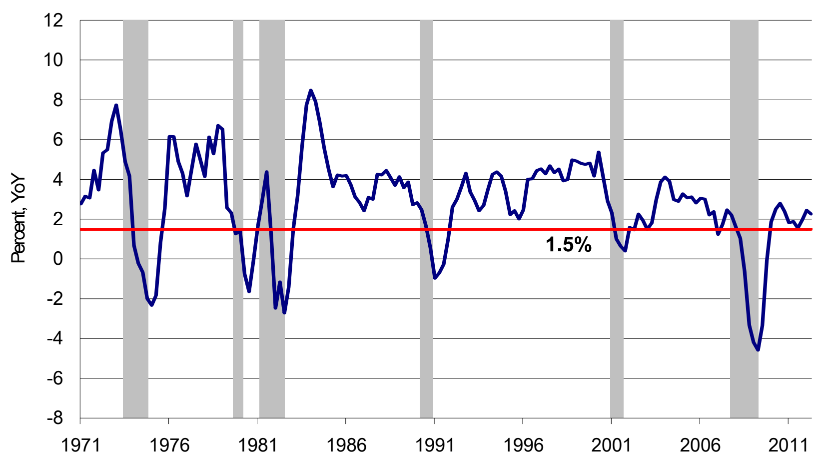
- The evidence presented in this essay points to a “stall speed” for U.S. real GDP growth. Specifically, when U.S. growth has cut below 1½ percent on a rolling four-quarter basis, it has tended to fall by nearly 3 percentage points over the following four quarters, and the economy has typically entered recession. With U.S. growth now running at 2¼ percent on this basis, we see the economy as being vulnerable to intensified stresses in Europe or disruptions associated with the U.S. “fiscal cliff.”
- The growth performance of a broad group of other countries also bears the imprint of stall-speed behavior. The exact growth thresholds vary somewhat but typically fall between 1 and 2 percent, broadly similar to the United States. We also find that growth rates in a number of individual countries, as well as in the advanced economies and the emerging markets in aggregate, are now close to their stall speeds. This highlights the vulnerability of global growth to further adverse shocks.
- The theory explaining stall speeds is far from settled. Even so, we argue that stall-speed behavior may reflect that the economy is more vulnerable when growth is low. Anemic growth may be a signal that the economy is already struggling with imbalances or reeling from the effects of a previous shock. Alternatively, stall-speeds may reflect the presence of self-reinforcing negative feedback loops.
- Perhaps our most striking result regards the role of the U.S. economy in driving global growth. We find that on average a 1 percentage point contraction in U.S. growth is associated with a subsequent decline in global growth of roughly 0.2 to 0.3 percentage point, depending on the empirical model. However, we also find that the spillovers are much larger as the U.S. economy cuts through its stall speed, with the estimated sensitivity of foreign growth roughly twice as large as at other times.
- The heightened magnitude of global spillovers as the U.S. economy approaches its stall speed underscores the importance of the concept of stall-speed in thinking about the U.S. growth process and re-affirms the strong linkages that exist between the United States and the rest of the global economy. We posit that these linkages arise mainly through confidence and related financial channels.
- Two final observations are worth noting. First, given the present proximity of U.S. growth to its stall speed, the global spillovers associated with the fiscal cliff could be sizable, potentially reducing growth in the rest of the world by 1½ percentage points over the next year according to our estimates. Second, while we find that spillovers from the euro area have not been as powerful as those from the United States, we are not sanguine about the global implications of intensified stresses in Europe. Such disruptions would no doubt affect the global economy through the same kinds of channels that we have identified for the United States.

Stall Speeds and Spillovers: Some New Evidence for the Global Economy

In a previous essay, we documented the "stall-speed" features of U.S. real GDP growth.[1] As shown in Figure 1, when U.S. growth has fallen below 1.5 percent (measured on a rolling four-quarter basis), growth has tended to slow significantly further and recession has often ensued. Equivalently, when the economy has failed to maintain some minimum rate of expansion, economic growth has typically fallen off in a sharp non-linear way.

Figure 1. U.S. Real GDP Growth: Stall Speed?



Note: Shading indicates recession.
Sources: Bureau of Economic Analysis, National Bureau of Economic Research, Haver Analytics, and Citi Research.

We now seek to extend this work to the global economy more generally. We search for evidence of comparable stall-speeds for other countries and regions. We also look for interdependencies and inter-linkages in growth across regions and country aggregates. For example, how does the evolution of growth in the United States or the euro area influence growth in the other advanced economies and in the emerging markets? We search for evidence of both "linear" linkages (i.e., when growth in one region falls by a percentage point, what are the typical effects on growth elsewhere) and "non-linear" stall-speed linkages (i.e., the implications for the rest of the world when growth in one region falls below its stall speed).

We find that the growth performance of a broad set of countries bears the imprint of statistically significant stall-speed behavior. The exact thresholds vary somewhat from country to country, but in most cases are in a range of 1 to 2 percent growth, broadly similar to that for the United States. As an important related point, we find that growth rates in a number of individual countries, as well as for the advanced economies and emerging market economies in aggregate, are now close to their estimated stall speeds. This highlights the vulnerability of the global economy to further shocks going forward, especially given the limited room for maneuver of monetary and fiscal policies in some countries.

In our related work examining cross-country spillovers, we find that U.S. growth plays a powerful and unique role in driving global growth through both linear and non-linear channels. Specifically, we find that a given decline in U.S. growth reduces the pace of expansion in other countries on average by roughly 20 to 30

[1] "Is the U.S. Economy Approaching 'Stall Speed'?" November 11, 2011.

percent of the U.S. decline. We also find, however, that when the U.S. economy hits its stall speed, U.S. growth has subsequently fallen by nearly 3 percentage points, and growth in the rest of the world has declined *half* as much. Growth abroad has thus shown particular sensitivity to spillovers from the United States after the U.S. economy has hit its stall speed. A full examination of the underlying drivers of this heightened sensitivity is beyond the scope of our current essay, but we conjecture that developments in the United States have important implications for global confidence. The prospect of sharp declines in U.S. growth, as the economy crosses through stall speed, generates marked uncertainties and negative spillovers for other countries through confidence and related financial channels.

The Stall-Speed Hypothesis

In this section, we aim to put some additional flesh on the notion of stall speed. Specifically, to the extent that evidence of stall-speed or other non-linearities in the growth process prevails, what kinds of economic forces might be at work? A key point is that the concept of stall speed—borrowed from the lexicon of physics—is not a standard or conventional characteristic of neo-classical macro models. Rather, the evidence marshaled in its defense has generally been empirical in nature. With this in mind, we put forward some thoughts as to what kinds of economic forces might give rise to stall speeds.

