How the U.S. economy resembles a (very) big business

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Introduction and summary

This article offers a perspective on analyzing the growth of the U.S. economy by treating the economy as a very large firm. A well-functioning economy maximizes households' well-being rather than firms' profits, so policymakers' objectives and motivations are not as clear-cut as those of company chief executives. Still, as in any business, identifying areas of weakness and relative strength in the economy is inherently valuable in guiding decision-making.

I present basic tools for measuring different business lines' contributions to the U.S. economy's growth. Then, I extend the economy-as-business analogy by using the same tools to measure the exposure of a large conglomerate to macroeconomic risks. While these tools are often used to evaluate the strengths and weaknesses of the economy with the goal of recommending appropriate monetary policy, they can also be used by profit-maximizing firm managers to better understand macroeconomic risks to firm performance.

If we consider the U.S. economy to be a large enterprise, how do we measure its performance? First, what does our company look like? This very fictional national firm employs all of the workers in the U.S. economy; owns all machinery, structures, and other productive assets; and returns its profits to its shareholders (the American public). The national firm also makes machinery, structures, and materials for its own account to add to its productive capacity. The national firm has two customers: the national family (to which every U.S. resident belongs) and a conglomerate government that encompasses local, state, and federal governments.

The following two key macroeconomic concepts allow assessment of a particular sector's contribution to overall economic growth as well as its sustainability: the *fundamental national product accounting identity* and the *contributions to growth formula.* These concepts can provide similar insights into a firm's performance, capturing the contribution of a particular product line (or group of product lines) to the firm's growth and the likely sustainability of that contribution.

Applying these concepts to the U.S. economy reveals that macroeconomic risks arise primarily from sectors such as nonresidential fixed investment (business investment) that change substantially from quarter to quarter and also account for a moderately large fraction of economic activity. Sectors of the economy that are responsible for a large fraction of national income, such as expenditures on nondurable goods and services, and whose growth changes relatively little from quarter to quarter represent small risks to overall economic activity. Other sectors, such as new home construction, with unstable but relatively small sales also represent small risks to growth. With these results in hand, I can assess an individual firm's growth, and the macroeconomic risks to it, by measuring what fraction of the firm's sales corresponds to particular sectors of the overall economy.

After developing this methodology, I go on to apply it. The first application is to a fictional hair salon that has exposure to only one sector of the U.S. economy, personal consumption expenditures on services. The second application is to a real conglomerate, General Electric Company (GE). This application makes use of publicly available data and is purely for illustrative purposes. A serious evaluation of any particular

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company would require much more data than employed here.

In the next section, I present basic concepts from national income and product accounting, which divides the U.S. economy's production into different business lines. (Readers already familiar with the definitions of gross domestic product, or GDP, and its major components might wish to skip this section.) In the following section, I develop the contributions to growth formula and use it to understand business cycle risks to the U.S. economy. Then I develop and analyze macroeconomic benchmarks for the fictional hair salon and for General Electric Company.

National income and product accounting

Macroeconomic policy requires quantifying the economic benefits accruing to the nation's residents over a given interval of time. In the United States, the U.S. Bureau of Economic Analysis (BEA) provides one set of such measures with its national income and product accounts (NIPA) data. These measure the value of *market-based* transactions for goods and services *produced during the time of interest*. For business cycle analysis, the time of interest is typically a calendar quarter (January through March, April through June, and so on). The fundamental national product accounting identity decomposes the total value of goods and services produced in the nation into distinct expenditure components. The NIPA data report these for each calendar quarter.

Figure 1 is taken from a BEA spreadsheet containing the NIPA data. This is the equivalent of a quarterly sales report for a very large firm. The top line of data gives the quarterly history of GDP, which is defined to equal

- The value of all final goods purchased by households and governments, plus
- The value of all capital machinery and structures purchased by producers, plus
- The value of goods added to inventories less the value of goods sold from inventories, plus
- The value of exports minus imports.

With one exception (detailed later), these purchases are all market transactions. All sales from businesses to households or governments contribute to GDP, but this definition excludes business-to-business transactions unless the recipient uses the purchase to augment productive capital or inventories. This exclusion rule ensures that no firm's subcontracting decisions (make or buy) have a direct impact on GDP.

The spreadsheet's remaining lines (in figure 1) report the expenditure components of GDP. There are four major components, personal consumption expenditures (line 2), gross private domestic investment (line 6), net exports of goods and services (line 13), and government consumption expenditures and gross investment (line 20). The spreadsheet reports each major component's constituent minor components beneath it. The definitions of these components and their relationships with each other can be best understood by examining the national product accounting identity, which expresses gross domestic product as the sum of these components. The national product accounting identity comes from the income statements of the three very hypothetical institutions mentioned previously—an extended national family to which every U.S. resident belongs; a national conglomerate firm owned by this family that is responsible for the production of all goods and services exchanged in the market; and a conglomerate government that combines federal, state, and local governments.

The national family

I represent the national family's income for quarter t with V_t. The BEA divides the national family's uses of after tax income ($V_t - T_t$) into personal consumption expenditures (C_t) and private savings (S_t).

$$1)\quad C_t + S_t = V_t - T_t.$$

Setting C_t above $V_t - T_t$ requires the national family to set $S_t < 0$. That is, consumption in excess of current inflows requires spending from assets or going into debt.

The BEA further subdivides personal consumption expenditures into three categories that are somewhat ambiguous but nevertheless useful: expenditures on services, nondurable goods, and durable goods. That is,

$$2)\quad C_t = C_t^S + C_t^N + C_t^D.$$

Lines 3, 4, and 5 of the spreadsheet in figure 1 report these three categories. Examples of services are hotel room rentals, movie theater admissions, and haircuts. Services also include rent paid for the occupation of residences. The BEA adds to this the implied rent paid by homeowners to themselves, so a family's choice between homeownership and renting has no impact on C_t^S.[1] Food, fuel, and any other goods expected to last less than three years are nondurable goods; all other goods, except for housing, are durable. Automobiles and furniture are the most important examples. Durable goods purchases resemble saving because their

FIGURE 1

Data from the national income and product accounts

	A	B	C	IJ	IK	IL	IM	IN
1	**Table 1.1.5. Gross Domestic Product**							
2	[Billions of dollars]; Seasonally adjusted at annual rates							
3	Quarterly data from 1947 To 2008							
4	Bureau of Economic Analysis							
5	Data published May 29, 2008							
6	File created 5/28/2008 8:37:54 AM							
7								
8	**Line**			**2007**	**2007**	**2007**	**2007**	**2008**
9				**1**	**2**	**3**	**4**	**1**
10	**1**	**Gross domestic product**	**A191RC1**	**13,551.9**	**13,768.8**	**13,970.5**	**14,074.2**	**14,195.6**
11	**2**	**Personal consumption expenditures**	**A002RC1**	**9,540.5**	**9,674.0**	**9,785.7**	**9,936.6**	**10,046.2**
12	3	Durable goods	B003RC1	1,074.0	1,074.7	1,081.6	1,082.5	1,064.7
13	4	Nondurable goods	B004RC1	2,759.4	2,822.7	2,846.3	2,904.5	2,948.8
14	5	Services	B005RC1	5,707.1	5,776.5	5,857.8	5,949.7	6,032.7
15	**6**	**Gross private domestic investment**	**A006RC1**	**2,117.3**	**2,139.1**	**2,162.9**	**2,082.1**	**2,041.3**
16	7	Fixed investment	A007RC1	2,118.9	2,133.9	2,127.5	2,109.5	2,064.5
17	8	Nonresidential	A008RC1	1,431.4	1,469.1	1,500.1	1,526.5	1,526.2
18	9	Structures	B009RC1	439.6	464.5	483.1	501.3	505.1
19	10	Equipment and software	B010RC1	991.8	1,004.5	1,017.1	1,025.3	1,021.1
20	11	Residential	A011RC1	687.5	664.8	627.3	582.9	538.4
21	12	Change in private inventories	A014RC1	-1.6	5.1	35.4	-27.4	-23.3
22	**13**	**Net exports of goods and services**	**A019RC1**	**-714.2**	**-714.2**	**-694.7**	**-708.9**	**-716.6**
23	14	Exports	B020RC1	1,549.9	1,598.7	1,685.7	1,737.7	1,786.3
24	15	Goods	A253RC1	1,084.0	1,115.2	1,191.3	1,221.1	1,256.0
25	16	Services	A646RC1	465.9	483.5	494.4	516.5	530.3
26	17	Imports	B021RC1	2,264.0	2,312.9	2,380.4	2,446.6	2,502.9
27	18	Goods	A255RC1	1,902.7	1,947.2	2,007.3	2,060.5	2,108.1
28	19	Services	B656RC1	361.4	365.7	373.2	386.0	394.8
29	**20**	**Government consumption expenditures and gross inve**	**A822RC1**	**2,608.3**	**2,670.0**	**2,716.5**	**2,764.4**	**2,824.7**
30	21	Federal	A823RC1	946.6	969.5	990.3	997.7	1,023.4
31	22	National defense	A824RC1	634.8	654.5	673.5	677.7	696.8
32	23	Nondefense	A825RC1	311.7	315.0	316.8	320.0	326.6
33	24	State and local	A829RC1	1,661.7	1,700.5	1,726.2	1,766.7	1,801.3
34								
35								

Notes: This figure shows the national income and product accounts spreadsheet as one would view it on the U.S. Bureau of Economic Analysis website. Quarterly data currently run from 1947 through 2008, though only 2007 and 2008 data are viewable here. These are the most recent data, available as of May 29, 2008.

