CENTER FOR APPLIED ECONOMICS AND POLICY RESEARCH

CAEPR Working Paper
#2007-001

Dependence on External Finance by Manufacturing Sector: Examining the Measure and its Properties

George von Furstenberg
National Science Foundation and Indiana University

and

Ulf von Kalckreuth
Deutsche Bundesbank

January 8, 2007

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George M. von Furstenberg
(National Science Foundation and Indiana University)

Ulf von Kalckreuth
(Deutsche Bundesbank)

Abstract:

Rajan and Zingales (1998) use U.S. Compustat firm data for the 1980s to obtain measures of manufacturing sectors' Dependence on External Finance (DEF), i.e., finance external to the firm. They take any differences in these measures to be structural/technological and thus applicable to other countries. Their joint assumptions about how to obtain representative values of DEF by sector and about why these values differ fundamentally between sectors have been adopted in additional studies seeking to show that sectors benefit unequally from a country's level of financial development. However, the assumptions as such have not been examined. The present study, conducted with cyclically adjusted annual measures of DEF derived from U.S. industry data for 1977-1997, attempts to do so using data that are aggregated by sector. We find that those variables that may be regarded as structural/technological have very low explanatory power, and that the DEF figures calculated from micro data do not correspond closely to what is obtained from aggregate figures. Hence key assumptions on which RZ's argumentation is based have not been validated.

Keywords: Growth and finance, financial development, industry structure

JEL-Classification: E50, G20, G30, O14, O16

Note: The Appendices starting on p. 35 are not for publication. They are contained in Discussion Paper Series 1: Economic Studies No. 30/2006 on the web site of the Deutsche Bundesbank, www.bundesbank.de.

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* Correspondence: George M. von Furstenberg, 995N SBE/SES, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230, USA; gvonfurs@nsf.gov; vonfurst@indiana.edu .
Ulf von Kalckreuth, Economics Deptartment, Deutsche Bundesbank, Wilhelm-Epstein-Strasse 14, D-60431 Frankfurt, Germany; ulf.von-kalckreuth@bundesbank.de .
The first draft of this paper was presented at the Allied Social Science Associations meetings in Boston, January 7, 2006. Since then detailed comments have been received from Dr. Heinz Herrmann of Deutsche Bundesbank. Further helpful comments incorporated into this revision were provided on subsequent occasions by Franco Spinelli of the University of Brescia and by Andrew Ellul, Eric Rasmusen, and Gregory Udell of the Indiana University Kelley School of Business. Michael D. Glenn of the National Income and Wealth Division, and Gabriel Medeiros of the Industry Division of the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce provided expert guidance to, and help with, the data sources. Presentation at the Seventh Center for Financial Studies Conference, co-sponsored by the European Central Bank and the Deutsche Bundesbank, in Berlin on September 29, 2006, and helpful comments by discussants led to additional revisions.

1 Introduction

This paper examines the measure of Dependence on External Finance (DEF) by manufacturing-industry sector introduced by Rajan and Zingales (RZ, 1998) and the evidence for the conceptual properties attributed to it. This work has had lasting influence: The authors' measure, and its application and interpretation, have been widely adopted and remain in use. For this reason both the construction of the measure and the characteristics attributed to it deserve close and respectful scrutiny.

A firm's DEF is defined as the difference between capital expenditures (CE) on fixed assets and cash flow (CF) from operations divided by CE, $DEF \equiv (CE - CF)/CE = 1 - CF/CE$. RZ derived that measure from Compustat Statements of Cash Flow and other Compustat data items for listed U.S. companies, selecting the median firm per sector. We contrast the particular features of the RZ measure with those of an alternative measure derived from a quite different database not hitherto utilized in this context. We check the correlation between these two U.S.-based measures and weight by the relative importance of industry sectors to check on the robustness of construction and the representativeness of the measures derived. We then use the alternative, macroeconomic, measure to shed light on the inherent characteristics attributed to RZ's original measure but not testable with it. Thus we focus on two key questions about the U.S. DEF data by use of our alternative data construct:

(1) *To what extent are the microeconomic U.S. data which RZ selected to characterize the DEF values of each sector suited to represent that whole sector's financing needs in the United States?*

(2) *Are the differences in the U.S. DEF values by sector attributable to identifiable factors that may be regarded as structural/technological?*

By examining solely the derivation and properties of DEF, the paper covers only the first step essential in scientific analysis. That step relates to the validation of measures central to a particular hypothesis and its tests. Now that DEF has been used as a building block of a new theory of comparative advantage without first completing that step, we are going back and asking whether the measure and known properties of DEF qualify the construct to play such a role. We next describe the theory in which DEF figures as the key operational concept.

1.1. A new theory of comparative advantage

As laid out for instance by Levine (2004), Rousseau and Wachtel (2005), and Arestis, Chortareas and Desli (2006), domestic financial development has implications for (a) risk sharing and consumption smoothing, (b) economic stability, (c) the level of economic growth, and (d) the structure of growth by sector. Only the last of these aspects, linking financial development to comparative advantage, concerns us here.[1]

Theories seeking to explain international differences in the relative growth rates of industries on the basis of comparative advantage typically are applied in two steps:

(i) First, technological characteristics are identified by sector from data gathered in advanced countries with the most developed and open factor and product markets. In applications of the Scandinavian (or Heckscher-Ohlin) theory of comparative advantage, for example, sectors may be characterized by production-function parameters representing their inherent degree of capital intensity.

(ii) Countries with differences in their relative endowments ─ in the previous example, an economy's endowment of capital versus labor ─, when brought into contact with one another through external opening only of product markets, then would display predictable differences in the industrial structure of growth: Labor-intensive industries would grow faster for a time than capital-intensive industries in countries relatively well endowed with labor, and the reverse would hold in those well endowed with capital. As a result, factor-specific international specialization of production would be enhanced.

Following this scheme, RZ (1998) classified manufacturing sectors in a way that could be relevant to comparative rates of growth by sector in different countries, depending on their level of domestic financial development (FD).[2] RZ's classification

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[1] Kose, Prasad, Rogoff and Wei (2006) have critically examined the first three factors or effects in a global context. Cetorelli and Strahan (2006, p. 2) have formulated the key current research questions relating to the growth effects of financial markets on the level and structure of industry-sector growth.

[2] FD is indicated by stock-to-flow ratios such as M2/GDP or credit to the private sector plus stock-market capitalization over GDP. Further distinctions are between bank-based and market-based systems (e.g., Beck and Levine, 2001) and by degree of concentration in the banking sector (Cetorelli and Gambera, 2001; Andersen and Tarp, 2003). Other characteristics considered are legal traditions relating to creditor rights and contract enforcement, and the quality of accounting systems and of regulations affecting intermediary development and efficiency (see RZ, 1998, p. 576; Levine, Loayza and Beck, 1999; de Serres *et al.*, 2006; and Ciccone and Papaioannou, 2006). The latter, as well as Caballero (2006) and others, also consider how much financial development reduces financial frictions and speeds technology adoption and capital reallocation. Berger and Udell (2005) consider the entire menu of lending and transactions technologies in use in a country, plus its structures of relationship

relied on a particular measure, the median firm's DEF, to reveal a latent technological characteristic of its sector. Assuming *local* financial development matters, as later confirmed by Guiso, Sapienza, and Zingales (2004) and Stulz (2005), they then investigated whether international differences in the structure of growth by sector can be linked to differences in domestic financial development that make it easier to raise funds from outside the firm in some countries than in others.