We begin by reviewing an important paper by Nalewalk (2011),[2] which sketches out an empirical model that captures key features of the stall-speed hypothesis. He assumes that the economy has two polar states: expansion periods (when the economy grows robustly) and recession periods (when the economy contracts). The key insight, however, is that the economy does not jump directly from the expansion state into the recession state. Rather, there is a layover in an intermediate “stall speed” state in which growth is slow but still above zero.

This framework provides intuition for the notion of stall speed, but also highlights two issues that merit attention. First, as the economy moves from expansion to recession, why might there be a layover in the slow-growth stall-speed state? Second, why should low rates of growth be associated with subsequent (sometimes sharp, non-linear) declines in growth and often recessions? In the paragraphs below, we put forward three complementary explanations that seek to shed light on these questions.

Business cycles with inertia in spending. Some business-cycle theories have advanced the view that imbalances tend to arise during periods of expansion. Such imbalances eventually require a period of recession and reorganization to purge away excesses, reduce economic inefficiencies, and reverse suboptimal allocations of resources. The move into recession thus reflects the manifestation of deep self-correcting economic forces. In this framework, the economy could in principle just jump from the expansion state to the recession state. However, in practice, an array of frictions, including inertia in spending decisions and informational asymmetries, mean that growth tends to slow incrementally over time—and the economy passes through the weak-growth stall-speed phase on the way to full-blown recession. In short, consumers recognize only gradually that the economy has shifted into the adverse state and, as a result, spending and hiring decision adjust sluggishly over time.

At low growth rates, the economy may be more sensitive to shocks. Weak growth may be a signal that the economy is already struggling with imbalances or is reeling

[2] J. Nalewalk, “Forecasting Recessions Using Stall Speeds,” Finance and Economics Discussion Series, Federal Reserve Board, April 2011.

from the effects of a previous shock. Accordingly, when growth is anemic, the economy may be fundamentally more vulnerable and confidence more brittle, so a shock of *a given size* creates larger disruptions and, hence, a higher probability of recession. For example, to the extent that households and firms have drawn down their financial buffers and other resources in response to one adverse shock, a second shock may trigger significantly deeper cuts in consumption, investment, and hiring decisions as agents pull back to protect their depleted balance sheets and to minimize the risk of bankruptcy and other financial stresses.

Self-reinforcing endogenous dynamics. A key empirical point is that the interaction between adverse shocks, vulnerabilities, and imbalances may not be just additive and linear. Rather, such interactions may kick off self-reinforcing, non-linear dynamics. As such, a third explanation focuses on thresholds and endogenous economic reactions. The idea is that, as the economy slows beyond some threshold growth rate, the decline in growth—in and of itself—undercuts confidence and stokes fears that growth may continue to fall. In response, households and firms tend to cut their expenditures and begin to hunker down. Such dynamics could easily become self-reinforcing and drag growth down further.

Of course, a key question for this explanation is what factors determine the threshold growth rate? We don't have a complete answer, but the observation above that the economy may be less resilient to shocks at low growth rates strikes us as relevant. Specifically, as growth declines to levels that may signal reduced resilience to further shocks, households and firms may have incentives to pull back pre-emptively in order to reduce actual and perceived vulnerabilities. While this response is perfectly rational for each person individually, the result for the macro-economy is a marked reduction in aggregate demand. The decline in growth is thus amplified by the endogenous response of households and firms to rising economic uncertainty.

Notably, this descent into recession is not inevitable but, rather, hinges on how households and firms react to ongoing economic uncertainties. Agents are monitoring the economic environment. If they are surprised on the upside, they should adjust their plans, allowing the economy to pick-up again. But the very fact that the economy typically has not rebounded once the stall speed has been reached suggests one of two possibilities. Either households and firms are fairly good at sensing a downturn is at hand or, alternatively, the deterioration in economic conditions associated with the descent to stall speed kicks off self-reinforcing dynamics that prove very powerful and difficult to escape.

Benchmark Empirical Framework

With these conceptual perspectives in hand, we now move to evaluate statistically the intuition embedded in our U.S. stall-speed graph presented above. We consider whether the stall-speed hypothesis stands up to more thorough empirical scrutiny, both for the United States and for other countries. If so, what growth rates of real GDP are most associated with stall speeds? And once that growth rate is crossed how much does growth typically decline?

Our workhorse empirical model regresses quarterly annualized GDP growth on a set of four binary variables, which we term "stall-speed dummies." The first of these dummy variables is set equal to one if four-quarter GDP growth moved below a given threshold one quarter ago. Similarly, the other three dummies are equal to one if GDP growth moved below the given threshold two, three, or four quarters ago, respectively. We define stall speed using four-quarter GDP growth as our indicator of economic performance because we see it as providing a relatively

reliable signal of the underlying state of the economy—quarterly GDP growth tends to be much more volatile.

As such, our key questions are (1) once GDP growth falls below certain thresholds, does it subsequently have a tendency to fall further, and if so, (2) by how much does growth fall once it reaches such thresholds (which we define as the stall speed)? With this in mind, our benchmark specification is as follows:

$$\textit{Quarterly Growth}_t = \alpha + \beta_1{*}dum(1) + \beta_2{*}dum(2) + \beta_3{*}dum(3) + \beta_4{*}dum(4) + \gamma{*}Z_t + \acute{\varepsilon}_t$$

Where: dum(n) = 1, if 4-quarter growth fell below a given threshold n quarters ago.

The Z_t variables include four lags of quarterly GDP growth. The intent of these variables is to control for any general inertia that may arise in quarter-to-quarter GDP growth. This allows us to better address the question, "What are the features and size of stall speed effects over and above any standard dynamics that may influence the path of growth?"

Our discussion below focuses on the magnitude and statistical significance of the β coefficients. We interpret these coefficients as capturing the cumulative effects (over four quarters) that occur when growth moves below a given threshold. Unless noted otherwise, our model is estimated on data running from 1971:Q1 to 2012:Q1.

Estimating Stall Speeds for the Global Economy

We now estimate our stall-speed model, first for the United States and then for other countries and for global aggregates (i.e., the Advanced Economies and the Emerging Markets). Consistent with our previous essay, our work strongly supports the presence of a stall speed for the United States. We also find evidence pointing to stall speeds for other parts of the world.

Figure 2 displays our results for the United States. The bars show the sum of the estimated coefficients on the four stall-speed dummies at each breakpoint or, equivalently, the average decline in GDP growth during the four quarters immediately after growth moves below a given threshold.[3] For the United States, the distribution of these estimated coefficients reaches its peak at a threshold growth rate of around 1.5 percent. Upon crossing this threshold, growth tends to fall by nearly 3 percentage points over the following four quarters.[4]

We note that U.S. growth is currently hovering just above this stall speed. During the four quarters ending in 2011:Q3, the economy expanded 1.55 percent, not quite crossing the historically important 1.5 percent threshold. Subsequently, the pace of growth has rebounded some, to 2¼ percent, but an adverse shock—either from developments in Europe or a mishandling of U.S. fiscal policy—could easily push growth below the stall speed.