Source: U.S. Bureau of Economic Analysis, *National Income and Product Accounts of the United States*.

ownership enhances the family's well-being currently and in the future. However, the BEA's conventions expense them just like purchases that have no persistent impact on the family.

All income not spent is, by definition, saved. An individual family can save by depositing funds in a bank, by purchasing a house (new or pre-existing), by acquiring stocks and other publicly traded securities, or by directly lending to another household. Whether these actions contribute to national saving depends on whether another individual family's decisions directly offset them. When one family purchases a pre-existing home from another family, the selling family's asset reduction offsets the buying family's asset accumulation. Similarly, one family's mortgage borrowing offsets the lending family's saving. In both cases, the net contribution to the national family's saving is zero.

In contrast, a family's purchase of a newly built home does contribute to the national household's savings because the transaction's counterparty (the construction firm) is not part of the national family. Similarly, foreign-financed mortgage borrowing reduces national saving.

The fact that many of the transactions by which individual households save are offset by other households' reduced saving must be kept in mind when considering how the national household can save. Aside from the purchase of new durable goods, the national family has four means of saving from its current income to improve its future: purchasing a new home or improving an existing one, investing in the conglomerate firm, investing abroad, or purchasing any available conglomerate government debt. The BEA calls the first vehicle *residential investment*. This directly enhances the economy's productive capacity by augmenting the stock of residential structures. The effects of investing in the conglomerate firm can be more subtle because one family purchasing the firm's stock *from another family* makes no contribution to national saving. The national family only saves when purchasing the conglomerate firm's securities at a public offering.

International investing is intimately entangled with international trade. Countries trade goods and services to pursue productive efficiency through comparative advantage and to consume goods and services that may not be available domestically. Let X_t and M_t stand for the values of exports and imports. When X_t exceeds M_t, we say that the nation runs a trade surplus. In this case, the national family is saving by extending credit to foreigners in return for $X_t - M_t$, the exports that foreigners did not pay for with an offsetting import. Conversely, if X_t falls short of M_t, then the country runs a trade deficit. The national family must cover this either by redeeming previously accumulated IOUs from foreigners or by issuing new IOUs of its own. Either way, the resulting reduction in wealth equals $M_t - X_t$.

The national family's final saving vehicle is the purchase of bonds issued by the conglomerate government. The government can use the proceeds of a household's purchase to either repurchase bonds held by another household (so that the national family's holdings of government debt remain unchanged), or the government can use the proceeds to undertake current expenditures. Suppose (counterfactually) that only American households hold the conglomerate government's debts and that all such debts are bonds that mature in one quarter.[2] If B_{t-1} is the face value of bonds purchased by the national household in the previous quarter, B_t is the face value of bonds purchased in the current quarter, and R_t is the interest rate on these bonds, then the national household's net investment in government debts equals $B_t / R_t - B_{t-1}$.

Bringing these four savings vehicles for the national household together allows us to write national private savings as

$$3)\quad S_t = I_t^R + Q_t + X_t - M_t + B_t / R_t - B_{t-1}.$$

Here, I_t^R and Q_t represent residential investment and the national family's net equity purchases. An individual household's total saving could have other contributions such as the accumulation of other households' debts. However, these all cancel when adding all households' savings to arrive at the national family's saving. Equation 3 only contains those contributions that do not cancel and represent true national saving.

The conglomerate government

Next, consider the conglomerate government, which collects taxes T_t from the national family and combines these with the net proceeds from the sale of government debt to pay for its current expenditures. Economists divide these into two categories, transfers and purchases. A transfer is the granting of funds to an individual with limited restrictions on their use. The federal government's largest transfer programs are Social Security, Medicare, and Medicaid. A government purchase is an exchange of funds for a specifically contracted good or service. For example, the salaries of government employees and the purchase of weapons systems are government purchases. Use A_t and G_t to represent the value of transfers and purchases by all governments so that the requirement that governments' uses of funds equal their sources of funds can be written as

$$4)\quad A_t + G_t + B_{t-1} = T_t + B_t/R_t.$$

Just as with the national family, transfers from one government to another (for example, federal grants to states) do not count toward T_t. When the conglomerate government's choices of A_t, G_t, and T_t require B_t to exceed B_{t-1}, we say that the government is running a deficit.

The national firm

The final institution to consider is the national firm, which produces all goods and services in the economy.[3] Its assets equal all productive machinery and structures in the country, along with the inventories of completed goods and any work in progress, and its sole liability is its equity. To produce, it employs members of the national family to operate its productive machinery and maintain its structures. Any single business seeking to purchase machinery, structures, or materials faces a make-or-buy decision. By definition there is no other (domestic) firm to sell anything to the national firm, so it must fulfill all of its materials and capital needs with its own production.

The national firm's funds come from the sale of goods and services and from issuing new equity. Let Y_t equal the value of all goods and services produced (both for external customers and the national firm's own account), and use K_t^I to represent the value of that production in inventory on the last day of quarter t. Goods in inventory sometimes lose their value. For example, food can spoil. For this reason, inventories held from quarter $t - 1$ to quarter t lose a fraction of their value. We call this the inventory loss rate and denote it with l_t. The national firm's sales combine receipts from sales of goods produced within the quarter with sales from goods sold out of inventory, $Y_t - K_t^I + (1 - l_t) K_{t-1}^I$.

The national firm's funds from equity issuance are equal to the national family's net purchases of equity discussed previously, Q_t. Nothing prevents the national firm from repurchasing its shares, in which case $Q_t < 0$. Assume for simplicity that the national firm returns all profits to its shareholders through such share repurchases so that this use of funds is represented as a negative source. The national firm's other two uses of funds are the purchase of machinery and structures on its own account, I_t^B, and payment of its wage bill, $W_t N_t$. Here, N_t is the number of hours worked by its employees and W_t is their average hourly wage. The national firm's sources and uses of funds must equal each other, so

$$5)\quad Y_t - K_t^I + (1 - l_t) K_{t-1}^I + Q_t = W_t N_t + I_t^B.$$

The BEA calls I_t^B business fixed investment and calls $K_t^I - (1 - l_t) K_{t-1}^I \equiv I_t^S$ net inventory accumulation. Lines 7 and 12 of the spreadsheet in figure 1 (p. 31) report these. They both contribute to the economy's future productive capacity.

The national product accounting identity

Profits from the national firm that are not reinvested enter the national family's budget as a negative value for Q_t. Similarly, the redemption of foreigners' IOUs enters the national family's budget as a negative value for $X_t - M_t$. Thus, the correct measure of income in equation 1 sums the other two sources of income for the national family, labor income (which must equal the national firm's wage bill) and transfers from the conglomerate government:

$$6)\quad V_t = W_t N_t + A_t.$$

The pieces required to assemble the fundamental national product accounting identity are now in place. To do so, use equations 2, 3, 4, and 6 to replace C_t, S_t, T_t, and V_t in equation 1. Then, eliminate $W_t N_t$ from the resulting equation using the expression for the national firm's profit in equation 5. Canceling terms that appear on both sides of the equation and isolating Y_t on the right-hand side yields the desired identity.

$$7)\quad C_t^N + C_t^S + C_t^D + I_t^R + I_t^B + X_t - M_t \\ + \left(K_t^I - l_t K_{t-1}^I\right) + G_t = Y_t.$$

The right-hand side equals the value of the national firm's output, gross domestic product. The left-hand side sums the values of its distinct uses: the three consumption expenditures, residential investment, business fixed investment, net exports, and inventory accumulation. The BEA creates the expenditure side of the NIPA data by statistically estimating each item in equation 7 separately. The BEA's estimate of GDP equals this sum.

There are three features of equation 7 worth noting. First, the national family's receipt of transfers from the government appears nowhere because transfers appear in both V_t and T_t. That is, increasing government transfer programs makes no direct contribution to national income. (Keynesian macroeconomic theories assert that such transfers raise income indirectly by reducing savings and encouraging present consumption. Whether this is indeed the case is the subject of much ongoing research.) Second, the national family's investments in government bonds contribute to both S_t and T_t with opposite signs, so they also cancel in equation 7. This is because G_t represents the conglomerate government's use of national income. Raising the national family's investments in government bonds merely allows the conglomerate government to lower current taxes. This implies that a temporary tax decrease financed with government debt has no direct impact on national income.[4] Finally, note that the national family's purchases of the national firm's stock (Q_t) contribute nothing to total national saving because the corresponding increases in the national firm's liabilities cancels them. However, the national firm's tangible investments $\left(I_t^B\right)$ remain.