1.2. Structural/technological reasons for differences in DEF by sector?

RZ (1998, p. 563) subsumed that "there is a technological reason why some industries depend more on external finance than others... [T]hese technological differences persist across countries, so that we can use an industry's dependence on external funds as identified in the United States as a measure of its dependence in other countries." They then tested the inference that a high (low) level of FD in a country favors the growth of industries most (least) dependent on external finance as revealed by US data for the 1980s.[3] Laeven, Klingebiel, and Krozner (2002) have added and tested the corollary that financial crises have a disproportionately negative impact on these sectors. Pre-2004 studies surveyed in von Furstenberg (2004) directly using RZ's estimates, and more recent studies using RZ-like data constructs[4] (e.g., Ciccone and Papaioannou, 2006; Serres *et al.*, 2006), with few exceptions (e.g., Andersen and Tarp, 2003; Fisman and Love, 2004), have tended to support the inference above. The 2006 studies cited above have focused on new issues, such as DEF's influence on the speed of capital reallocation between sectors or across (sub-national) regulatory boundaries.

As technological factors why some sectors depend more on external finance than others, RZ (p. 563) list differences in initial project scale, the gestation period, the cash

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lending, to predict the effectiveness of financial services for particular sectors. Edison *et al.* (2002), Chari and Henry (2002), and Abiad, Oomes, and Ueda (2004) focus instead on identifying the effect of *international* financial integration on economic growth to which FDI may contribute.

[3] Because of the cross-sectional orientation of their work, RZ (1998) do not consider how especially rapid advances in FD may affect the structure of growth in a country even if the sample-period average level of its FD is low. This is done in von Furstenberg (2004) for Poland after its emergence from socialism. The study finds no support for the Rybczynski-effect hypothesis that more of the factor "finance" through rapid FD favors the growth of industry-sectors more the higher their DEF.

[4] An RZ-like measure is defined as the median of the time-averaged DEF values of firms in each industry sector. This median is regarded as yielding a fixed and universal characteristic of that sector. Laeven, Klingebiel, and Krozner (2002) apply the RZ data construction method exactly but to a particular set of 3-digit ISIC industries. Firm-level databases other than Compustat and averages for periods other than the 1980s may also be used in RZ-like measures.

harvest period, and the amount of follow-on investments required. RZ did not test whether any of these correlate as expected with their measure of DEF by sector. And indeed the bearing of the factors they listed on the DEF values of firms could well be limited to the start-up phase of their business and to any subsequent growth spurts. As others since have demonstrated directly, industries that are populated by young and small firms have the highest sensitivity to cash flow and the greatest DEF.[5] Yet, considering, say, the history of Microsoft's position in its sector, the distribution of firms by size, age and financing needs is not likely to be fixed and universal in a sector.

To address this problem of sectors maturing and experiencing changing financing needs, RZ gave separate attention to the "young" and "mature" among "all" companies and to the extent to which growth is produced by an increase in the number of firms in a sector rather than an increase in their average size. They found (pp. 577-579) that while the development of financial markets has a disproportional impact on the growth in the number of firms, the interaction between their measure of DEF and an array of proxies for financial development is not statistically significant for growth in the average size of firms and, unexpectedly, much weaker for "young" than for "all" companies in a sector. Hence what exactly is behind differences in DEF by sector that could make these differences structural/technological as RZ maintain has remained uncertain.

Reducing that uncertainty is difficult because *structural/technological*, when used to describe factors accounting for differences in DEF between sectors, technically is a fuzzy characteristic. Properties of production functions such as the specification of human capital and technological progress, scale effects, elasticity of factor substitution, and factor intensity may have nearly 100 percent membership in the concept. Characteristics of input use within sectors, such as the depreciation rate and materials intensity, or the degree of dependence on external inputs, have a smaller, but still high, degree of membership. Characteristics that may be relevant to the cash flow process in relation to investment, such as the riskiness of a sector and its leverage and collateralization potential, may also claim some degree of membership in the concept of being structural/technological.

[5] See, for instance, Beck *et al.* (2005), and Acharya, Imbs, and Sturgess (2006). Cooley and Quadrini (2003), and Clementi and Hopenhayen (2006) discuss models in which the cash flow sensitivity of investment varies with size only since size is positively correlated with the age of firms, or vice versa.

RZ's own conjectures offer some guidance on where to look for structural/ technological origins of differences in U.S. DEF by industry sectors: They have to lie in financing structures directly associated with the cash flow generation process and its relation to planned investment. Indeed, they (1998, pp. 581-583) demonstrate (through the absence of significant interaction of DEF with endowment variables other than the level of FD, such as average years of schooling completed, in growth regressions) that differences in their measures of U.S. DEF by sector are indeed inherently financial. RZ likewise reject the hypothesis that financial development is just a concomitant of economic development. They then look upon the DEF values observed in the United States as a fundamental characteristic of industry sectors that interacts with the degree of FD in 41 other countries to determine their patterns of comparative advantage.

Whether DEF can in fact be viewed as a fundamental characteristic of manufacturing sectors in the United States and, at least latently, in other countries and over time may have implications for price relations in finance as well as for the expected industry structure of economic growth. Cochrane (2005, p. 18; see pp. 95-103 for references) notes that, to explain pricing anomalies, empirical papers now routinely form portfolios by sorting on characteristics other than the three Fama-French "priced factors" that include firm size and book-to-market-value portfolios. Among such other sorting criteria for listed firms may be their industry-production (e.g., primary metals) or final-demand (e.g., consumer durables) sector when differences in return characteristics of firms in such sectors are not fully explained by CAPM valuation plus priced factor models. Cochrane (2005, p. 22) conjectures that good cash-flow news could bring growth options into the money, and this event could increase the systematic risk (betas) of the winner stocks. Cash-flow news then has more effect on highly levered, or otherwise external-financing constrained, high DEF than on low DEF sectors. If this systematic risk element is not priced as expected, DEF by sector could itself become a priced factor, identifying an anomalous pattern found in the equilibrium cross-section of returns, if DEF were, in fact, a fundamental characteristic of these industry sectors. Hence the critical question of whether DEF is a characteristic of firms that is distributed over manufacturing sectors in a way that is anchored in stable fundamentals is of broad consequence beyond the work of Rajan and Zingales (1998) that brought us to it.

1.3. Outline by section

Using a rich and self-contained macroeconomic data source, we rely on aggregate U.S. industry-level data from the (U.S. Department of Commerce) Bureau of Economic Analysis (BEA), rather than firm-level data, to yield annual DEF_{it} values for the i = 1,…S, S = 21 sectors and t = 1,...T, T = 21 years, 1977-97. This is the maximum number of years, straddling RZ's 1980-89 data combination period, for which all the data used here were available on a consistent basis. It will be convenient to use Reliance on Internal Finance, RIF, where RIF = 1 – DEF = CF/CE, instead of DEF, because our DEF values are often negative. In Section 2 we compare the databases used by RZ and by us and subject our annual RIF data to explicit cyclical adjustment rather than using decadal averaging as in RZ. Section 3 decomposes variations in our cyclically-adjusted measure, RIF^{adj}, along with variations in its explanatory variables, into between-sector and within-sector variations. In this decomposition the primary grouping criterion is either the manufacturing sector or the year of observation, and weights, W_i, by size of investment in a sector are applied. Section 4 identifies and models non-cyclical constituents of RIF that are the primary determinants of RIF^{adj}. Using the between-sector and within-sector deviations of all variables separately, Section 5 presents the two sets of regression results. Section 6 interprets these results by considering which of the determinants of RIF^{adj} may deserve to be called structural/technological.