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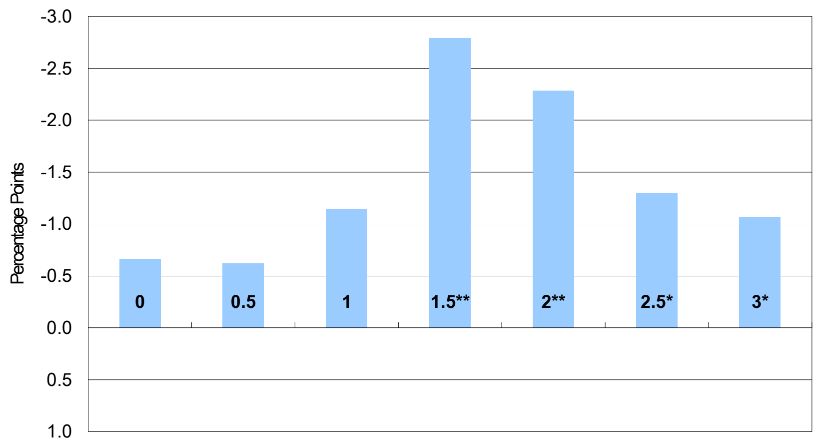
[3] In Figure 2 (and our other figures), a single asterisk indicates statistical significance at the 10 percent level; a double asterisk indicates significance at the 5 percent level.

[4] Notably, these estimates are broadly in line with Nalewalk's empirical work. He found that in his transition (stall-speed) state, economic growth tended to run around 1.5 percent and then fell roughly 3 percentage points to around -1.5 percent in the recession state.

Figure 2. U.S. Stall Speed: Does Growth Falter After Crossing a Certain Threshold?

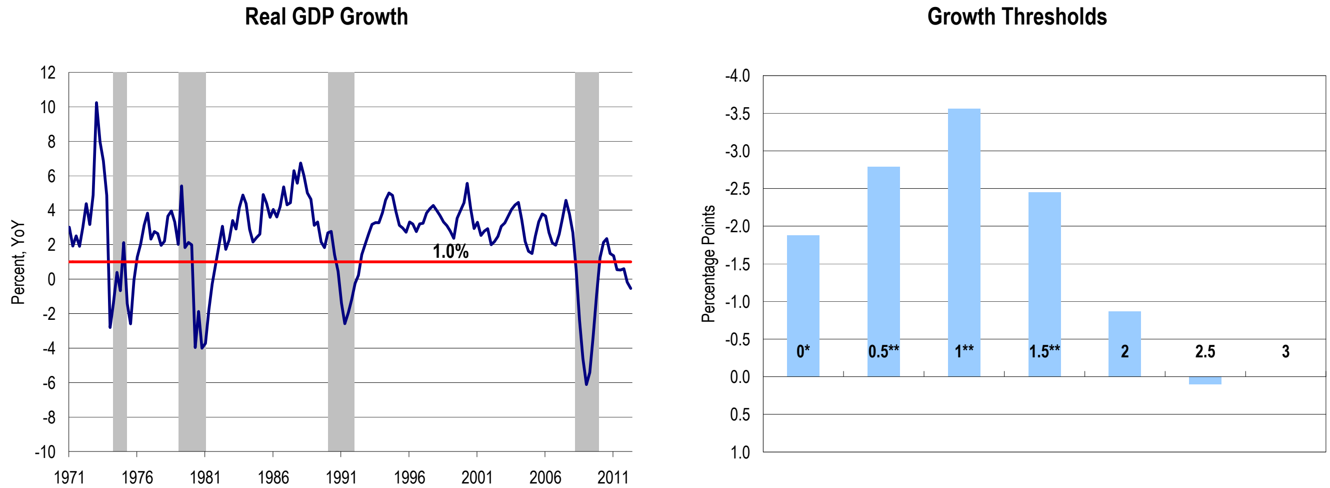


*Sum of coefficients significant at 10% level. **Sum of coefficients significant at 5% level.
Source: Citi Research.

These results suggest an important question: Why should the stall speed be 1½ percent, rather than an even lower number? Shouldn't the economy be more vulnerable to shocks at still lower rates of growth? In response, we emphasize that the properties of stall speed must be interpreted within the context of more general business-cycle dynamics. Growth does not fall forever. The economy's natural equilibration mechanisms start to manifest themselves more powerfully as growth declines, eventually halting the economy's contraction. Monetary and fiscal policy reactions may also play an important stabilizing role. As such, a stall speed bears some resemblance to an inflection point at which the decline in activity tends to accelerate, but which is still a fair distance from the eventual trough.

Results for other countries. Having confirmed the presence of a stall speed for the United States, we now investigate whether stall speeds exist for other countries as well. Of these, the results for the United Kingdom are the most compelling. As highlighted in Figure 3, the U.K. shows evidence of a statistically significant stall speed, centered at around 1 percent. We note that over the past 40 years, growth in the United Kingdom has fallen below this 1 percent threshold on five previous occasions. In each instance, growth on a four-quarter basis has subsequently fallen to rates of -2 percent or lower. To date, the current episode has held broadly true to form. Four-quarter growth slipped below 1 percent in mid-2011 and has since dropped to negative ½ percent. And a further weakening of U.K. growth (although not our baseline call) remains a distinct risk. On the one hand, significant headwinds remain in play—including high levels of private indebtedness, limited credit availability, fiscal drag, and potential spillovers from stresses in the euro-area. On the other hand, the Bank of England is engaged in an aggressive easing campaign and if the economy continues to contract the government may consider tempering the pace of fiscal consolidation.

Figure 3. United Kingdom



Note: Recession shading for the UK and other countries (except the euro area) is from the Economic Cycle Research Institute (ECRI), which uses NBER methodology.
Sources: Office for National Statistics, ECRI, Haver Analytics, and Citi Research.

Figure 4 presents results for the euro area, Japan, and Mexico.[5] For the euro area, we find evidence of a statistically significant stall speed in the neighborhood of 1 to 1.5 percent,[6] but the drag on growth associated with crossing the stall speed (1 percentage point or so) is much smaller than for the United States and the United Kingdom. Notably, we also find that growth in the euro area is already well below its estimated stall speed, suggesting that the sharp decline in euro-area growth that has occurred over the past several quarters may have in part reflected stall speed related forces.

For Japan, the results are broadly similar in spirit to those for the euro area, with a stall speed estimated at around 1 percent. That said, Japanese growth before the bursting of the bubble in 1991 was extraordinarily rapid—almost always well above the estimated 1 percent stall speed; in contrast, over the past 20 years, Japanese growth has cut through this breakpoint on a number of occasions—often on its way to marked further declines.