National income shares

A contributor to macroeconomic policy requires familiarity with how the national family earns and spends its income. To help build this, table 1 reports the average values for the national product accounting identity's components relative to GDP decade by decade from the end of the Korean War (1953:Q4) through the most recent data released by the BEA (2008:Q1). Personal consumption expenditures represent the majority of GDP in all decades, and this share has climbed. The share of all personal consumption expenditures combined equaled about 62 percent through the 1950s, 1960s, and 1970s. In the 1980s, it climbed slightly to 64 percent, and this climb continued through the 1990s. For the current decade, personal consumption expenditures account for about 70 percent of GDP. Nondurable goods' expenditure share fell steadily from the 1950s through the 1990s (from 30.2 percent to 20.3 percent) and has since leveled off, while purchases of

TABLE 1

Shares of gross domestic product

Date range	Personal consumption expenditures: Nondurable goods	Personal consumption expenditures: Services	Personal consumption expenditures: Durable goods	Fixed investment: Residential	Fixed investment: Nonresidential	Inventory	Net exports	Government purchases
	(percent)							
1953:Q4–1959:Q4	30.2	23.9	8.6	5.3	9.5	0.4	0.3	21.8
1960:Q1–1969:Q4	27.1	26.3	8.4	4.6	9.8	1.0	0.6	22.1
1970:Q1–1979:Q4	25.0	28.8	8.6	4.9	11.1	0.7	–0.2	21.0
1980:Q1–1989:Q4	22.7	33.4	8.3	4.4	12.1	0.4	–1.8	20.6
1990:Q1–1999:Q4	20.3	38.5	8.2	4.1	10.9	0.5	–1.3	18.8
2000:Q1–2008:Q1	20.1	41.4	8.4	5.2	10.7	0.2	–4.8	18.8

Source: Author's calculations based on data from the U.S. Bureau of Economic Analysis, *National Income and Product Accounts of the United States*.

durable goods have remained constant at about 8.5 percent. This implies that the well-documented growth of consumer services has accounted for more than all of the growth in personal consumption expenditures. Its share of GDP expenditures has nearly doubled from the 1950s through the current decade.

The national family directly augments domestically sited productive capacity with its residential, nonresidential, and inventory investments. Over the sample period (1953:Q4–2008:Q1), residential investment has accounted for 4.8 percent of GDP. The post-war boom in the 1950s drove this to 5.3 percent. This share fell off during the 1960s, rose again in the 1970s to nearly 5 percent, and then fell during the 1980s and 1990s. For the current decade, it nearly equals its value for the 1950s. In this sense, residential investment is currently of unusual importance for the macroeconomy. Nonresidential investment represented 10.7 percent of GDP over the sample period. This share climbed from the 1950s through the 1980s (from 9.5 to 12.1 percent) and then fell to its approximate average level for the 1990s and the current decade. Unlike most other expenditure shares, it is possible for investment in inventories to be *negative* if inventories are sold faster than they can be replenished. However, the average inventory investment over the sample period was positive at 0.5 percent of GDP. This share varied considerably from decade to decade but always remained at or below 1 percent.

The final two expenditure shares are net exports and government purchases. It is well known that the United States ran small trade surpluses in the immediate post-Korean War decades, which then turned to somewhat larger trade deficits. The current trade deficit (4.8 percent of GDP) is a distinctive feature of the present macroeconomic situation. Government purchases represented 21.8 percent of GDP in the 1950s, and this grew slightly in the 1960s. Thereafter this share fell in two distinct steps, from the 1960s to the 1970s and from the 1980s to the 1990s. For the current decade, government purchases' share of GDP equals 18.8 percent.

Some growth accounting

The national product accounting identity paves the way toward an accounting for the national firm's growth. The BEA spreadsheet in figure 1 (p. 31) displays the values of product categories *in dollars*. A dollar is only worth what it will buy, and inflation has diminished that purchasing power on and off over the entire post-Korean War period. Macroeconomic policymakers account for this by examining inflation-adjusted GDP. Its construction begins with a measure of the dollar's purchasing power, P_t. Dividing Y_t by this yields *real* GDP; that is, $y_t = Y_t/P_t$. The BEA produces several measures of P_t. By construction, these equal one on average over the year 2000. The corresponding real GDP is measured in year 2000 dollars. Measuring P_t is not straightforward because there are literally millions of transaction prices. If inflation made these all move in lock step with each other, then P_t could be constructed using the growth rate of any one of them. In fact prices do not move together nearly so perfectly. Properly measuring P_t in this case requires accounting for each transaction's share of expenditures and for the changes in expenditure shares these price changes induce. A complete description of how the BEA constructs P_t is beyond the scope of this article, but appendix A gives an overview of the procedure.

Real GDP measures the national firm's growth. For each decade from the 1950s through the present, figure 2 plots its value relative to the first observed value in that decade. Clearly, economic growth dominates these observations. Although the economy contracted twice in the 1950s, first immediately after the Korean War and again in late 1957 and early 1958, real GDP at the end of the decade was 20 percent higher than at the close of the war (as shown by the difference between 1.20 and 1.00 in panel A). The 1960s also started with a mild contraction, but growth equaled a spectacular 50 percent for the decade. The 1970s and early 1980s saw substantially greater ups and downs in real GDP, but growth for both decades was about 35 percent. Real GDP contracted at the beginning of the 1990s, but growth for the decade equaled that for the 1970s and 1980s. The beginning of the current decade also got off to a slow start, but growth thus far equals 21 percent. This essentially equals the growth performance in the post-Korean War 1950s.

The quarter-to-quarter fluctuations in the pace of economic growth make up the business cycle. The national family's long-run well-being depends most of all on economic growth. Because growth rates compound, even a slightly higher long-run growth rate can dramatically improve the national family's welfare. The observed business cycle fluctuations would be a small price to pay for that, so one might conclude that the business cycle has little importance: Macroeconomic policy should focus on maintaining a high level of growth and let the business cycle take care of itself. Unsurprisingly, this view has little currency among policymakers because it presumes that economic growth can be separated from the business cycle. The frequency with which severe contractions of GDP result in decades of stagnant or negative growth, as in the United States during the 1930s or Japan during the 1990s, suggests that this conclusion is overly hopeful. If we suppose instead that the economy's business cycles sometimes impact its growth performance, then business cycle policy in those times is growth policy.

A macroeconomic policymaker seeking to understand the business cycle needs to know how the national firm's various product lines contribute to it. For this, the contributions to growth formula is helpful. This writes the growth rate of GDP as contributions from the growth of the components on the left-hand side of the national product accounting identity (equation 7). If there were no inflation, we could derive this formula by dividing both sides of the identity by Y_{t-1}, subtracting one from both sides, and rearranging:

$$8)\quad \frac{Y_t - Y_{t-1}}{Y_{t-1}} = \left(\frac{C^N_{t-1}}{Y_{t-1}}\right)\frac{C^N_t - C^N_{t-1}}{C^N_{t-1}} + \left(\frac{C^S_{t-1}}{Y_{t-1}}\right)\frac{C^S_t - C^S_{t-1}}{C^S_{t-1}}$$
$$+\left(\frac{C^D_{t-1}}{Y_{t-1}}\right)\frac{C^D_t - C^D_{t-1}}{C^D_{t-1}} + \left(\frac{I^R_{t-1}}{Y_{t-1}}\right)\frac{I^R_t - I^R_{t-1}}{I^R_{t-1}}$$
$$+\left(\frac{I^B_{t-1}}{Y_{t-1}}\right)\frac{I^B_t - I^B_{t-1}}{I^B_{t-1}} + \left(\frac{I^S_{t-1}}{Y_{t-1}}\right)\frac{I^S_t - I^S_{t-1}}{I^S_{t-1}}$$
$$+\left(\frac{X_{t-1}}{Y_{t-1}}\right)\frac{X_t - X_{t-1}}{X_{t-1}} - \left(\frac{M_{t-1}}{Y_{t-1}}\right)\frac{M_t - M_{t-1}}{M_{t-1}}$$
$$+\left(\frac{G_{t-1}}{Y_{t-1}}\right)\frac{G_t - G_{t-1}}{G_{t-1}}.$$