Our measure, RIF^{adj}, thus is meant for testing (1) the representativeness of data obtained from the median firm and (2) for shedding light on the properties attributed to such data. This second objective is facilitated because BEA offers a variety of integrated databases comprising national income, product, and fixed-asset accounting that are useful to characterize economic and financial conditions and relative price changes by sector and over time. These connected databases make it possible to investigate possibly structural/technological reasons for differences in RIF^{adj} by sector.

2. Alternative databases and data adjustments

This section answers the first of our two research questions, about the representa-tiveness of the RZ measure, by describing the construction of their measure and of our alternative measure which we derived from a different source. It then describes the cyclical adjustment of the latter.

2.1. Available macroeconomic and microeconomic U.S. databases compared

The RZ Compustat-based measures, one per sector i, are the DEF_i values obtained for the median exchange-listed firm in the respective distributions by DEF_i of "young", "mature" and "all companies." To recall, the ratio on which we focus is $RIF_i = (CF/CE)_i = 1 - DEF_i$. Cash Flow, CF, is estimated as the gross (of capital consumption allowances) return on capital, minus taxes, including product and (corporation) income taxes, and minus net interest paid. Although not only fixed capital assets, but also intangible capital and working capital, including inventories, need to be financed and require a return, RZ use Compustat North America's annual data item #128, defined as consisting of gross "additions to the company's property, plant, and equipment, excluding amounts arising from acquisitions." They thus limit Capital Expenditures, CE, to gross investment in fixed capital assets, while reflecting inventory change and changes in receivables and payables in the measure of cash flow.

The BEA data are aggregates for all the establishments of corporations and proprietors engaged in manufacturing in the United States. They thus represent entire industry sectors rather than having each sector represented by its median (by size of DEF) Compustat-based measure for exchange-listed U.S. firms. Compustat assigns each firm to a single Standard Industrial Classification (SIC) that is derived from its largest sector of operations even though the firm may have operations in several sectors and consolidated subsidiaries in several countries (on consolidation see Mills and Plesko, 2003, p. 869). By contrast, establishments are U.S.-based and much more specialized and numerous than firms. Establishments, defined for the purposes of the SIC as "economic units, generally at a single physical location, where business is conducted or where services or industrial operations are performed," are far less likely than entire firms to straddle industry sectors.[6] In short, listed firms, on account of their size, may be

[6] The definition is from http://www.bea.doc.gov/bea/dn/FAweb/Articles.Intro.html. Investment in fixed assets by establishment is benchmarked to the Census of Capital Expenditures conducted in conjunction with the decennial Economic Census (its most recent date was 1997) and updated with data from the Annual Capital Expenditure Survey. Principal source data for value-added components and the extent to which they were obtained on an establishment basis or require conversion from an enterprise to an establishment basis are identified in Moyer et al. (2004, especially Table C, p. 46). The allocation of net interest paid by each firm to establishments in the different SIC sectors it may contain, which is done on the basis of their net stock of fixed capital, indicates that CF reported for establishments is not entirely divorced from characteristics, such as the borrowing ability, of the firm to which they belong.

conglomerates of quite different production facilities and outputs, while establishments in a given SIC class are much more homogeneous in those regards.

Furthermore, if sectors typically consist of a few large and many more small listed firms, chances are that the median firm is small, though not necessarily young,[7] and that the large, well-established firms that carry much of the weight lie on the left (right) side of it in the distribution by size of DEF (RIF). To illustrate with RZ's own data (1998, p. 567), one such sector that would appear to fit this description is Drugs and Medicines (ISIC 3522). Its DEF is reported as 2.06 for "young" companies, 0.03 for mature companies, and 1.46 for "all" companies. Hence pooling young and mature has the median of "all" listed firms look rather "young" in this sector.[8] This may explain in part why the BEA-based average aggregate measures of DEF and $DEF^{adj} = 1 - RIF^{adj}$ shown in cols. [3] and [6] of Table 1 are lower than the RZ measures for the median listed firm even when that firm is drawn from the subset of "mature" companies that went public ten or more years ago.[9] The fact that median firms may not well represent the balance-sheet and income-sector account aggregates for their entire sector has been noted by others who also found that sector-wide DEF values are frequently negative, meaning

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7 If the median firm is relatively small, it does not fit well with RZ's (1998, p. 560) characterizations: "Under the assumption that capital markets in the United States, *especially for the large listed firms we analyze*, are relatively frictionless, this method allows us to identify an industry's technological demand for external financing. Under the further assumption that such a technological demand carries over to other countries, we examine whether industries that are more dependent on external financing grow relatively faster in countries that, a priori, are more financially developed" (italics added). On the other hand, if the median firm were large and mature, none of the reasons RZ suggested for regarding differences in the resulting measures of DEF between sectors as structural/technological would apply.

8 There are other lessons to be learned about the instability of component estimates based on median firm DEF characteristics. RZ's estimates (1998, p. 567) show that mature companies in ISIC 362, glass (and related products) had the same DEF, 0.03, as in the drug sector. But the DEF for "young" companies was 1.52, and for "all" companies only 0.53 in the glass sector. Because, unlike in the drugs-biotech sector, the number of small and young listed companies in the glass sector is relatively small and scale economies loom large, "all" companies look rather "mature" in the glass sector, but "young" in the drug sector. Hence going by "mature" companies, the DEF values for the drugs and glass sectors are exactly the same. For "young" companies they are a third higher for "drugs" than "glass." But for "all" companies they are almost three times as high on account of the compositional asymmetry just noted.

9 As shown near the end of cols. [3] and [2] of Table 1, the annual average of cyclically adjusted DEF (DEF^{adj}) values for 1980-89 was -0.94 unweighted and -0.64 weighted, compared with values of 0.02 and 0.08 for RZ's mature companies (at least 10 years past their IPO). The preferred weighting here is by the square root of the CE weights, W_i, so that the variances-covariances reported in Table 2 will be weighted by these size weights, W_i. The weighting of the Sum of Squared Total (SST), Within-Sector (SSW), and Between-Sector (SSB) deviations in the Limdep Version 8 program used throughout is fully laid out in Appendix 3. For details on comparing BEA-based and RZ's data concepts and values see Appendix 2. Values of DEF < 0 and RIF > 1 does not signify net portfolio investment by the median firm or sector concerned as long as dividends are paid at a rate (in relation to CE) at least equal equal to the excess of RIF over 1.