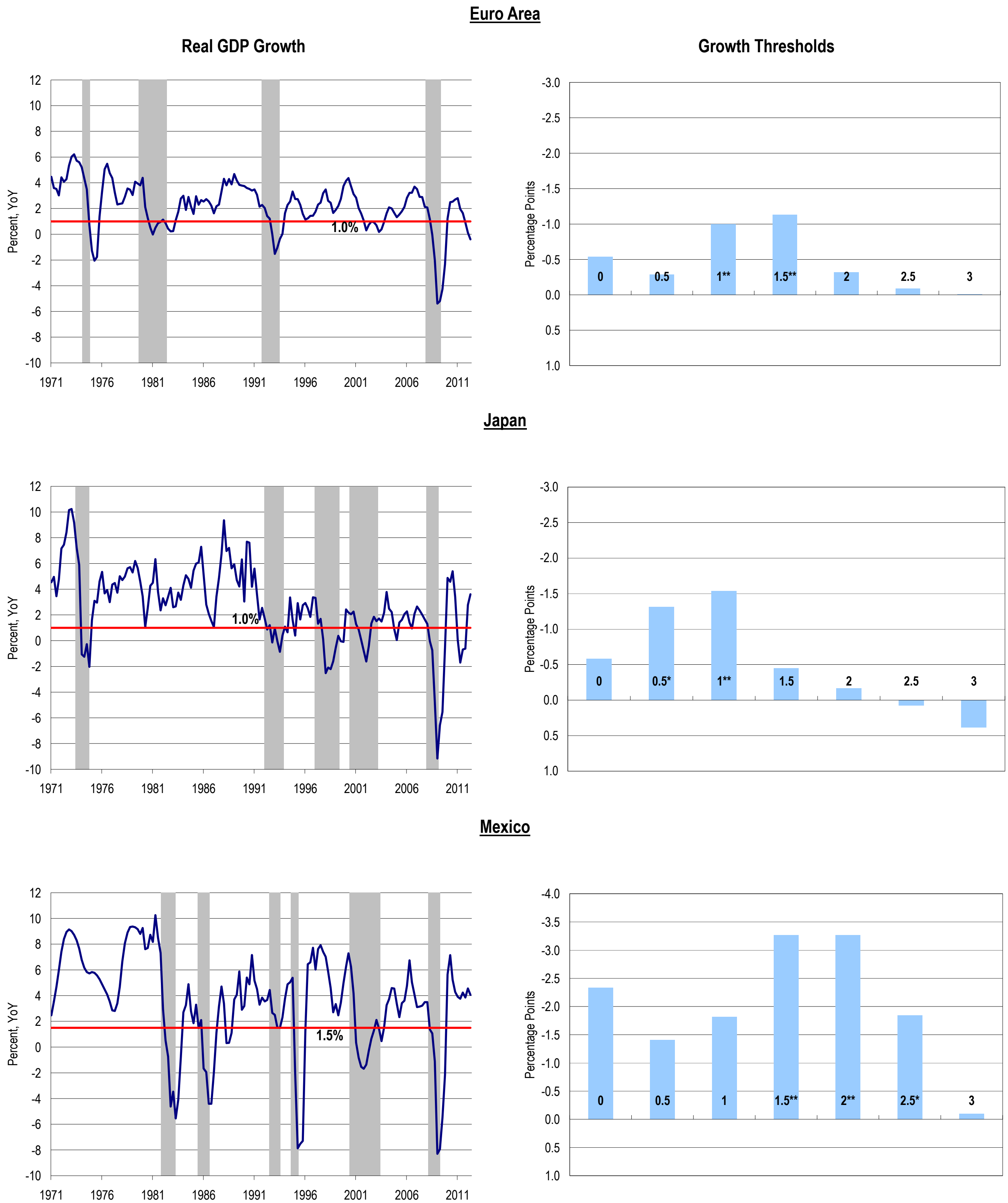
Although Mexican growth over the past 40 years has been volatile, the stall-speed results look much like those for the U.S. economy, with growth falling roughly 3 percentage points on average after crossing a range of 1.5 to 2 percent, no doubt reflecting Mexico's close linkages with the United States. The good news is that the recent pace of the country's growth has been comfortably above this estimated stall speed.

We also tested the stall-speed hypothesis for Canada and Australia, two commodity-producing advanced economies. Both of these countries show evidence of statistically significant stall speeds centered at growth of around zero,

[5] We find that the results for the euro area and Japan are strongest for the three quarters after crossing a particular threshold. As such, the reported estimates for these economies are based on three threshold dummies, rather than for four threshold dummies as reported elsewhere.

[6] Our aggregate for the euro area includes Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, and Spain. These are countries for which we were able to obtain data for the full sample period, including the 1970s.

Figure 4. Stall Speeds for Other Economies



Note: Data incorporate 2012 revisions from national accounts for all countries, where necessary; euro area shading from Center for Economic Policy Research.
Sources: OECD, ECRI, Center for Economic Policy Research, Haver Analytics, and Citi Research.

somewhat lower than for the other countries that we have studied. Finally, we note that we examined the Chinese GDP data for signs of stall-speed as well. Unsurprisingly, we came up empty handed, most likely reflecting that over our sample period the Chinese economy has never actually stalled.

On balance, we conclude that the data for a broad group of countries do seem to bear the imprint of statistically significant stall-speed behavior. The exact growth thresholds vary somewhat from country to country but typically fall into a range somewhere between 1 and 2 percent for the United States, the United Kingdom, the euro area, Japan, and Mexico. For Canada and Australia, the stall speed is centered at zero. This variation in stall-speed thresholds likely reflects differing vulnerabilities to shocks and, more generally, differences in the overall variability of growth, the flexibility of the economy in adjusting to shocks, and the responsiveness of monetary and fiscal policies.

Results for global aggregates. We now split the world into advanced economies (AEs) and emerging markets (EMs) and test for the presence of stall speeds for these aggregates.[7] We conjecture that such groups of countries might manifest similar stall-speed behavior due to the presence of common shocks, similar underlying economic structures, and potential trade and financial linkages. The data for the advanced economies start in 1971:Q1, while the data for the emerging market economies begin a decade later, in 1981:Q1.

Notably, as shown in Figure 5, our empirical work uncovers evidence of a stall speed for the advanced economies at 1.5 to 2 percent growth, very similar to the range detected for the United States. We note that four-quarter growth in the AEs has recently run near (or even slightly below) this estimated threshold, highlighting the vulnerability of growth in these economies in the event of intensified adverse shocks. This is particularly the case given the constraints on monetary and fiscal policy in many of these economies.