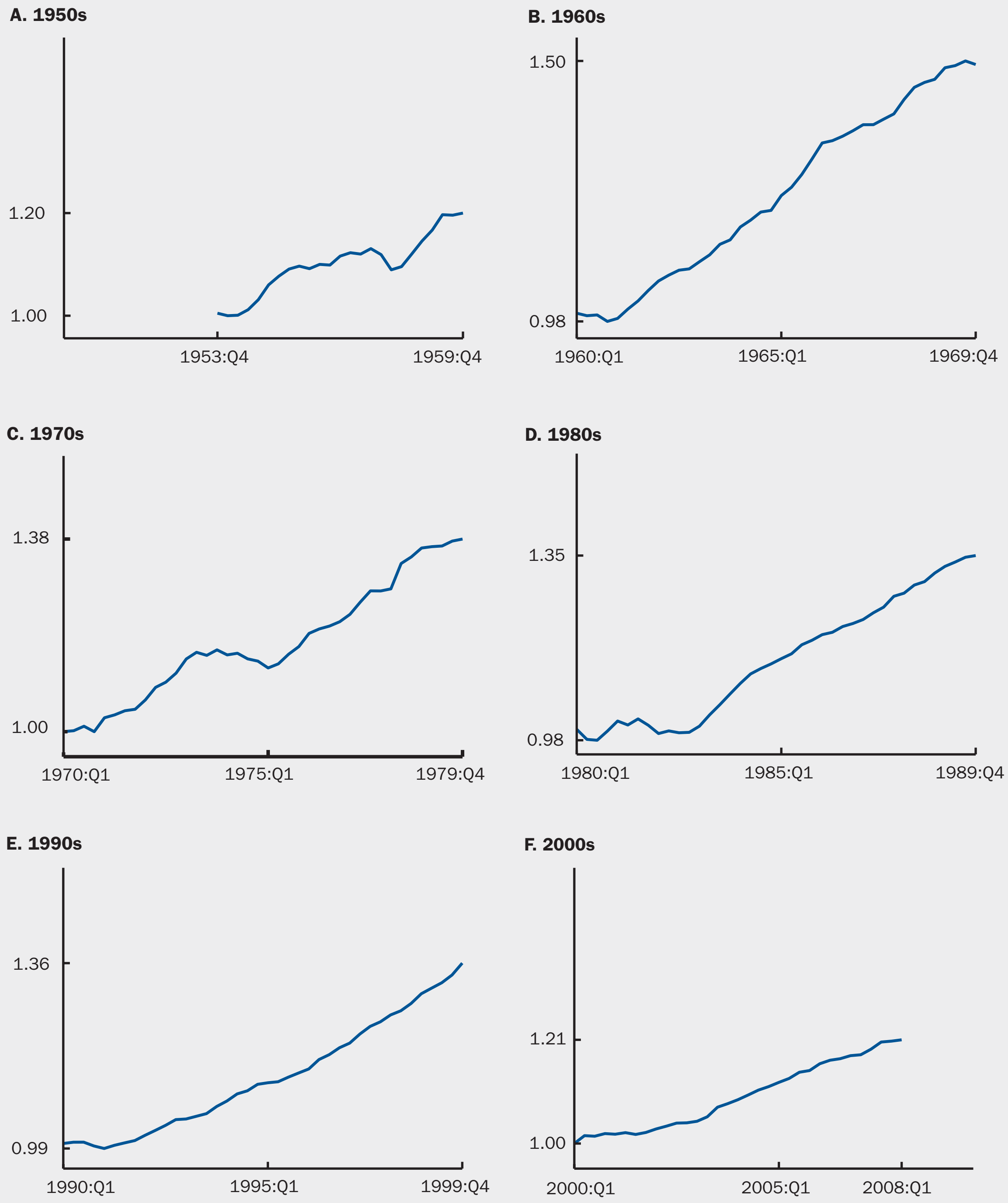
The left-hand side has only GDP growth, while the right-hand side sums the growth rates of each GDP component multiplied by its share of expenditures in the previous quarter. Each of these products is the contribution of an expenditure to GDP growth. The formula shows that the influence of a given expenditure on overall GDP growth involves both its own movement and its share of GDP. If two expenditures have the same percentage reduction, then the one with the smaller expenditure share will lower GDP less. Of course, abstracting from inflation sets a lot of macroeconomic reality to the side. Accounting for inflation changes the contributions to growth formula in two ways: The expenditures' growth rates are adjusted using expenditure-specific measures of inflation, as well as slightly modified expenditure shares. The basic insights of equation 8 remain: An expenditure's contribution to growth equals the product of its percentage growth rate and its expenditure share. (Appendix B presents the derivation of the contributions to growth formula that accounts for inflation.)

Applying the contributions to growth formula to the post-Korean War NIPA data yields figure 3. Each of its eight panels (one for each component of GDP) plots the contribution to GDP growth from one expenditure component. The shaded areas mark recessions as defined by the National Bureau of Economic Research's (NBER) business cycle dating committee. These are periods of sustained GDP contraction. The most recent one began in March 2001 and ended in November 2001.

The first impression from examining figure 3 is that none of the expenditure components present particularly large risks to GDP growth individually except for inventory investment. Its contribution to growth can move wildly from quarter to quarter, but it does not completely account for fluctuations in GDP growth by itself. The other expenditure components'

FIGURE 2

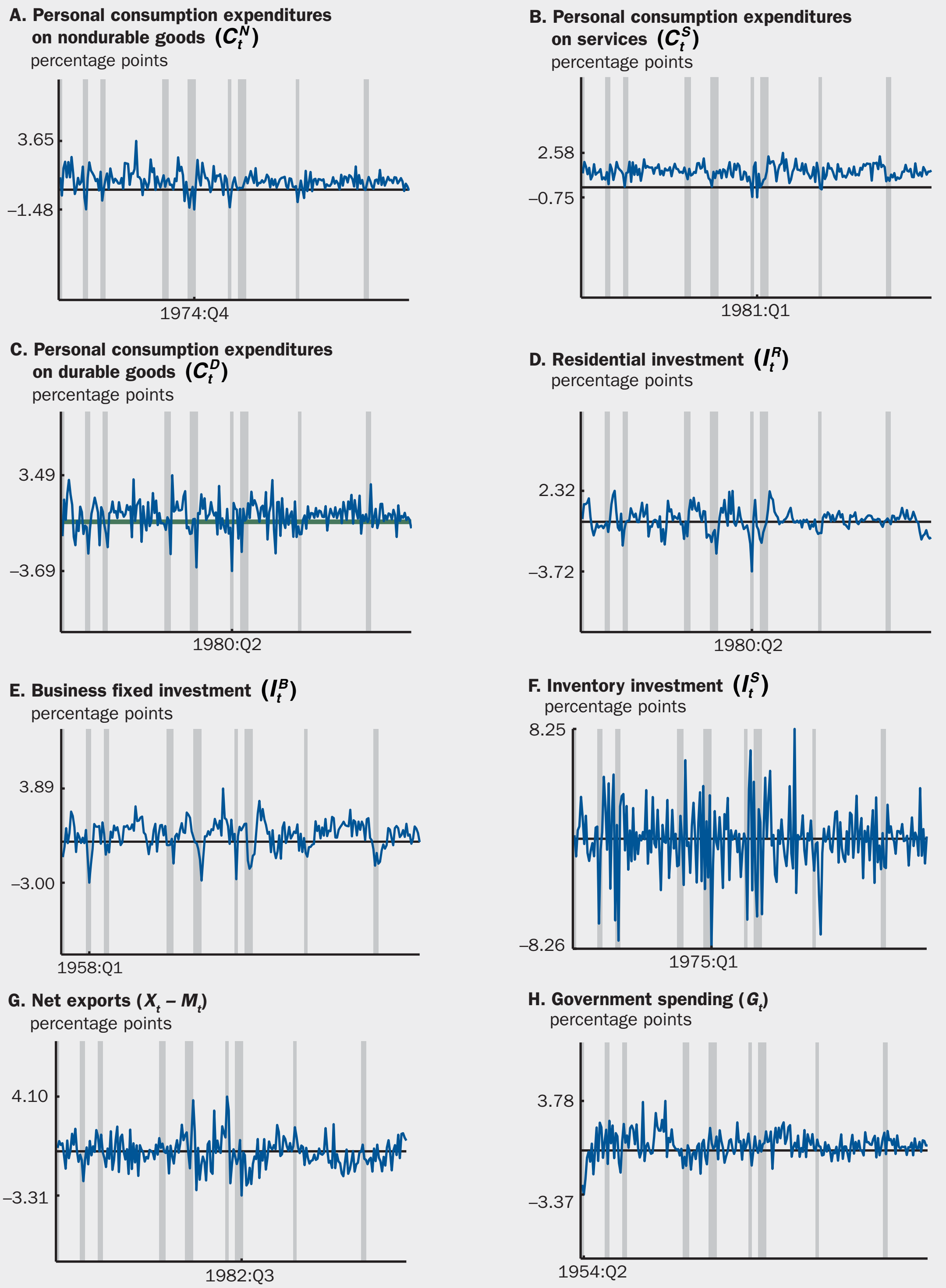
Real gross domestic product



Notes: Each panel plots the value of real gross domestic product scaled by its value in the first quarter plotted in that panel. Each vertical axis marks the highest and lowest values in that panel.
Source: Author's calculations based on data from the U.S. Bureau of Economic Analysis, *National Income and Product Accounts of the United States*.