Table 1. Reclassified RZ DEF Measures for "All" and "Mature" Companies, and BEA Measures of DEF, Various Periods, for 1987 SIC U.S. Manufacturing Sectors and their Weighted Averages

	1980-1989 RZ Def		DEF^{adj}	DEF (BEA)		
	All	Mature	1980-89	1976-86	1980-89	1987-97
Column:	[1]	[2]	[3]	[4]	[5]	[6]
Lumber	0.280	0.250	-2.684	-2.151	-2.850	-3.460
Furniture	0.240	0.330	-0.900	-0.835	-0.980	-1.000
Stone Clay Glass	0.199	0.113	0.031	0.011	0.094	-0.355
Primary Metals	0.058	0.082	0.045	0.112	0.099	-0.137
Fabricated Metal	0.240	0.040	-1.199	-1.054	-1.269	-1.589
Machinery	0.626	0.232	-0.651	-0.667	-0.736	-0.902
Electric Machinery	0.954	0.339	-0.864	-0.278	-0.654	-1.806
Motor Vehicles	0.390	0.110	-1.383	-1.251	-1.720	-1.421
Other Transpo. Eq.	0.325	0.148	1.225	1.449	1.050	1.120
Instruments	0.960	0.190	0.477	-0.040	0.568	1.003
Misc. Manufacture	0.470	-0.050	-3.279	-2.280	-3.235	-4.133
Food & Beverages	0.127	-0.071	-0.671	-0.670	-0.822	-0.727
Tobacco	-0.450	-0.380	-1.118	-1.465	-1.061	-5.023
Textiles	0.137	0.043	-0.222	-0.265	-0.152	-0.199
Apparel	0.030	-0.020	-2.355	-2.272	-2.303	-2.197
Paper	0.160	0.120	-0.198	-0.131	-0.212	-0.229
Printing	0.200	0.140	-1.241	-1.477	-1.121	-0.952
Chemical Products	0.476	-0.052	-0.849	-0.602	-0.905	-1.159
Petrol.& Coal Prod.	0.078	0.004	0.862	1.230	1.075	0.565
Rubber & Plastics	0.957	-0.120	-0.144	-0.234	-0.169	0.106
Leather Products	-0.115	-1.019	-4.532	-2.653	-4.357	-6.755
Average	0.302	0.020	-0.936	-0.739	-0.936	-1.393
--Weighted by $W_i^{0.5}$	0.370	0.078	-0.645	-0.518	-0.658	-0.934
--Weighted by W_i	0.412	0.096	-0.567	-0.445	-0.586	-0.811

Notes: The data in columns [1] and [2], reclassified from 36 ISIC Rev. 2 sectors to 21 1987 SIC sectors, are derived in Appendix Tables A2 and A3, respectively. ISIC Rev. 2 stands for International Standard Industrial Classification, Revision 2. Weighting is by the capital expenditure weights by sector (W_i) later shown in column [4] of Table 2, with the square-root weights, $W_i^{0.5}$, for the present purpose of presenting a selection of weighted averages below the line, conveniently normalized to sum to 1.

that cash flow tends to exceed capital expenditures in the aggregate. To get closer to the RZ values, de Serres *et al.* (2006, p. 44), for instance, experimentally excluded all firms with more than 1,000 employees "so as to have more industries with positive dependence ratios."

The BEA data also show that, judging by capital expenditures (CE) on fixed assets, which is the denominator of both DEF and RIF, the largest and the smallest of the 21 distinct SIC sectors differ in size by a factor of 75. Large sectors have aggregate RIF values that cluster together, are poorly aligned with those based on the median firm, and are lower on average than for the smaller sectors. The difference weighting by CE makes is underscored by the correlation between the RZ decadal (1980-89) measures (redistributed into the 21 BEA sectors) for "mature" companies and our average annual measures for 1980-89 being 0.53 unweighted, but -0.06 weighted. The correlation of our measure with the RZ measure for "all" companies is even more distant: 0.24 unweighted and -0.11 weighted. Hence the RZ measures are at best weakly macroeconomically representative for manufacturing sectors in the United States, the country from which they were derived.[10]

2.2. Cyclical adjustment of RIF_{it} to obtain RIF^{adj}_{it}

Continuing to take RZ (1998) as reference guide, whereas RZ sought to eliminate the influence of "cyclical" factors through decade-long aggregation, directly adjusting the annual RIF data for each sector provides better control and preserves annual residuals that may contain information on changing non-cyclical characteristics.[11] Even if successful in cyclical adjustment, neither method ensures that the resulting estimates represent a stationary (RZ's measure) or potentially moving (our measure) equilibrium.

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[10] The correlation between RZ's own measures of DEF for "all companies" and "mature" companies is 0.475 unweighted (and 0.612 with our weights). RZ (1998, p. 572, Part B[1]) report the almost identical value of 0.46 for their 36 sectors. This suggests that relevant features of their data have been preserved in the conversion to the 21 sectors for which data are provided by the BEA in the sources followed. These sources are identified in Appendix 2.

[11] Constructing a decennial (decadal) data set does not provide the best estimate of the desired information. It may be granted that in sectors with low growth and little price change, aggregating numerator and denominator of RIF over a decade, before dividing, yields a value that is almost the same as the 10-year average of *annual* values of RIF for the same sector. Yet, as a BIS publication (Skoczylas and Tissot, 2005, p. 11) has criticized, cyclical adjustment by means of averaging over a complete cycle assumes that no structural change can occur during a business cycle, "an assumption that seems too restrictive."

In RZ's estimates, idiosyncrasies of the median listed firm[12] in the DEF distribution by sector may add to the lack of representativeness compared with our aggregate measure.

As specified in detail in Appendix 1, cyclical adjustment aims to eliminate the effect of aggregate-demand shocks and sector-specific supply shocks from the solution of an employment and output optimization model with nominal wage rigidity. The model uses a three-factor production function, including intermediate inputs, and Dixit-Stiglitz aggregation of both quantities and prices of the S sectors. The latter involves a uniform elasticity of substitution of $\theta >> 1$ between any two products that also equals the relative-price elasticity of demand for each sector's share of output. In the short-run, output by sector responds to aggregate demand disturbances affecting manufacturing as a whole and to supply disturbances affecting specific sectors within it. These supply disturbances are represented by temporary deviations from trend in two sector-specific relative prices that the model requires and our BEA "Industry" database, unlike Compustat, affords. We then proceed to estimate, and from there to eliminate, the effect of these cyclical disturbances on RIF, while keeping all other, possibly structural, innovations.

The two relative prices that may be subject to cyclical disturbances from their trend are first the price (P) of sector i's gross output (GO_{it}) relative to that of the total manufacturing (m) sector at time t (GO_{mt}), PGO_{it}/PGO_{mt}, and second the price of sector i's intermediate inputs (II_{it}) in relation to its value added (VA_{it}), or PII_{it} /PVA_{it}. All deviation rates in these relative prices from trend were estimated as residuals from a regression with linear time trend fitted to the log-transformed data for the period 1977-1997. As reported in Appendix 2, which covers data sources, industry classifications, and construction of variables at the industry level, the industry data required were available only up to 1997 on the 1987 Standard Industrial Classification (SIC87) basis that can be made comparable to the international classification, ISIC Rev. 2, for 36 sectors used in RZ (1998). Although the aggregate demand disturbances were taken to be of monetary origin, the derivation in Appendix 1 shows that their effects can be

[12] For instance, for radio, television and communications equipment manufacturing (ISIC 3832), RZ (1998, p. 567) report that the median firm in "all" companies had external dependence greater than 1, with its 1980-89 aggregate of cash flow negative. At the same time, the ratio of its capital expenditures to net property, plant and equipment was the fifth highest among the 36 sectors, indicating strong growth. In fact, during this and the next decade, the radio and television equipment part of this sector was withering away in the United States while communications equipment manufacturing was still

represented equivalently by the logarithmic deviation rates (D) in total manufacturing employment (L_{mt}) from trend, $DlnL_{mt}$. Because industry sectors have different exposures to these transitory factors, time-series regressions for each sector are used to adjust each sector's 21 annual RIF measures separately for its own "cyclical" effects.