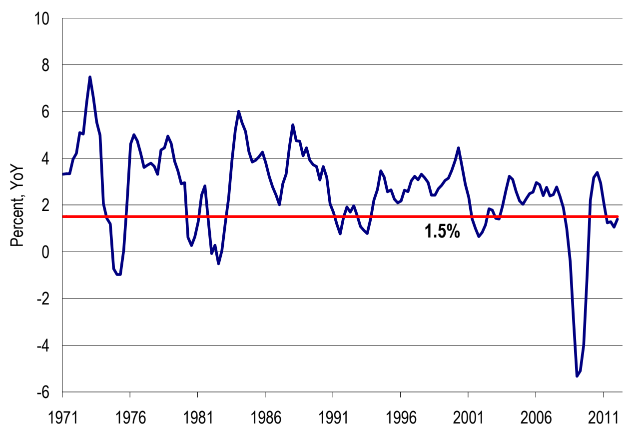
The results for the EMs merit careful reflection. On the one hand, our formal empirical work does not deliver evidence of meaningful effects. On the other hand, a visual inspection of the chart of emerging market growth suggests a stall speed at around 4 percent. Namely, when aggregate EM growth has dipped below 4 percent, it typically has fallen further—by at least another percentage point and sometimes by as much as 3 percentage points. The good news is that EM growth at present is hovering at around 5 percent, still somewhat above this observed threshold. Moreover, on a number of occasions over the past 30 years EM growth has fallen into the 4 to 5 percent range, but has subsequently jumped back up. And we see these economies as generally still having scope for monetary and fiscal stimulus. These observations leave us somewhat more optimistic about the outlook for the emerging market economies than for the advanced economies. That said, history suggests that an adverse shock to the advanced economies could have significant implications for the EMs, a theme that we explore in more detail below.

[7] Our advanced economy aggregate includes 18 countries: United States, Canada, Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, Japan, Australia, and New Zealand. The emerging markets aggregate consists of 14 countries: Brazil, Chile, Mexico, Hungary, China, Hong Kong, India, Indonesia, Korea, Malaysia, Singapore, Taiwan, Thailand, and South Africa. Within each aggregate, countries are weighted according to their nominal GDPs, converted at market exchange rates.

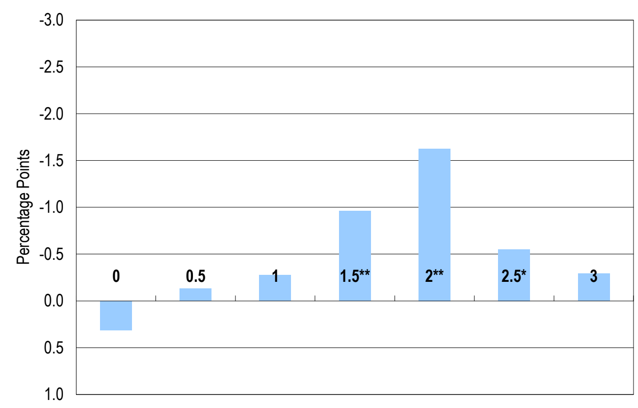
Figure 5. Stall Speeds for Global Aggregates