FIGURE 3

Contributions to real gross domestic product growth



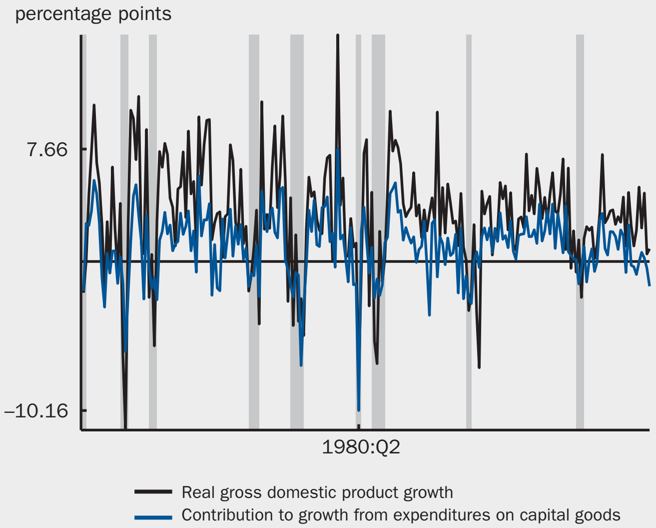
Notes: Each panel plots the component's contribution to real gross domestic product growth from 1954:Q1 through 2008:Q1. Each vertical axis marks the respective component's minimum and maximum values as annual growth rates in percentage points, and each horizontal axis marks the date at which it achieved its minimum value. The panels' vertical scales are the same, so one can compare the contributions' movements visually. The shaded areas mark recessions as defined by the National Bureau of Economic Research.
Source: Author's calculations based on data from the U.S. Bureau of Economic Analysis, *National Income and Product Accounts of the United States.*

contributions move much less over time. The contributions from personal consumption expenditures on nondurable goods and on services both evolve smoothly, and government purchases' contribution appears to be similarly stable. The contribution from personal consumption expenditures on durable goods moves more (as expected because the national household can easily delay these purchases), but it also does not come close to replicating GDP over any sustained period. The same is true for residential investment, business fixed investment, and net exports.

If no particular sector's contributions pose a great risk to GDP growth individually, then GDP fluctuations must arise from *correlated small risks*. That is, even if any given sector can contribute at most 1 percentage point to GDP growth, four such sectors all achieving this maximum rate simultaneously can raise GDP growth by 4 percentage points. This is exactly what happened during the second quarter of 1978, when annualized GDP growth achieved its maximum observed value of 15.45 percentage points. In that quarter, business fixed investment's contribution also hit its maximum value in the sample, 3.89 percentage points. The contributions from other spending on the other two capital goods categories (personal consumption expenditures on durable goods and residential investment) were also substantially above their averages in that quarter (2.87 percentage points and 1.08 percentage points versus averages of 0.45 percentage points and 0.12 percentage points).

FIGURE 4

Contribution to real gross domestic product growth from expenditures on capital goods



Notes: This figure plots the combined contribution of the three capital goods categories—personal consumption expenditures on durable goods, business fixed investment, and residential investment—to real gross domestic product growth from 1954:Q1 through 2008:Q1. The vertical axis marks the contribution's minimum and maximum values as an annual growth rate in percentage points, and the horizontal axis marks the date at which it achieved its minimum value. The shaded areas mark recessions as defined by the National Bureau of Economic Research.

Source: Author's calculations based on data from the U.S. Bureau of Economic Analysis, *National Income and Product Accounts of the United States*.

Figures 4 and 5 reinforce and refine the point that risks common to expenditure categories drive most changes of GDP growth. Figure 4 sums the three capital goods categories' contributions to growth, and figure 5 sums the contributions of personal consumption expenditures on nondurable goods and services. Both figures also plot real GDP growth. Taken together, the three capital goods categories contribute substantially to changes in GDP growth. For example, in 1980:Q2 their contribution to growth equaled –10.2 percentage points, while the actual GDP growth rate equaled –8 percentage points. It is interesting to note that the contribution of personal consumption expenditures on nondurable goods and services hit its minimum value (–2.0 percentage points) in the same quarter; so, there are apparently risks that hit all expenditure categories. However, the typical movements of the personal consumption expenditures contribution are much smaller than those coming from capital goods.

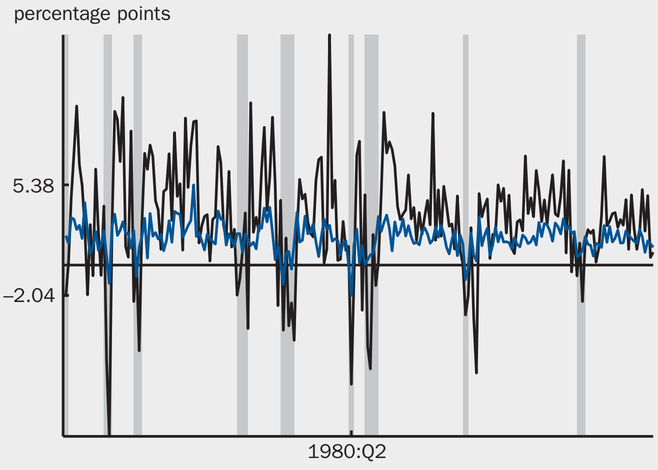
Figures 3, 4, and 5 together show that the most substantial risks to GDP growth come from common movements in expenditures on capital goods. Factors that are more specific than that have never substantially driven the business cycle. For example, the ongoing slump in residential investment presents only very small risks to GDP growth if the slump is confined to that sector alone, but it can substantially influence the overall economy if spillover effects cause other sectors to contract.

Assessing a firm's macroeconomic risks

The analysis in the preceding sections sets the stage for assessing a given business's exposure to macroeconomic risk. This proceeds in two steps: Correct the company of interest's recent sales growth for inflation, and construct a counterfactual benchmark growth rate for a company with the same distribution of sales across NIPA categories but with each product's sales growth perfectly synchronized to the growth of its corresponding NIPA category. The first step determines the influence of category-specific inflation on the business's growth, and the second allows us to examine the influence of macroeconomic risks on similarly positioned businesses in the past.

FIGURE 5

Contribution to real gross domestic product growth from nondurable consumption expenditures



Notes: This figure plots the combined contribution of the two nondurable consumption categories—personal consumption expenditures on nondurable goods, as well as on services—to real gross domestic product growth from 1954:Q1 through 2008:Q1. The vertical axis marks the contribution's minimum and maximum values as an annual growth rate in percentage points, and the horizontal axis marks the date at which it achieved its minimum value. The shaded areas mark recessions as defined by the National Bureau of Economic Research.

Source: Author's calculations based on data from the U.S. Bureau of Economic Analysis, *National Income and Product Accounts of the United States*.

Hair salon

Before I implement this assessment for a large conglomerate firm, I begin by considering how to do this for a fictional firm with a single product: haircuts. Table 2 reports revenues for a fictional hair salon for four years. Most hair salons receive revenues from both cutting and styling services and the retail sale of hair care products. To keep this example simple, suppose that this salon's revenues come entirely from cutting and styling. These expenditures contribute to personal consumption expenditures on services (line 5 in the spreadsheet of figure 1 on p. 31). Table 2's third line reports the NIPA price index for this category, and its fourth line gives the ratio of the first to the third lines (multiplied by 100). This equals the salon's revenues in year 2000 dollars. This simple inflation adjustment brings the salon's revenue growth down by an average of 3.4 percentage points. Over the three years given, the salon's real growth equals 2.9 percent. Since the salon's revenues all come from the sale of services, the real growth rate of personal consumption expenditures on services is a relevant macroeconomic benchmark. For these years, this *always* equaled 2.7 percent. The analysis of panel B of figure 3 (p. 37) implies that this firm is then exposed to very little macroeconomic risk.

General Electric Company

Assessing macroeconomic risk for a single-product business requires little more than looking up the correct price index and real growth rate from the NIPA data. For a conglomerate firm selling multiple products, the inflation adjustment and the construction of a macroeconomic benchmark use the macroeconomic tools discussed previously. I illustrate this here with an application to publicly available data for one firm, General Electric Company. Like many other firms, General Electric reports sales and profits for several operating segments. Each of these groups together lines of business with similar customers. In its 2006 annual report, General Electric breaks its performance down into six operating segments.

- GE Infrastructure contains the production and sales of big-ticket capital items, such as electric generators and jet aircraft engines. It also encompasses the sale of services (including financial services) to the capital items' purchasers.
- GE Commercial Finance provides financial services to firms to finance the purchases of major capital assets.
- GE Money provides financial services to consumers.
- GE Healthcare produces diagnostic equipment and software.
- NBC Universal produces entertainment programming (and thereby advertising revenue).
- GE Industrial produces white goods (major household appliances such as refrigerators and stoves), consumer hardware, and some specialty plastics.