The cyclical deviations in $RIF_{it} = (CF/CE)_{it}$, which are to be eliminated by use of equation (1), then are estimated sector-by-sector with the equation:

$$RIF_{it} = a_i + b_i\, DlnL_{mt} + c_i\, Dln(PGO_{it}/PGO_{mt}) + d_i\, Dln(PII_{it}/PVA_{it}) + e_{it} \qquad (1)$$

The cyclically-adjusted values, $RIF^{adj}_{it,}$ are obtained by setting all three temporary deviations from trend, each starting with D, to zero. Equation (1) then yields RIF^{adj}_{it} as the sum of the sector's intercept, a_i, and its time-specific non-cyclical annual remainder, e_{it}. The adjustment leaves the mean of RIF^{adj}_{it} for the data period as a whole precisely the same as that of RIF_{it} for any i but with a variance that is only 68-69% as large as that of RIF_{it} on average per sector, both with and without weighting. According to column 3 of Table 2, the range of this variance ratio, equal to $1-R^2$, is from 23% in the highly cyclical Primary Metal Industries, to 96% in the category of Miscellaneous Manufacturing Industries producing mostly consumer items that are in steady demand.

Comparing the unweighted and weighted averages in columns 3 and 5 of Table 2 shows that weighting the variance ratios of each sector by its average annual investment share during the 1980s made little difference in this instance. However, it is important to note from columns 1 and 4 that tobacco and leather products, each with a weight of well under 1 percent, account for over 60% of the total variance of RIF^{adj}_{it}.[13] To keep small sectors from dominating the results makes weighting essential in this investigation that aims to uncover representative macroeconomic relationships.

The cyclical and transitory factors affecting RIF_{it} are not stable structural/technological characteristics of industry sectors. Rather they relate to the degree of their

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thriving. Hence it would not appear that the median U.S. firm could deliver a good approximation to equilibrium DEF in the sector for the United States, let alone for the rest of the world, in this instance.

13 It is tempting to attribute this outlier status to small sectors being more specialized and pure than large sectors that yield averages over a wider range of establishments. However, this need not be so: While establishments in the tobacco sector are perhaps quite homogeneous, miscellaneous manufacturing industries, another small sector, produce an odd collection of manufactures not elsewhere classified. This collection includes jewellery and plated ware, musical instruments, toys and athletic goods, writing utensils and artists' materials, costume novelties, brooms and brushes, and caskets.

Table 2. Variances of RIF With and Without Adjustment for "Cyclical" Effects, also with unexplained percentage of the variance weighted by sectors' capital expenditure (CE) shares

Column:	Variance of Adjusted RIF [1]	Variance of Unadjusted RIF [2]	[1]as%of[2] equals $100(1 - R^2)$ [3]	CE Share 1980-89 Avg.=W_i [4]	Entries in [3] Weighted by CE Share [5]
Lumber & Wood Pr.	0.95096	1.08019	88.03578	0.02186	1.92445
Furniture & Fixtures	0.32545	0.44339	73.40097	0.00903	0.66298
Stone, Clay & Glass	0.18858	0.25394	74.26260	0.03017	2.24021
Primary Metal Ind.	0.05221	0.22635	23.06501	0.05701	1.31500
Fabricated Metal Pr.	0.15995	0.19007	84.15274	0.05044	4.24497
IndMachinery&Equip	0.11212	0.13788	81.31166	0.10301	8.37601
Electr&Electronic Eq.	0.61631	0.70327	87.63471	0.10414	9.12589
Motor Vehicles& Eq.	1.09177	1.55869	70.04420	0.06655	4.66127
Other Transport. Eq.	0.37621	0.91553	41.09199	0.04988	2.04954
Instruments&Related	0.39406	0.41774	94.33218	0.04710	4.44350
Misc. Manuf. Indust.	1.53432	1.59304	96.31391	0.00875	0.84302
Food & Kindred Pr.	0.04042	0.12677	31.88350	0.08483	2.70453
Tobacco Products	5.83179	8.62577	67.60893	0.00865	0.58449
Textile Mill Products	0.02283	0.06352	35.94520	0.02230	0.80171
Apparel& O.Tex.Pr.	0.14755	0.21346	69.12280	0.00906	0.62636
Paper & Allied Pr.	0.02975	0.04858	61.23345	0.06936	4.24691
Printing & Publishing	0.11262	0.15667	71.88864	0.05292	3.80416
Chemicals & Allied	0.13381	0.14542	92.01373	0.12272	11.29148
Petrol. and Coal Pr.	0.37138	0.67678	54.87514	0.04575	2.51072
Rubber&MiscPlastics	0.05513	0.09963	55.33538	0.03484	1.92792
Leather& Leather Pr.	5.83837	6.47070	90.22789	0.00164	0.14779
Sum,[5]=Weight.Avg.	18.385*	...	...	1.00000	**68.53292**
Arithmetic Avg.	0.87550	1.14988	**68.75145**	...	...
Geometric Mean	0.25539	0.39540	64.59030	...	...

* This sum of the sectoral variances of RIF^{adj}, times 21, the number of observations per sector, equals the *within-sector* sum of squares, SSW(i), of 386.1 shown in the Part A[1] of Table 3.

exposure to fluctuations in aggregate and sectoral demand, and in supply and demand conditions for intermediate inputs used by the establishments in a particular industry sector.[14] After adjusting for these factors, 89 of the 210 pairwise correlation coefficients between the time series of RIF^{adj}_{it} for 21 manufacturing-industry sectors, i.e., over 40 percent, are negative so that any remaining time-linked factors with a joint impact on all sectors are unimportant, as we subsequently confirm.

In sum, it was found that the cyclical and transitory factors on average account for almost one-third of the variance of RIF_{it} by sector. Eliminating their influence on RIF_{it} yields the cyclically adjusted variable RIF^{adj}_{it}. Because this variable is comparable to the RZ measure of $RIF^{RZ} \equiv 1 - DEF^{RZ}$, it is the data whose behavior across sectors and over time is analyzed in the remainder of this paper.

3. Determinants of between-group and within-group variation in RIF^{adj}_{it}

This section deals with a number of methodological issues, in particular the need for weighting, before showing the construction of between-group and within-group deviations in variables and descriptive statistics for them.

3.1. Methodological issues

The RZ assumption about differences in RIF^{RZ} being structural/technological, relates solely to the interpretation of *between-group* effects, where Group = Sector(i), since they derive only a single cross-section of data. This imposed limitation cannot mean that such differences in actuality remain frozen between sectors and cannot change permanently within sectors. For time series by sector, separating between-group effects from *within-group* effects is a standard feature of panel data ANOVA. Such effects are represented by the sum of squares of between-group variations SSB, and within-group variations, SSW, so that the total sum of squares, SST, is entirely decomposed into SSB + SSW, and the decomposition depends on the grouping criterion

[14] Although there have been models of intermittent or endogenously fluctuating production on account of extreme economies of scale or coordination failures (e.g., hog cycles), the cyclical exposure of a manufacturing sector is not usually regarded as a structural supply-side characteristic of a sector. Like RZ (1998), we do not pursue the possibility that persistent overall characteristics of demand for the products of particular sectors, such as their durability, would be of structural/technological origin and linked to differences in RIF^{adj}_{it} or RIF^{RZ}_{i} by sector from the product demand side.

used. Grouping by year of observation rather than sector, so that Group = Time(t), in part serves the diagnostic function of checking on the relative size of time-linked versus sector-linked structural differences and whether the latter dominate. Because if there were major breaks in RIF_{it} during RZ's 10-year or our 21-year observation period, focusing on its average values by sector over the entire period would be invalid. Given that structural breaks may well occur within sectors during lengthy periods, they should be allowed to reveal themselves.