Advanced Economies

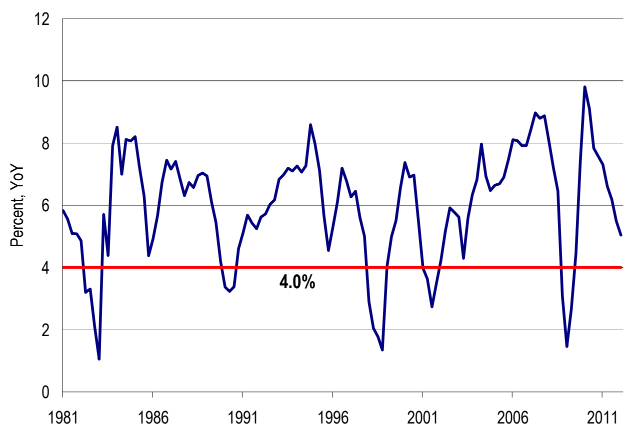
Real GDP Growth

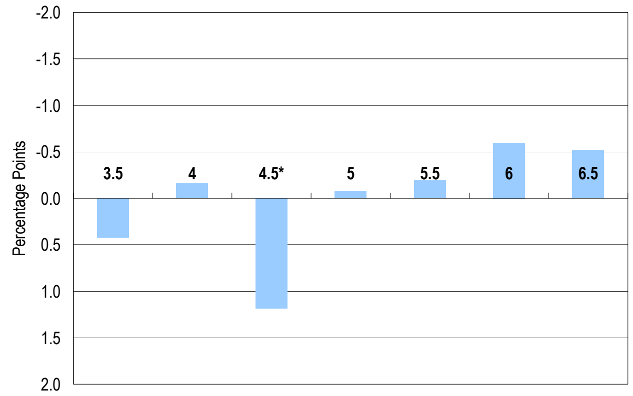


Growth Thresholds

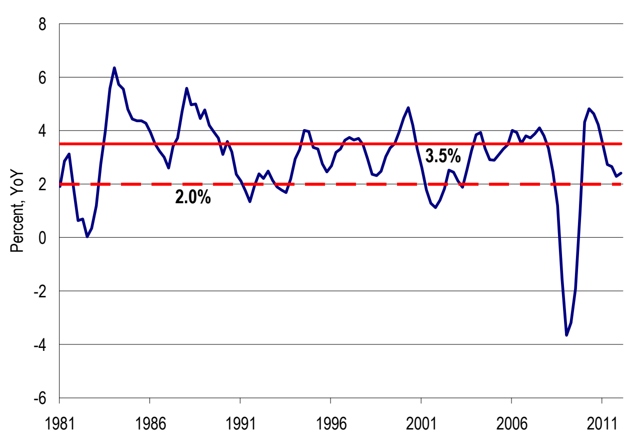


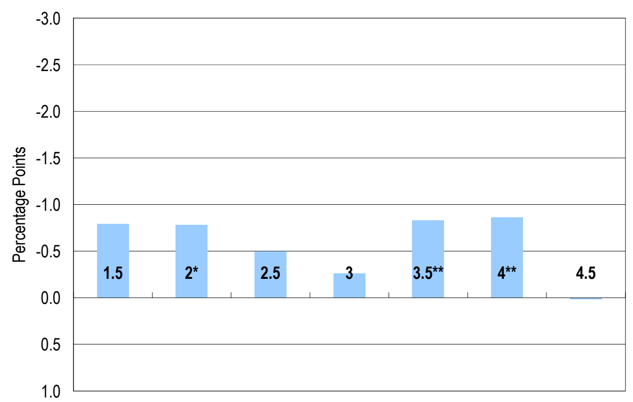
Emerging Markets





World





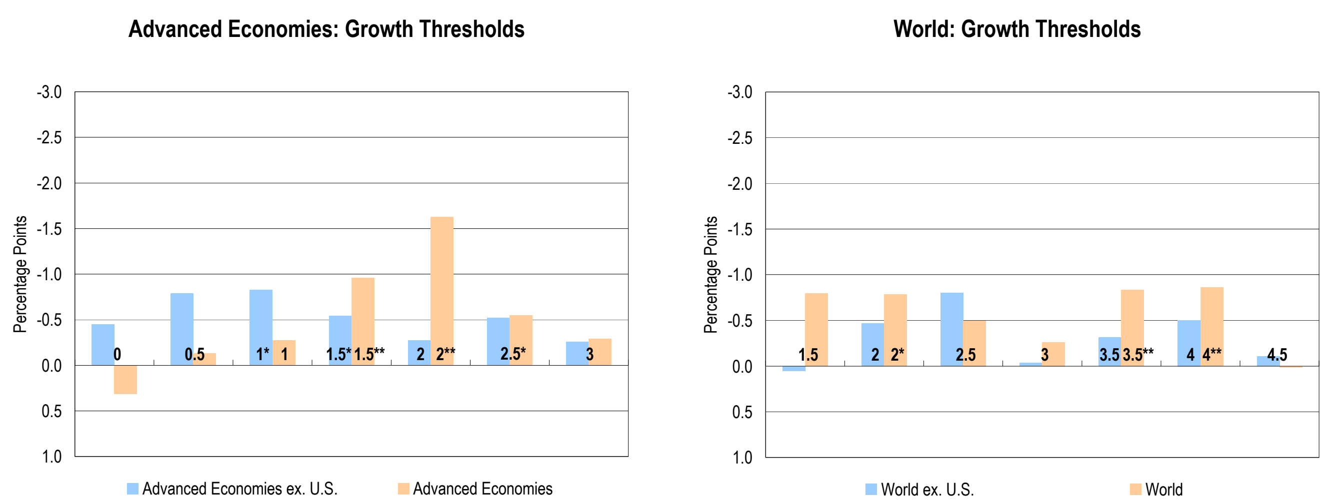
Sources: OECD, ECRI, Haver Analytics, and Citi Research.

Finally, as seen in the bottom panels of Figure 5, we find evidence of a statistically significant stall speed for overall global growth, somewhere in the neighborhood of 3.5 percent. Our results suggest that when growth cuts below this threshold, it tends to fall another ¾ percentage point or so over the following four quarters. This effect is smaller than the estimates for many of the underlying countries and aggregates. Business cycles across countries and regions are imperfectly correlated and, accordingly, global growth has been somewhat more stable than that of most individual countries, generally cycling in a fairly narrow range of 2 to 4 percent.

Taken at face value, these results would suggest that global growth—which is currently hovering at 2.5 percent—has already hit its 3.5 percent stall speed, contracted a little more than ¾ percentage point, and likely has now bottomed out. However, in past episodes when global growth has subsequently cut below 2 percent, it has either fallen significantly further (as in the early 1980s and through the global financial crisis) or growth has stagnated for a several-year period (as in the early 1990s and the first part of the 2000s). Consistent with these observations, our work finds that 2 percent indeed represents a secondary stall speed for global growth, with the estimated effect scoring significance at the 10 percent level. As such, the global economy seems to be in quite vulnerable territory at present.

We conclude this section by noting an important caveat regarding these results. As highlighted in the left panel of Figure 6, the stall speed results for the advanced economies seem to inherit their properties in large measure from the United States. When the U.S. economy is excluded from the aggregate, the shape of the distribution flattens out significantly, moves slightly to the left, and is less statistically significant. Similarly, as shown in the right panel, the estimates for the world economy are generally smaller in magnitude and less statistically significant when the United States is excluded. We believe that the effects of the United States on these global aggregates are occurring through two broad channels. First, as U.S. growth cuts below a given threshold, this drags down global growth directly, since the United States represents a sizable share of the global economy. Second, the slowdown in U.S. growth spills over to the rest of the world through trade, financial, and confidence channels, and this reduces growth in other countries as well. We assess the nature of these spillovers in the next section.

Figure 6. Effect of U.S. Growth on Global Stall Speeds



Source: Citi Research

Global Spillovers and Inter-Linkages

We now extend our analysis to examine some additional features of the global growth process, focusing in particular on the inter-linkages among broad groups of countries. Specifically, in the spirit of our work reported in the previous section, we first divide the global economy into three separate pieces: the emerging markets, the United States, and the advanced economies excluding the United States. We then use these aggregates to search for evidence of both "linear" spillovers (i.e., when growth in one part of the world falls by a percentage point, what are the effects on growth elsewhere) and "non-linear" stall-speed spillovers (i.e., when growth in one part of the world cuts below certain thresholds, what are the implications for activity in other parts of the world). The most striking result is that we find evidence that U.S. growth plays a powerful and unique role in driving global growth, through both linear and non-linear channels.

Linear spillovers. We start with the following question: Are there meaningful dynamic linkages across these three parts of the global economy? To examine this, we run a series of Granger causality tests. These tests assess whether lags of a given variable tend to presage moves in some other variable. For example, does the path of U.S. growth systematically drive growth in the emerging market economies? The results are displayed in Table 1, where p-values below 0.10 indicate that the given independent variable Granger causes the dependent variable. The key conclusions from the table are clear:

- U.S. growth Granger causes growth in both the other advanced economies and the emerging market economies.
- Growth in the other advanced economies Granger causes growth in the United States (highlighting the linkages among the advanced economies) but does not Granger cause growth in the emerging market economies.
- And growth in the EMs does not Granger cause growth in either the United States or other advanced economies.

The results in Table 2 are broadly similar in flavor. Specifically, we report the coefficients obtained when we regress growth in a given part of the world on four (quarterly) lags of itself and four lags of first one and then the other of the two remaining aggregates. Consistent with the Granger causality tests, a sustained 1 percentage point increase in U.S. growth has tended to raise growth in other advanced economies and the emerging markets by roughly 0.2 percentage point.

Table 1. Granger Causality Tests

		Dependent Variable		
		AE ex. U.S.	*EM*	*U.S.*
Independent Variable	*AE ex. U.S.*	…	N *(0.54)*	Y *(0.01)*
	EM	N *(0.14)*	…	N *(0.45)*
	U.S.	Y *(0.01)*	Y *(0.00)*	…

Note: Y indicates that one variable Granger causes another at the 10% level or better. P-values in parentheses.
Source: Citi Research.

The impact of the other advanced economies on the United States is about half as large, at around 0.1 percentage point. Although only the effect of the United States on the other advanced economies rises to standard levels of statistical significance, these results are economically significant, especially in light of the results obtained from the Granger causality tests. The other estimates in Table 2 enter with a negative sign and are not statistically significant.

Table 2. Sum of Coefficients on Lagged GDP Growth

Independent Variable	Dependent Variable: *AE ex. U.S.*	*EM*	*U.S.*
AE ex. U.S.	…	-0.13	0.11
EM	-0.02	…	-0.19
U.S.	0.24**	0.20	…

Source: Citi Research.