TABLE 2

Revenues and performance of a fictional hair salon

	2007	2006	2005	2004
Revenues *(dollars)*	1,200	1,125	1,050	1,000
Nominal revenue growth *(percent)*	6.6	7.1	5.0	
Price index for services	124.58	120.73	116.73	112.93
Revenues *(2000 dollars)*	963.24	931.83	899.51	885.50
Real revenue growth *(percent)*	3.4	3.6	1.6	
Growth of macroeconomic benchmark *(percent)*	2.7	2.7	2.7	

TABLE 3

General Electric Company's operating revenues

Operating segment	2006	2005	2004	2003	2002
	millions of dollars				
GE Infrastructure	47,429	41,803	37,373	36,569	40,119
GE Commercial Finance	23,792	20,646	19,524	16,927	15,688
GE Money	21,759	19,416	15,734	12,845	10,266
GE Healthcare	16,562	15,153	13,456	10,198	8,955
NBC Universal	16,188	14,689	12,886	6,871	7,149
GE Industrial	33,494	32,631	30,722	24,988	26,154
Total segment revenues	159,224	144,338	129,695	108,398	108,331
Corporate items and eliminations	4,167	3,618	4,596	5,023	3,636
Consolidated revenues	163,391	147,956	134,291	113,421	111,967

Note: Data are for General Electric Company and its consolidated affiliates.
Source: General Electric Company, *2006 Annual Report: Invest and Deliver*, p. 53.

For General Electric, table 3 displays the relevant data. This table from its 2006 annual report lists each operating segment's sales (in U.S. dollars) for five years (2002–06). Just as with the macroeconomic data, I begin with each segment's share of total revenue, which table 4 lists for 2004. Consistent with GE's industrial origins, the GE Infrastructure and GE Industrial segments account for more than half of the company's revenues. Consumer services (GE Money and NBC Universal) account for just less than 20 percent, and the remaining 25 percent of revenues come from the GE Commercial Finance and GE Healthcare segments.

The segments' shares allow the calculation of their contributions to growth. In equation 8, I wrote the rate of GDP growth (in dollars) as the share-weighted average of its expenditure components' growth rates. Just so, we can write GE's growth rate as the share-weighted average of its segments' growth rates. Table 5 reports this decomposition of growth for 2005 and 2006. This calculation used segment growth rates adjusted for the effects of those acquisitions and divestitures mentioned in the 2006 annual report's managerial discussion of these figures. Overall revenue growth was similar for GE in those two years at 9.0 percent and 9.6 percent.

Inflation adjustment

The straight decomposition of revenue growth in table 5 ignores the effects of inflation. If inflation affects the prices of all goods equally, then taking account of inflation would only lower the measured growth of total revenues and leave each segment's relative contribution unchanged. Of course inflation affects some goods more than others. For example, the prices of capital goods (measured with the price index for business fixed investment) actually fell in both 2005 and 2006. In this more realistic case, accounting for inflation proceeds in two steps:

- Assign a GDP expenditure category to each segment; and
- Combine the NIPA price indexes for these categories with the segments' revenue histories in the contributions to growth formula in appendix B to calculate each segment's contribution to the company's real revenue growth.

TABLE 4

Share of General Electric Company's revenues, by operating segment, 2004

Operating segment	Percentage of revenues
GE Infrastructure	33.7
GE Commercial Finance	15.6
GE Money	11.9
GE Healthcare	9.4
NBC Universal	6.3
GE Industrial	23.1

Source: Author's calculations based on data from General Electric Company, *2006 Annual Report: Invest and Deliver*, p. 53.

TABLE 5

Contributions to General Electric Company's nominal revenue growth, by operating segment

Operating segment	2006	2005
	(percent)	*(percent)*
GE Infrastructure	3.9	3.4
GE Commercial Finance	2.2	0.6
GE Money	1.0	1.4
GE Healthcare	1.0	0.7
NBC Universal	1.0	1.4
GE Industrial	0.5	1.5
Total segment revenues	9.6	9.0

Note: For these calculations, each segment's growth was adjusted for the effects of acquisitions and divestitures mentioned in the 2006 annual report's managerial discussion.
Source: Author's calculations based on data from General Electric Company, *2006 Annual Report: Invest and Deliver*, p. 53.

Choosing which GDP expenditure's price index should be used for a given segment can be straightforward when a segment's sales directly contribute to GDP. In the case of General Electric, GE Healthcare and GE Infrastructure both contribute to business fixed investment of equipment and software and GE Money's revenues are part of personal consumption expenditures on services. The sales of General Electric's other segments do not *arithmetically* contribute to GDP because they sell goods and services that other producers use to create products for sales to final consumers. For example, NBC Universal sells advertising. Firms use this to enhance the value of the products they sell to consumers, so it contributes in that way to personal consumption expenditures. General Electric's other segments sell products to consumers and producers in multiple NIPA expenditure categories. Without detailed information on those segments' sales, the best measure of their prices is the price index for GDP as a whole. Table 6 summarizes my choices of price indexes for General Electric's segments.

Table 7 reports the segments' contributions to inflation-adjusted revenue growth given these price index choices. Just as with the contributions in table 5, these use acquisition-adjusted growth rates. Overall inflation was just over 3 percent for both 2005 and 2006, but adjusting GE's revenues for inflation knocks only 2 percentage points off of overall revenue growth (compare the last lines in tables 5 and 7). This reflects their heavy concentration in capital investment goods where inflation tends to be lower. To see this, note that GE Infrastructure and GE Healthcare together do not account for *any* of the 2 percentage point adjustment (their values are the same in both tables 5 and 7).

Macroeconomic benchmarks

The final step in evaluating GE's exposure to macroeconomic risk is the construction of a relevant benchmark growth series. Here, I offer two such benchmarks. They both answer the question, How would the economy have evolved if the mix of products produced were always identical to GE's mix? Their point of difference is the moment in time when the product mix is measured. The first benchmark uses the contributions to growth formula to continuously account for the company's changing orientation. The second holds the product mix fixed at the most recent year's values. The first is more useful for gauging past performance, and the second can be used to ask how the company would have fared in the past had it been configured as it is in the present.

TABLE 6

National income and product accounts (NIPA) price indexes for General Electric Company's operating segments

Operating segment	NIPA price index
GE Infrastructure	Business fixed investment, equipment and software
GE Commercial Finance	Gross domestic product
GE Money	Personal consumption expenditures, services
GE Healthcare	Business fixed investment, equipment and software
NBC Universal	Personal consumption expenditures
GE Industrial	Gross domestic product

Note: These are the author's subjective choices of NIPA price indexes for General Electric's operating segments.

The first macroeconomic benchmark arises from the following calculation: Apply the contributions to growth formula to General Electric with the NIPA expenditure category listed in table 6 replacing each segment's real growth rate. This measures how revenues would have grown if each of GE's segments had tracked its NIPA counterpart exactly. The result will differ from overall GDP growth because GE does not produce a representative variety of all goods and services. Table 8 reports the result of this calculation, and its comparison with table 7 is instructive. The macroeconomic benchmark grew 4.1 percent in both 2005 and 2006, which is substantially below General Electric's actual real growth rates of 6.9 percent and 7.6 percent. The GE Infrastructure segment accounts for nearly 2 percentage points of this "overperformance" in both years. Three other segments grew faster than their NIPA counterparts in both years—GE Money, GE Healthcare, and NBC Universal. Together, they account for 1.5 and 0.9 percentage points of GE's higher growth in 2005 and 2006. There were only two cases where a GE segment contributed less to growth than its NIPA counterpart: GE Commercial Finance in 2005 and GE Industrial in 2006.

General Electric differs from the nation's economy in several respects. It has extensive operations and sales abroad. It specializes in submarkets within NIPA expenditure categories. For example, medical equipment, aircraft engines, and generators are only three of the thousands of capital goods produced in the U.S. Developments in these specific markets that are out of General Electric's control can nevertheless disproportionately affect its performance. For these reasons, the comparison of tables 7 and 8 only starts the conversation about General Electric's performance relative to its macroeconomic benchmark. Continuing the conversation requires information on market-specific developments and operational performance that lies beyond the scope of this article.

The first benchmark accounts for the business's changing product mix, using the contributions to growth formula, but this accounting might actually obscure the information needed for macroeconomic risk assessment. For example, consider a business that once produced mostly consumer services but has recently expanded into residential investment. The first macroeconomic benchmark for it fluctuated little in recent recessions, but it would be a mistake to conclude that it has little exposure now to risk. To address this issue, we can calculate a second macroeconomic benchmark that holds the operating segments' shares at their most recently observed values. Figure 6 plots this for General Electric. For comparison's sake, the figure also plots overall real GDP growth.