It is also useful from a macroeconomic standpoint to check whether any evidence on SSB(i)/SST(i) holds up when sectors are weighted by the highly unequal relative-size factors, W_i, whose application is detailed in Appendix 3. In general, weighted regressions are used for two distinct purposes. One is to reduce measurement uncertainty. For instance, if the reliability of measurement instruments, or of "witnesses" to events, is known to differ, weighting their readings by the inverse of their measurement error variance (divided by the sum of all such inverses) would be efficient to get the most accurate, minimum-variance measure. A second use is to reduce inference error that could arise without weighting if the importance of observations differed because the economic "mass" behind them was far from equal, and small and large sectors did not act alike. In the present application, weighting thus is used to check whether the tail, i.e., small industry sectors, would otherwise be wagging the dog.

It turns out that weighting by a measure of the relative size of manufacturing-industry sectors ─ their share in the 1980-89 average annual expenditures on fixed capital assets in manufacturing ─ improves the representativeness of results by achieving outlier control of the light-weight sectors: The sum of squared deviations in the dependent variable, RIF^{adj}_{it}, falls by over 60 percent when weighting-factor W_i, normalized to w_i, is applied. For any year t, the sum of these normalized weights is equal to the number of sectors, S = 21. Repeated T = 21 times, the sum of the weights on all observations thus is equal to their number (N), or to N = ST = 441. Because the sum of the weights w_{it} then is the same as in the "unweighted" case where $w_i = 1$ for all i at any t, "unweighted" and "weighted" results reported in Table 3 can be compared directly.

When Group = Sector(i), decomposition into the underlying between-sector deviations and within-sector deviations is comparatively simple because the weights are aligned with the grouping criterion. In that case, the S *between-sector* deviations of sector-specific means of any variable X from the overall (weighted) average are:

$$BSX_i \equiv \overline{X_i} - \sum_t \sum_i (W_i X_{it}) / (T \sum_i W_i) \qquad (2)$$

where the last term is the weighted average of all observations. These deviations, which enter into the calculation of SSB(i), also are constructed for the independent variables used to explain sectoral differences in $RIF^{adj}{}_i$ in later regressions.

Similarly, the total number of ST within-sector deviations of the annual data from their sector-specific mean over time for given i are:

$$WSX_{it} \equiv X_{it} - \sum_t (W_i X_{it}) / (\sum_t W_i) = X_{it} - \overline{X_i}. \qquad (3)$$

These types of deviations enter into the calculation of SSW(i) and are constructed also for independent variables used (together with time fixed (TFX) effects) in later regressions attempting to explain within-sector variations in $RIF^{adj}{}_{it}$. When Group = Time(t) analogous definitions apply for BSX_t and WSX_{ti} .

3.2. Results, with and without weighting, for descriptive statistics and SST

The results in the first column of Table 3 show that between-sector effects, and not between-year effects, account for most of the SST in both decompositions. With or without use of the sectoral weighting variable W_i, SSB(i)/SST is in the 0.69-0.71 range while SSB(t)/SST is 0.05-0.04.[15] Because between-sector effects are based on sample- period averages, all between-year effects have to show up among within-sector variations, but the results suggest that total within-sector deviations in the cyclically-adjusted data contain mostly idiosyncratic, and not common, temporal disturbances. For instance, referring to the "unweighted" results in Part A of Table 3, the TFX effect accounts for only SSB(t)/SSW(i) = 52.68/386.10 = 0.04/0.291 = 13.7 percent of SSW(i).

SSB(i)/SST is also several times greater than SSB(t)/SST for all the explanatory variables deduced from constituents of RIF^{adj} in the next section. These constituents, already shown in Table 3, are (1) the long-term average growth rate of the net stock of

[15] Note that SST(i) = SST(t) = SST.

Table 3. Descriptive Statistics and Between-Groups to Total Sources of Variation: SSB/SST Equals R^2 for the Respective Group Effects

Variable:	RIF^{adj} [1]	GK [2]	NIP/PK [3]	II/GO [4]	DELTA [5]
		A. Unweighted			
Mean	2.0775	0.0215	0.0401	0.6254	0.0815
St. Dev.	1.7375	0.0224	0.0490	0.0908	0.0134
SST	1328.26	0.2199	1.0543	3.6305	0.0786
Group=Time					
SSB(t)	52.68	0.0490	0.0618	0.0294	0.0066
SSW(t)	1275.58	0.1709	0.9925	3.6011	0.0720
(SSB/SST)(t)	***0.040***	***0.223***	***0.059***	***0.008***	***0.084***
Group=Sector					
SSB(i)	942.16	0.1080	0.6237	3.2305	0.0649
SSW(i)	386.10	0.1119	0.4306	0.4000	0.0137
(SSB/SST)(i)	***0.709***	***0.491***	***0.592***	***0.890***	***0.826***
			Weighted*		
Mean	1.6314	0.0265	0.0272	0.6314	0.0830
St. Dev.	1.0676	0.0212	0.0373	0.0973	0.0139
SST	501.50	0.1984	0.6134	4.1649	0.0854
Group=Time					
SSB(t)	26.39	0.0474	0.0432	0.0325	0.0100
SSW(t)	475.11	0.1510	0.5702	4.1324	0.0754
(SSB/SST)(t)	***0.053***	***0.239***	***0.070***	***0.008***	***0.117***
Group=Sector					
SSB(i)	347.94	0.0946	0.3802	3.8578	0.0683
SSW(i)	153.56	0.1038	0.2332	0.3071	0.0171
(SSB/SST)(i)	***0.694***	***0.477***	***0.620***	***0.926***	***0.800***

Glossary

(Explanatory variables from GK to DELTA are defined on the next page.)
SST: Total Sum of Squares = 440(St. Dev.)^2.
SSB: Amount of SST attributable to variation Between Groups.
SSW: Amount of SST attributable to variation Within Groups.
SSB/SST is identified as R^2 in a variable's one-way ANOVA that is produced by the fixed effects model specified without covariates. SST = SSB + SSW in that model with the breakdown depending on the choice of grouping criterion.

* Weighting variable is the 1980-89 average annual CE shares by sector, with the 441 observations sorted first by i=1,…S, S=21 manufacturing-industry sectors when Group=Sector(i), and first by t=1,…T, T=21 years when Group=Time(t).

fixed capital, GK_{it} ; (2) net interest paid in relation to the current replacement cost of that stock of capital, $(NIP/PK)_{it}$; (3) the share of intermediate inputs in gross output, $(II/GO)_{it}$; and (4) the depreciation rate of the fixed stock of capital per sector, $DELTA_{it}$.

Table 3 also shows that weighting makes the greatest difference for RIF^{adj}_{it}. Its SST falls by more than 60 percent, from 1328.26 unweighted to 501.50 on a weighted basis, and SSB(i) falls by a similar percentage from 942.16 to 347.94. This signifies that the RIF^{adj}_{i} values of the largest sectors tend to lie close together and have a much lower variance than for the smallest sectors. Investigating this clustering further, it turns out that the smallest three, i.e., one-seventh, of all sectors, with a combined weight of 1.9 percent, accounted for 52.3 percent of SSB(i)=942.16 (col. 1, Table 3), while the largest three sectors, with a combined weight of 33.0 percent, accounted for only 0.3 percent of the same SSB(i) unweighted. Hence weighting by size of sector here makes a major difference to how much variation there is to explain. It is also noteworthy that the weighted average of all 441 observations on RIF^{adj}, $\sum_t \sum_i (W_i X_{it}) / (T \sum_i W_i) = 1.63$, is well below the simple average, $\overline{X} = 2.08$. Thus small sectors tend to have higher average values of RIF^{adj} than large sectors in this database.