As an additional test of the features of these data, we break our group of countries into four regional aggregates—Advanced North America, Latin America, Europe, and Asia—and run Granger causality tests.[8] The results, shown in Table 3, are broadly consistent with the observations in the previous paragraphs. Advanced North America (principally the United States) Granger causes growth in all three of the other regions. In addition, Europe Granger causes growth in North America, again pointing to the importance of linkages among the advanced economies.

Table 3. Regional Granger Causality Tests

Independent Variable	Dependent Variable: *Advanced No. America*	*Europe*	*Asia*	*Latin America*
Advanced No. America	…	Y *(0.00)*	Y *(0.00)*	Y *(0.06)*
Europe	Y *(0.03)*	…	N *(0.35)*	N *(0.47)*
Asia	N *(0.76)*	N *(0.13)*	…	Y *(0.01)*
Latin America	N *(0.13)*	N *(0.46)*	Y *(0.03)*	…

Note: Y indicates that one variable Granger causes another at the 10% level or better. P-values in parentheses.
Source: Citi Research.

Finally, we find that Latin American and Asia Granger cause growth in each other; we interpret this relationship as indicating that the emerging market economies have been subject to common shocks and highlighting the growing trade and financial linkages among these economies.

Non-linear spillovers. We now search for the presence of any non-linear, stall-speed-related spillovers that may be driving global growth. Specifically, we regress

[8] These aggregates are defined as follows: Advanced North America consists of the United States and Canada; Latin America includes Brazil, Chile, and Mexico; Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom; and Asia includes Japan, Australia, New Zealand, and China, Hong Kong, India, Indonesia, Korea, Malaysia, Singapore, Taiwan, and Thailand.

real GDP growth in the United States, the advanced economies excluding the United States, and the emerging markets on four lags of themselves and the stall-speed dummies for other regions. The key question is, as growth in one of these major parts of the global economy declines below a given threshold, do we see out-sized drag on growth in other parts of the global economy?

The results of this exercise are reported in Figure 7. Specifically, the top left panel shows that when U.S. economic growth (on a four-quarter basis) cuts below a threshold of roughly 1.5 to 2 percent (the U.S. stall speed), this tends to be associated with a statistically significant decline in growth in other advanced economies of roughly 1.25 to 1.5 percentage points. Similarly, we find evidence of non-linear spillovers from U.S. growth to emerging markets; the threshold for U.S. growth of 1.5 percent is statistically significant and is associated with a decline in emerging market growth of about 1.5 percentage points.

In the previous section, we showed that U.S. growth has significant linear effects on growth elsewhere in the world. Specifically, if U.S. growth over the course of a year is a percentage point lower, it tends to reduce growth elsewhere by about 0.2 percentage point on average. We have also shown that when U.S. growth drops below 1.5 percent on a rolling four-quarter basis, U.S. growth typically declines by almost 3 percentage points over the following four quarters. Putting these two estimates together suggests that when U.S. growth cuts below its 1.5 percent stall speed, growth in other countries would be expected to fall by roughly 0.6 percentage point on average.

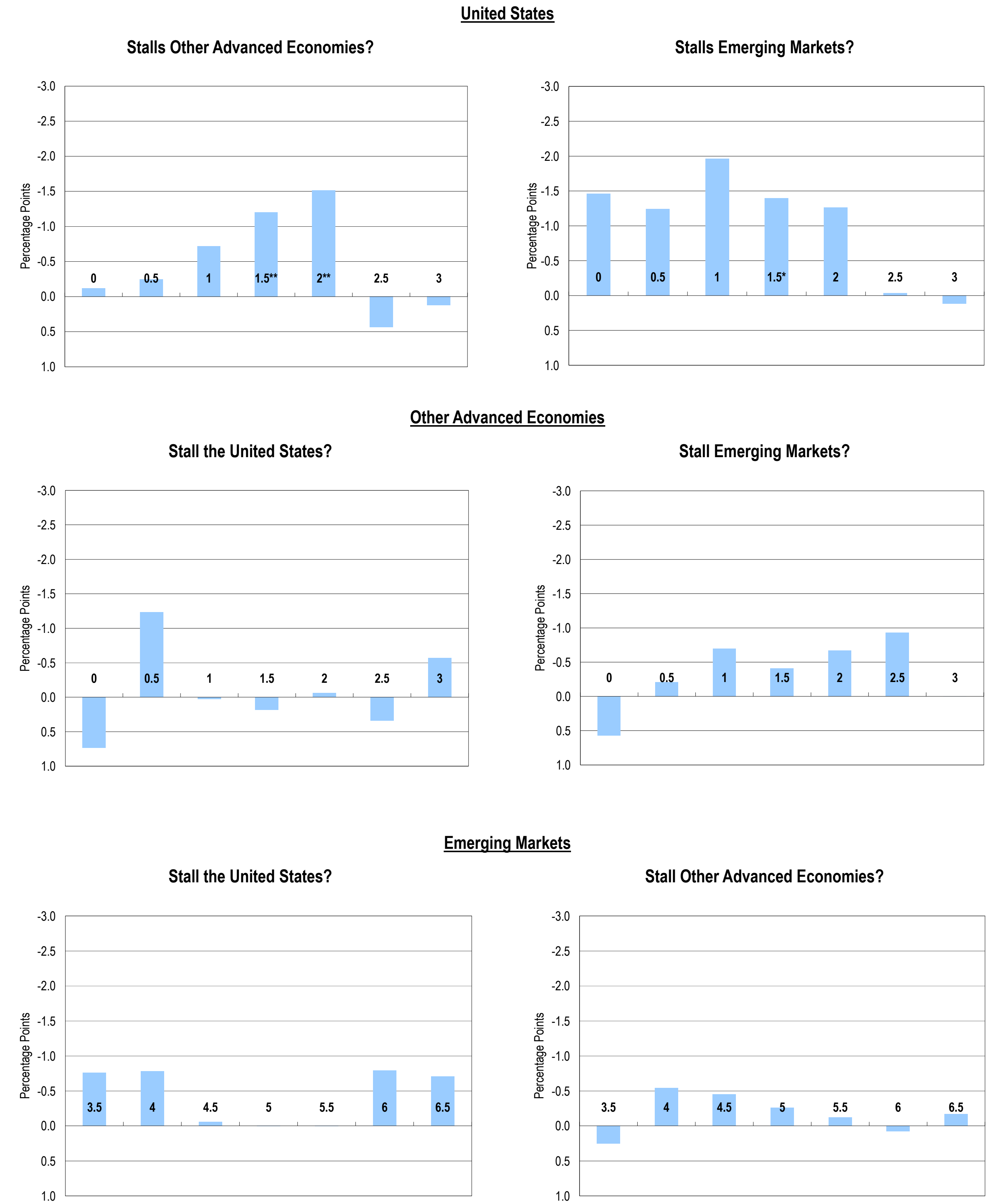
Notably, however, the spillover effects that we find around the U.S. stall speed are much larger. When the U.S. economy hits its stall speed, U.S. growth falls by nearly 3 percentage points, and our estimates indicate that growth in the rest of the world falls by roughly half as much. In short, our work suggests that other economies are generally sensitive to U.S. growth, but such sensitivity has been particularly strong when the U.S. economy has hit its stall speed.