Examining the two series during NBER-dated recessions (the shaded periods) is instructive. A company oriented as GE is now would have been highly sensitive to macroeconomic risk. The most recent recession (in 2001) was concentrated in precisely the industries GE serves, so its macroeconomic benchmark growth rate was well below zero for about two years. During this period, overall real GDP growth was negative for only two quarters. Although the most recent recession's heavy concentration in business fixed investment was exceptional, the comparison of the second macroeconomic benchmark with

TABLE 7

Contributions to General Electric Company's inflation-adjusted revenue growth, by operating segment

Operating segment	2006	2005
	(percent)	*(percent)*
GE Infrastructure	3.9	3.4
GE Commercial Finance	1.7	0.1
GE Money	0.5	0.9
GE Healthcare	1.0	0.7
NBC Universal	0.7	1.1
GE Industrial	–0.2	0.7
Total segment revenues	7.6	6.9

Note: For these calculations, each segment's growth was adjusted for the effects of acquisitions and divestitures as described in the text.
Sources: Author's calculations based on data from the U.S. Bureau of Economic Analysis, *National Income and Product Accounts of the United States*; and General Electric Company, *2006 Annual Report: Invest and Deliver*, p. 53.

TABLE 8

Macroeconomic counterfactual contributions to General Electric Company's inflation-adjusted revenue growth, by operating segment

Operating segment	2006	2005
	(percent)	*(percent)*
GE Infrastructure	1.7	1.7
GE Commercial Finance	0.4	0.4
GE Money	0.4	0.3
GE Healthcare	0.6	0.6
NBC Universal	0.3	0.3
GE Industrial	0.7	0.7
Total segment revenues	4.1	4.1

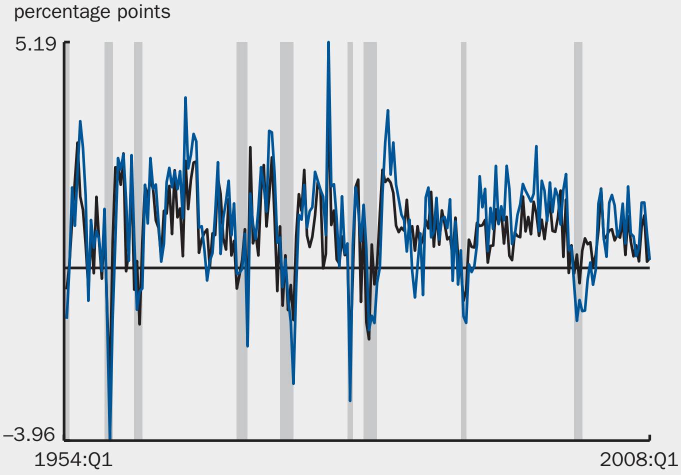
Note: For these calculations, each segment's growth was adjusted for the effects of acquisitions and divestitures as described in the text.
Sources: Author's calculations based on data from the U.S. Bureau of Economic Analysis, *National Income and Product Accounts of the United States*; and General Electric Company, *2006 Annual Report: Invest and Deliver*, p. 53.

real GDP growth during earlier recessions yields the same conclusion. The company's concentration in industries with customers who can easily delay their purchases leaves it substantially exposed to macroeconomic risk.

To quantify GE's exposure, we can calculate the standard deviation of its macroeconomic benchmark growth and compare it with the standard deviation of GDP growth.[5] For the period plotted, the macroeconomic benchmark's standard deviation equals 1.22 percent, while that for GDP growth is 0.91 percent. Thus, the benchmark is approximately 33 percent more sensitive to business cycle fluctuations than is the economy as a whole.

FIGURE 6

Macroeconomic benchmark growth for General Electric Company



Note: The benchmark was constructed using 2006 General Electric operating segment shares and the assignment of operating segments to national income and product accounts' price indexes in table 6.

Sources: Author's calculations based on data from the U.S. Bureau of Economic Analysis, *National Income and Product Accounts of the United States*; and General Electric Company, *2006 Annual Report: Invest and Deliver*, p. 53.

Conclusion

This article presented two basic tools for measuring business cycle fluctuations, the national product accounting identity and the contributions to growth formula, and applied them to evaluate a particular conglomerate's exposure to macroeconomic risk. The application was illustrative only because it omitted factors such as the scope of the company's international operations and sales that are important for that company. The macroeconomic benchmarks presented here can only start a conversation about a business's place in the larger economy. Finishing it and moving on to action requires more information and the subjective judgment of those whose wealth is at stake.

NOTES

[1]This is the only case in which the BEA attempts to measure the value of a service produced in the home.

[2]Of course, foreign governments and institutions hold substantial U.S. government debt. Within this simple framework, I can represent these financial investments by supposing that the national household issues IOUs to foreigners to finance the purchase of government debt. Thus, the convenient restriction that only U.S. households hold government debt entails no important loss of generality.

[3]For expositional simplicity only, this discussion presumes that the conglomerate government has no employees and engages in no production of its own. In reality, the BEA adds the values of government employees' salaries to G_t.

[4]This assumes that the tax decrease has no effect on the national household's incentive to work, which is the case when the tax is collected like a poll tax. In the United States, much tax revenue comes from taxing labor income. Lowering such a tax and financing the shortfall with debt can temporarily expand income, but even this might not serve the household's interests.

[5]For any sequence of observations $x_1, x_2, \ldots, x_T$, the mean and standard deviation are defined as $\bar{x} = (x_1 + x_2 + \cdots + x_T)/T$ and $\hat{\sigma} = \sqrt{(x_1-\bar{x})^2 + (x_2-\bar{x})^2 + \cdots + (x_T-\bar{x})^2}$. If all of the observations are identical, then the standard deviation equals zero. Differences between the observations raise the standard deviation, so it is a measure of dispersion.

Observations of the national income and product accounting identities' components reveal how the value of goods and services *measured in dollars* evolves, but erosion of the dollar's purchasing power makes these measures insufficient for tracking economic growth. The BEA fills this gap with measures of how the prices of goods in each product category change.

If each category had only one good (or service) for sale, then accounting for inflation would be simple. Let X_t represent the *nominal value* of some expenditure component, and let P_t give the dollar-denominated price for its single good or service. For example, if the category in question was nondurable goods and the only good in that category was bananas, then P_t would equal the dollar price of one pound of bananas and X_t/P_t would equal the pounds of bananas purchased in the quarter, also called the quarter's *real expenditure*. The real expenditure's growth rate is

$$\text{A1)} \qquad G_t = \frac{X_t}{P_t}\frac{P_{t-1}}{X_{t-1}} - 1.$$

Of course, there are hundreds of thousands of distinct goods or services that contribute to any given expenditure category. Nevertheless, the BEA constructs the real growth rate of each expenditure category by using equation A1. For this, it replaces P_t with an index of prices for goods in the category. Constructing such an index when there are only two goods in the category suffices to illustrate the principles involved. Suppose that personal consumption expenditures on nondurable goods covers only apples and oranges. Use P_t^A and P_t^O for their dollar prices (per pound) and Q_t^A and Q_t^O for the number of pounds sold. Two German economists, Étienne Laspeyres and Hermann Paasche, offered solutions to the problem of combining these data to measure how the price of fruit changed between the previous and current quarters. Laspeyres proposed measuring P_t / P_{t-1} with a *weighted* average growth of individual goods prices. Each weight equals the expenditure share on that good in the base period.

$$\text{A2)} \qquad Laspeyres_t = \frac{P_{t-1}^A Q_{t-1}^A}{P_{t-1}^A Q_{t-1}^A + P_{t-1}^O Q_{t-1}^O}\frac{P_t^A}{P_{t-1}^A} + \frac{P_{t-1}^O Q_{t-1}^O}{P_{t-1}^A Q_{t-1}^A + P_{t-1}^O Q_{t-1}^O}\frac{P_t^O}{P_{t-1}^O}$$

$$= \frac{P_t^A Q_{t-1}^A + P_t^O Q_{t-1}^O}{P_{t-1}^A Q_{t-1}^A + P_{t-1}^O Q_{t-1}^O}.$$

The second expression makes clear that $Laspeyres_t$ equals the cost of acquiring the previous quarter's purchases at the current quarter's prices relative to their cost in the original quarter. Paasche's alternative suggestion is to measure the cost of the current quarter's purchases relative to the same purchases made at the previous quarter's prices.

$$\text{A3)} \qquad Paasche_t = \frac{P_t^A Q_t^A + P_t^O Q_t^O}{P_{t-1}^A Q_t^A + P_{t-1}^O Q_t^O}.$$

Both of these suggestions measure the growth of prices, which is all that equation A1 requires. They both realistically weight prices based on the national family's actual purchase decisions, but both of them rely an arbitrary selection of the date at which we measure their purchases. To avoid this arbitrariness, the BEA measures the rate of change with the geometric average of the Laspeyres and Paasche measures. This idea was originally due to Irving Fisher:

$$\text{A4)} \qquad Fisher_t = \sqrt{Laspeyres_t \times Paasche_t}\ .$$

The expressions for $Laspeyres_t$ and $Paasche_t$ can both be easily extended to the case with more than two goods. With these in hand, the BEA constructs P_t by setting its value in the first quarter of the data to one and setting its values for later quarters recursively with

$$P_t = Fisher_t P_{t-1}.$$

To make the series more easily interpretable, the BEA finishes by multiplying by 100 and dividing by the average value of P_t during a base year (which is currently 2000). The resulting series indicates how many dollars it requires in any given quarter to buy the same goods and services that $100 could purchase in 2000. The BEA labels this the *real* expenditure series corresponding to X_t. In this article, I use $x_t \equiv X_t/P_t$ to represent this real series. For example, c_t^N, c_t^S, and c_t^D respectively equal real personal consumption expenditures on nondurable goods, services, and durable goods.