4. Determinants of between- and within-sector differences in RIF^{adj}

Identification of the determinants of between-sector and within-sector variations in RIF^{adj}_{it} is essential preparation for deciding the extent to which sectoral differences in RIF^{adj} are attributable to factors deemed structural/technological and to what extent these factors are persistent and universal. We look for such structural factors by considering those that would be expected to affect the cyclically-adjusted measure of RIF = CF/CE because they may differ characteristically by sector.

4.1. Modeling non-cyclical determinants of RIF^{adj}_{it}

In the derivation that follows, all amounts appearing in the numerator or denominator of RIF are scaled by $P_K K$, the net stock of capital, K, valued at replacement cost by use of the price index, P_K. CF_{it} then is:

$$CF_{it} = \{(1 - Z_{it})[\rho_{it} - (r_{it} + \pi_t^e)(D_{it}/P_{Kit}K_{it})] + \delta_{it}\}P_{Kit}K_{it} \text{ or}$$

$CF_{it} = (\rho_{it} - nip_{it} - z_{it} + \delta_{it})\, P_{Kit}K_{it}$, where (4)

- ρ_{it} is the real net rate of return on all types of capital employed in sector i. Conceptually it needs to be adjusted by subtracting the rate of real capital gains expected on fixed assets, $\pi_{Kit}^{e} - \pi_{it}^{e}$, so that the result equals the nominal net rate of return minus π_{Kit}^{e}. Monopoly profits per unit of capital, equal to $\theta^{-1}(PQ/P_K K)_{it}$ as modeled, are included.
- nip_{it}, net interest paid on debt (D_i) per unit of capital, is equal to $(r_{it} + \pi_t^{e})(D_{it}/P_{Kit}K_{it})$.
- z_{it} is the yield of taxes imposed at the rate Z_{it} on business income net of interest paid, with the tax yield again expressed per unit of capital in sector i.
- δ_{it} is the exponential-decay rate of economic depreciation of the net stock of capital.
- π_{Kit}^{e}, π_{it}^{e}, and π_t^{e} are inflation rates expected on sector i's stock of capital, its output, and on total output, so that lenders to sector i set the nominal interest rate as $(r_{it} + \pi_t^{e})$.

Turning to the denominator of RIF^{adj}_{it}, the standard decomposition of CE_{it} is (a) into net investment that makes the real net stock of fixed capital grow at the rate g_{Kit} and (b) economic depreciation of that stock at the rate δ_{it}. CF_{it}, conceptually and in fact, includes a return on working and intangible capital and not just on fixed capital. Although not implementable directly in the BEA industry-data source followed, at least the change in working capital, including inventories, expressed as the fraction Δinv_{it} of $P_{Ki}K_i$, thus should be added to CE_{it} to account more fully for all the ─ in this case net ─ investments, normally positive, that need to be financed in growing sectors.

$$CE_{it}^{*} = CE_{it} + (\Delta inv_{it})P_{Kit}K_{it} = (g_{Kit} + \delta_{it} + \Delta inv_{it})\, P_{Kit}K_{it}\,. \quad (5)$$

Using equations (4) and (5) yields the following representation of RIF^{adj}_{it} by components that may differ systematically by sector with predictable effects on RIF^{adj}_{it} :

$$RIF^{adj}(it) = \frac{CF(it)}{CE^{*}(it)} = \frac{\rho(it) - nip(it) - z(it) + \delta(it)}{g_K(it) + \delta(it) + \Delta inv(it)}. \quad (6)$$

Of these elements, only differences in tax-intensity per unit of capital, z_{it}, are assumed to have no sector-systematic effects because of offsetting movement in ρ_{it}: Systematic differences in net-of-depreciation after-tax returns on capital created by non-neutralities of the business income tax system will not persist as they tend to be offset through tax shifting. Because there are differences in the extent to which firms in different sectors pay dividends, changes in the taxation of dividends could also be non-neutral by sector. However there are well-developed theories of invariance to dividend taxation for firms that use retentions, rather than equity issues, as a marginal source of funds and pay dividends with residual cash flow (Auerbach and Hassett, 2003).[16]

4.2. Predicted effects of the explanatory variables

Differences in individual components other than z_{it} in equation (6) may not be neutralized, and their predicted ceteris paribus effects on RIF^{adj}_{it} are laid out next.

- nip_{it}. In theory, sectoral differences in leverage would have to affect the distribution of RIF^{adj}_{it} by sector. If the Modigliani-Miller theorem holds, the form of financing has no influence on the net (of depreciation) rate of return on invested capital required in any given business risk class. Then if more of that return is used for net interest payments going to bondholders and loan departments, less is left for stockholders. Hence if leverage differs systematically by sector for any reason, so should RIF^{adj}_{it}, with the relation with nip_{it} expected to be negative.

- δ_{it}. Predictions with regard to δ_{it}, the ratio of current-cost depreciation to the net stock of private fixed assets by industry sector, depend on the size of RIF^{adj}_{it} relative to 1. The reason is that δ_i appears in both numerator and denominator of RIF^{adj}_{it}. Hence if $RIF^{adj}_{it} < 1$ so that $DEF^{adj}_{it} > 0$ as RZ generally found with their data, a rise in the depreciation rate δ_i would be expected to raise the ratio RIF^{adj}_{it} ceteris paribus. However, since we find most often that $RIF^{adj}_{it} > 1$, the predominant effect of higher δ_{it} on RIF^{adj}_{it} is expected to be negative.

- g_{Kit}. Unlike the *level* of the net stock of capital that scales both numerator and denominator of RIF^{adj}_{it} and thus cancels out, the real rate of growth of that stock,

[16] Chetty and Saez (2005) and Auerbach and Hassett (2006) since have empirically rejected such invariance.

g_{Kit}, appears only in the denominator of equation (6). Hence, ceteris paribus, the expected relation between g_{Kit} and RIF^{adj}_{it} is negative.

- Δinv_{it}. This is net investment in working capital per unit of fixed capital assets in a sector. The only measure of RIF^{adj}_{it} that could be constructed from the BEA data is the measure constructed with denominator CE_{it} which is normally less than CE^*_{it} because it omits Δinv_{it}. The use of capital expenditures on fixed assets alone, CE_{it}, understates the investment expenditures to be associated with the cash-flow return CF_{it} the more, the greater is Δinv_{it}. So a higher characteristic level of Δinv_{it}, which is proxied by the ratio of intermediate inputs to gross output in a sector, $(II/GO)_{it}$, is expected to raise the BEA-based RIF^{adj}_{it} above its true value. Now the omission of Δinv_{it} from the denominator by itself may not matter greatly given that net inventory change in manufacturing over the period 1990-1997 was only 5 percent as large as investment in plant and equipment. While the real net stock of fixed capital in U.S. manufacturing has more than tripled (rising by a factor of 3.36) from 1977 to 1997, the real stock of inventories has only a little more than doubled (factor 2.28) over this period. However, there is a second factor that firms up expectations of a positive effect: By the end of the sample period in 1997, the net stock of inventories still was 28 percent as large as that of fixed capital assets and thus appreciable for the manufacturing sector as a whole. This percentage likely is greater the higher the value of II/GO per sector. Then the earnings required on capital committed to inventories will loom larger in the numerator, relative to investment in plant and equipment in the denominator, in any sector the more its establishments rely on intermediate inputs in relation to gross output. Hence both the implied addition to the numerator of RIF^{adj}_{it} and the reduction in its denominator point to a positive association with II/GO_{it}.