As shown in the remaining panels of Figure 7, we do not see comparable spillover effects flowing from any of the other groups of countries. The estimated coefficients are not statistically significant and are much smaller in magnitude than those for the United States.

Panel estimates. As a final assessment of the spillover effects that we have identified, we run several panel regressions, i.e., we do not aggregate the data into weighted series, but rather allow each country in the sample to enter separately.[9] The upshot is a set of results broadly similar those that we have reported above. Specifically, the direct effect of U.S. growth on other countries comes in somewhat higher than in Table 2, at a little over 0.3 on average, and is statistically significant. Once we include U.S. stall-speed dummies in the regression (Figure 8), we find that when U.S. growth cuts below 2 percent, this is associated with sizable and statistically significant subsequent declines in growth in other countries.

[9] These panel regressions include country fixed effects.

Figure 7. Global Stall-Speed Linkages*

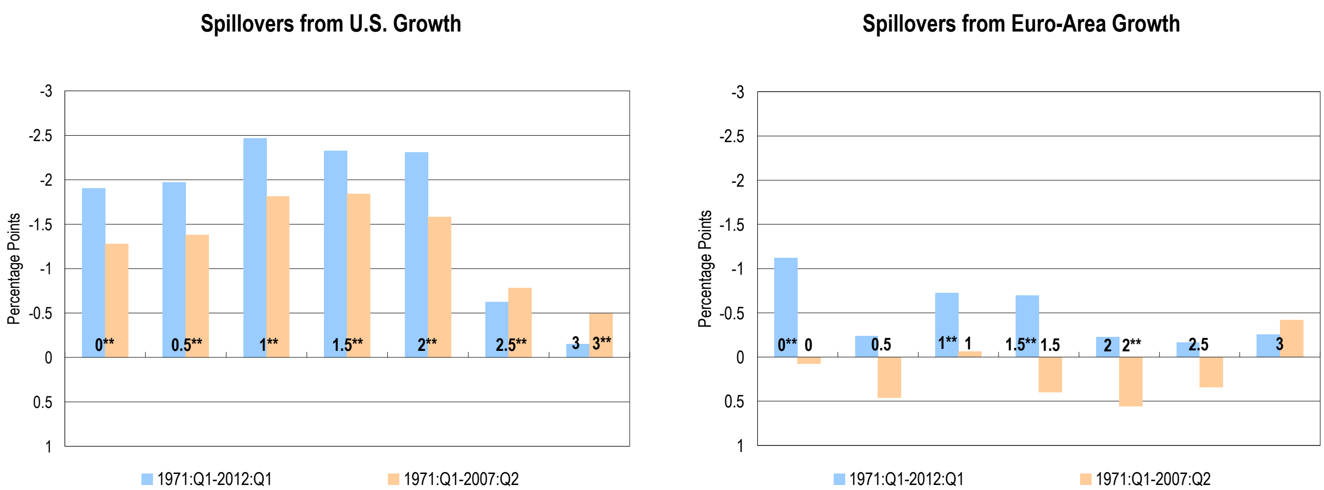


*Bars represent the spillovers to one aggregate when growth in another aggregate falls below the indicated threshold.
Source: Citi Research

As a test of the robustness of these results, we estimate the regressions ending the data sample in 2007:Q2, thus excluding the recent global financial crisis, when the sharp decline in U.S. growth largely drove a sizable global downturn. The resulting coefficients are slightly smaller in magnitude when this episode is not included, but are still sizable and statistically significant.

As shown in the left panel of Figure 8, we use our panel of countries to conduct a broadly similar exercise for the euro area, but the results are much weaker. Using data for the full 40-year sample, we find evidence of statistically significant spillovers to other countries at euro-area growth thresholds of zero, 1 percent, and 1.5 percent. But, notably, the magnitude of these estimates is much smaller than for the United States. And when the global financial crisis is excluded from the sample, the estimated coefficients have the wrong sign or are statistically insignificant. This is not to say that a significant shock emanating from the euro area would not have meaningful effects for growth in other countries. But at least over the past 40 years, the euro area does not seem to have played as central a role in driving global growth as has the United States.

Figure 8. Panel Analysis: Global Spillovers



Source: Citi Research.

Some Concluding Thoughts

In this essay, we have documented important non-linearities associated with stall speeds, both in the growth process of individual countries and in generating global spillovers, especially from the U.S. economy to the rest of the world. We have found that global growth is sensitive to moves in U.S. growth in general, but particularly so as U.S. growth approaches and cuts below its stall speed. We have estimated a range of empirical models and have found these results to be robust.

Although a full examination of the channels that give rise to these linkages between U.S. and global growth extends well beyond the scope of our essay, we conclude with a few reflections on this issue. Our working hypothesis is that the unique global role of the U.S. economy flows mainly from the financial features of the economy, particularly the large size of U.S. asset markets and the exposure of foreign institutions and investors to those markets. A sharp slowing in the trajectory of U.S. growth tends to create strains on U.S. financial markets, which in turn spill over to financial markets and institutions in other countries. The upshot is an

increase in global uncertainty and declines in confidence that quickly pass through into economic activity abroad. By the same token, we are doubtful that the powerful spillovers from the United States that we have documented are driven largely by trade linkages; the role of the United States in this sphere is much less unique.

Another striking feature of our results is that growth rates in a number of countries are now close to their estimated stall speeds. This suggests that any number of shocks—including the continued possibility of disruptions in the euro area or geopolitical stresses in the Middle East (with attendant implications for global oil markets)—could push global growth below its stall speed. History suggests that this, in turn, would likely bring a sharp, further decline in global growth.

The U.S. “fiscal cliff” also stands as a particularly vexing risk in this regard. With U.S. growth currently at 2¼ percent on a four-quarter basis, the stresses associated with going over the fiscal cliff could easily push the U.S. economy through its 1½ percent stall speed, which historically has brought with it a 3 percentage point decline in U.S. growth and plunged the country into recession. Moreover, as the U.S. economy crosses its stall speed, the spillovers to the rest of the world have traditionally been about half as large as the downward pull on the United States, suggesting that aggregate global growth—now running at 2½ percent—could easily sink to 1 percent or even lower. As such, our work indicates that upcoming decisions regarding the path of U.S. fiscal policy have first-order implications for the global growth outlook.

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