Of course, we can apply the Fisher deflation procedure to create real values of each national product component. Before working with these, a note of caution regarding addition is in order. There are two conceivable ways of calculating the real values of all personal consumption expenditures. First, one could create a Fisher price index based on all goods in personal consumption expenditure (call it P_t^C) and then calculate $c_t = \left(C_t^N + C_t^S + C_t^D\right)/P_t^C$. Second, one could simply add the components' real values, $c_t^N + c_t^S + c_t^D$. Will these answers equal each other? Yes, if no two goods or services in personal consumption expenditures have prices that change relative to each other. In the two-good example used previously, this requires that the number of oranges the national family must sacrifice in order to acquire one more apple cannot change with time: $P_{t-1}^A / P_{t-1}^O = P_t^A / P_t^O$. In this very special case, the Laspeyres, Paasche, and Fisher price indexes all equal each other; and all prices grow in lock step. Outside of this very special case, the two calculations of real personal consumption expenditures will differ. By construction, the first calculation uses the Fisher price index. The second calculation can only be useful as a possible shortcut to the first. It is not, so we dispose of it. This illustrates a general principle: The real analogues of the components in the national product accounting identity *do not sum to real income except in the base year*.

Calculating the exact Fisher-deflated real analogue to a sum of two product components requires applying the Fisher procedure to the original price and quantity observations from both components. Of course, the BEA does not provide these, so a useful (and accurate) approximation to this exact calculation is to apply the Fisher procedure to the components themselves. For example, to calculate approximate real personal consumption expenditures on nondurable goods and services, replace Q_t^A, Q_t^O, P_t^A, and P_t^O in equations A2 and A3 with c_t^N, c_t^S, P_t^{CN}, and P_t^{CS}. Since the BEA reports real personal consumption expenditures as well as the real expenditures for each of its three components, it is possible to assess how well this "chain-addition" procedure works. The approximate real personal consumption expenditure differs from its exact counterpart by at most 3/100 of a percentage point over the post-Korean War sample period.

APPENDIX B. CONTRIBUTIONS TO GROWTH

By construction, GDP sums the national family's expenditures in the various categories. To gain a greater understanding of the sources of growth, one might wish to decompose GDP growth into the expenditures' distinct contributions. Suppose that the only two goods produced in the nation are apples and oranges, so that $Y_t = P_t^A Q_t^A + P_t^O Q_t^O$.

Definition 1

The contribution of expenditures on apples to the growth of GDP from quarter t – 1 to quarter t equals

$$100 \times \left(P_t^A Q_t^N - P_{t-1}^A Q_{t-1}^A \right) / Y_{t-1},$$

the reduction of the GDP growth rate that would have occurred if the national family had left its expenditures on apples unchanged from quarter t – 1 to quarter t and income from some source adjusted simultaneously so that the national product accounting identity continues to hold good.

The contribution of expenditures on oranges is defined analogously, and summing them yields 100 × $(Y_t - Y_{t-1})/Y_{t-1}$, the growth rate of nominal GDP.

Nominal GDP growth convolves real economic expansion with price inflation, so calculating the various contributions to it reveals little about the expansion of the national family's real purchasing power. For this reason, we might be more interested in the impact on real GDP growth of holding the *quantity* of apples fixed. We can call this the growth impact of real apple expenditures.

Definition 2

The growth impact of apple expenditures from quarter t – 1 to quarter t equals the actual growth rate of real GDP minus the growth rate recalculated after replacing Q_t^A's value with Q_{t-1}^A's value.

We can make the same calculation for real orange expenditures, but these two growth impacts will not sum to the growth of real GDP. This reflects the inconvenient truth noted previously that the sum of real expenditures does not equal the real expenditure on the sum *unless* $P_t^A / P_t^O = P_{t-1}^A / P_{t-1}^O$. Hence, the growth impacts of apple and orange expenditures—while potentially interesting—cannot serve as the basis for an accounting of real GDP growth.

The single exception to the general proposition that the sum of real expenditures does not equal the real expenditure on the sum offers us the possibility of defining contributions to growth by artificially imposing that all relative prices remain the same. Use P_{t-1}^{A*}, P_{t-1}^{O*}, P_t^{A*}, and P_t^{O*} to denote these alternative (counterfactual prices) that satisfy $P_{t-1}^{A*} / P_{t-1}^{O*} = P_t^{A*} / P_t^{O*}$. What values should we assign them? Consider

B1) $$P_{t-1}^{A*} = \frac{P_{t-1}^A + P_t^A / \pi_t^F}{1 + \sqrt{\pi_t^L / \pi_t^P}}, \quad P_t^{A*} = \pi_t^F P_{t-1}^{A*},$$

$$P_{t-1}^{O*} = \frac{P_{t-1}^O + P_t^O / \pi_t^F}{1 + \sqrt{\pi_t^L / \pi_t^P}}, \quad P_t^{O*} = \pi_t^F P_{t-1}^{O*}.$$

These satisfy the restriction that relative prices do not change, and either quarter's nominal GDP calculated with them equals its original value. To show this, start with the definition of nominal GDP for quarter $t-1$ with the alternative prices. Substituting the alternative prices definitions and manipulating yields

$$\begin{aligned}
Y^{*}_{t-1} &= P^{A*}_{t-1}Q^{A}_{t-1} + P^{O*}_{t-1}Q^{O}_{t-1} \\
&= \frac{P^{A}_{t-1} + P^{A}_{t}/\pi^{F}_{t}}{1+\sqrt{\pi^{L}_{t}/\pi^{P}_{t}}}Q^{A}_{t-1} + \frac{P^{O}_{t-1} + P^{O}_{t}/\pi^{F}_{t}}{1+\sqrt{\pi^{L}_{t}/\pi^{P}_{t}}}Q^{O}_{t-1} \\
&= \frac{P^{A}_{t-1}Q^{A}_{t-1} + P^{O}_{t-1}Q^{O}_{t-1}}{1+\sqrt{\pi^{L}_{t}/\pi^{P}_{t}}} \\
&\quad + \frac{P^{A}_{t}Q^{A}_{t-1} + P^{O}_{t}Q^{O}_{t-1}}{\pi^{F}_{t}} \frac{1}{1+\sqrt{\pi^{L}_{t}/\pi^{P}_{t}}}.
\end{aligned}$$

Next, replace $P^{A}_{t}Q^{A}_{t-1} + P^{O}_{t}Q^{O}_{t-1}$ with $\pi^{L}_{t}Y_{t-1}$ to get

$$Y^{*}_{t-1} = \frac{Y_{t-1}}{1+\sqrt{\pi^{L}_{t}/\pi^{P}_{t}}} + \frac{\pi^{L}_{t}}{\pi^{F}_{t}}\frac{Y_{t-1}}{1+\sqrt{\pi^{L}_{t}/\pi^{P}_{t}}}.$$

The definition of π^{F}_{t} implies that $\pi^{L}_{t}/\pi^{F}_{t} = \sqrt{\pi^{L}_{t}/\pi^{P}_{t}}$, so the right-hand side equals Y_{t-1}. A parallel argument shows that $Y^{*}_{t} = Y_{t}$, so changing to the alternative prices leaves nominal GDP growth unchanged. The Laspeyres, Paasche, and Fisher price indexes constructed with these prices and the original quantities all equal π^{F}_{t}, so replacing the alternative prices also leaves real GDP growth unchanged. All of this leads to the following definition.

Definition 3

The contribution of real apple purchases to real GDP growth equals

$$\frac{P^{A*}_{t-1}\left(Q^{A}_{t} - Q^{A}_{t-1}\right)}{Y_{t-1}}.$$

This added to the analogously defined contribution of real orange purchases does sum to real GDP growth.

This equation defines the contributions to growth when two components contribute to GDP, but the same approach also works with a larger number of components: Average a category's price index in quarter $t-1$ with its value in quarter t divided by π^{F}_{t}, divide by $1+\sqrt{\pi^{L}_{t}/\pi^{P}_{t}}$, and use this for P^{A*}_{t-1} in definition 3.

REFERENCE

General Electric Company, 2007, *2006 Annual Report: Invest and Deliver*, Fairfield, CT.