Overall, δ_{it} and $(II/GO)_{it}$ are the variables affecting RIF^{adj}_{it} that have the greatest claim to reflecting structural/technological features of manufacturing sectors. This holds in particular since the industrial classification is by establishment in the BEA "Industry" data source rather than by legal form of organization, as in Compustat. Establishments with a capital stock that is weighted toward equipment and software, rather than plant and structures, have high values of δ_i. Furthermore, in the BEA source, intermediate inputs used in a sector are defined input-output style as what is obtained from inside and outside the sector in which the establishments are operating. Hence the ratio of the value of intermediate inputs to gross output, $(II/GO)_{it}$, is indicative of efficient production organization within and between sectors and not a function of industrial ownership concentration having to do, for instance, with the degree of vertical integration within exchange-listed firms that are assigned to a particular sector in their entirety.

5. Regression results

To test the above conjectures empirically and to lay the groundwork for identification and assessment of effects that merit being called structural/technological, we now run two types of regressions. These are based on the partition of all variables into their between-sector deviations, constructed as BSX_i (equation (2)), and their within-sector deviations, constructed as WSX_{it} (equation (3)). Estimates using the within-sector deviations are presented with and without the small TFX effects. Results are shown in Table 4, first with unweighted data and then when derived with the weighting variable.

5.1. Actual effects on RIF^{adj}_{it}

The findings below indicate the degree to which an industry sector's reliance on internal finance may be related to particular, partly technology-driven, characteristics.

GK (g_{Kit}). This variable captures the effect of differences in underlying growth rates of the real net stock of fixed capital (K) both between sectors, and within sectors over time. To guard against cyclical distortions, the capital stock values bracketing this calculation are set well apart and themselves stabilized by being given broad bases. This is done to capture sustained growth features of industry sectors. The two bases or pillars for calculating the average annual growth rates are centered at t-6 and t, so that GK is the average annual rate of growth of K over six years. But instead of taking the actual annual values of K at t-6 and t which may be affected by temporary disturbances, the normal value at those times is estimated as a geometric average of three years of observations centered on t-6 and t, respectively.[17] Thus, only a third of the annual capital stock data used in the calculation of GK are replaced each year.

[17] Hence the bases from and to which to calculate GK are constructed with net stocks of capital for years t-7 to t-5, and for years t-1 to t+1, reaching forward as far as 1998. Fortunately, the required chain-type quantity indexes for the net stock of private fixed assets are reported on the SIC87 basis through 2001.

Table 4. Regression Results and Correlations, Without and With Weights, Group = Sector

A. Results with all sectors weighted equally

RIF^{adj} – *Between groups* deviation of sectoral means from overall mean - OLS

	GK	NIP/PK	II/GO	DELTA	R^2
Regression Coefficient	-26.72	19.65	-6.50	27.14	0.587
(t-value) or S	(-1.60)	(2.54)	(-1.98)	(1.11)	21

RIF^{adj} – *Within groups* deviation of data from respective sectoral mean - OLS

	GK	NIP/PK	II/GO	DELTA	R^2
Regression Coefficient	-24.84	-3.41	-11.23	-8.64	0.277
(t-value) or TS=N	(-9.73)	(-2.42)	(-7.66)	(-1.17)	441
Previous with Time Fixed Effects					
Regression Coefficient	-22.37	-4.67	-11.98	-22.91	0.333
(t-value) or TS=N	(-6.84)	(-3.07)	(-8.12)	(-2.39)	441

Correlation matrix: Lower diagonal, *between groups*; Upper, *within groups*

	GK	NIP/PK	II/GO	DELTA	RIF^{adj}
GK	**1**	-0.07	0.06	-0.35	-0.42
NIP/PK	-0.30	**1**	-0.50	0.13	0.09
II/GO	-0.23	-0.28	**1**	-0.15	-0.32
DELTA	0.44	-0.40	-0.33	**1**	0.14
RIF^{adj}	-0.25	0.61	-0.53	0.02	**1**

B. Results with weighting variable W_i

RIF^{adj} – *Between groups* deviation of sectoral means from overall mean – OLS

	GK	NIP/PK	II/GO	DELTA	R^2
Regression Coefficient	-34.84	13.42	-3.71	46.81	0.315
(t-value) or S	(-2.33)	(1.91)	(-1.47)	(2.16)	21

RIF^{adj} – *Within groups* deviation of data from respective sectoral mean – OLS

	GK	NIP/PK	II/GO	DELTA	R^2
Regression Coefficient	-7.98	-2.49	-6.30	12.71	0.167
(t-value) or TS=N	(-4.34)	(-1.99)	(-5.86)	(2.68)	441
Previous with Time Fixed Effects					
Regression Coefficient	-7.39	-2.71	-6.60	6.90	0.257
(t-value) or TS=N	(-3.27)	(-2.09)	(-6.14)	(1.09)	441

Correlation matrix: Lower diagonal, *between groups*; Upper, *within groups*

	GK	NIP/PK	II/GO	DELTA	RIF^{adj}
GK	**1**	-0.30	-0.23	0.44	-0.25
NIP/PK	-0.37	**1**	-0.28	-0.40	0.61
II/GO	-0.20	-0.29	**1**	-0.33	-0.53
DELTA	0.46	-0.42	-0.32	**1**	0.02
RIF^{adj}	-0.31	0.65	-0.53	-0.01	**1**

The resulting measure of GK bears the required negative relation to both the BSX_i and WSX_{it} components of RIF^{adj}_{it}. Differences in rates of growth of capital between sectors, on 21-year average, could well be due to like differences in profitability that were not only expected, but also realized in part, given the length of the sample period. To the extent some of this reverse causation has affected the industry averages to a degree that depends on each sector's responsiveness and "time to build," it may have reduced size and significance of the negative effect of GK_i on RIF^{adj}_i across sectors. Within sectors however, or from year to year, GK_{it} may well rise reliably in expectation of higher future profits well down the road, particularly in new industries. Hence within sectors, the uni-directional or ceteris paribus effect of an increase in GK_{it} *lowering* RIF^{adj}_{it} in equation (6) comes through most clearly.

This negative relationship in the data for the United States spells conceptual trouble for RZ's starting assumption according to which the level of domestic financial development (FD) determines which industries may be expected to grow more rapidly than captured by industry fixed effects for all countries. The problem posed for this theory by our finding a negative effect of GK_{it} on RIF^{adj}_{it} (or positive effect on DEF^{adj}_{it}) with data for the United States is this: If the distribution of the BSX_i (i.e., between-sector) representation of RIF^{adj}_i is shaped by the capital-stock growth rates of manufacturing industries in the United States in the 1980s, and these growth rates differ from those experienced by these same industries in other countries,[18] as they must if theories of comparative advantage are to be brought to bear, the industry sectors that are growing fastest (after allowing for industry fixed effects) in other countries inevitably have higher U.S.-RIF^{adj}_i (lower U.S.-DEF_i) values assigned to them than the sectors that grow most rapidly in the United States. Then since almost all of these countries also are at lower levels of FD than the United States, RZ's hypotheses about the structure of growth in different countries would appear to be validated essentially automatically. Hence the more pronounced the negative effect of GK_i on RIF^{adj}_i in the United States, the greater is the risk of Type II error.

[18] Sustained differences in growth rates by sector within countries may be due to national, rather than global, factors, including differences in technology catch-up opportunities, incumbency effects, and national industrial policy. On the demand side, differences in sectoral income elasticities, and hence in sectoral growth rates, may be associated with large differences in per capita PPP-GDP even if countries have the same overall rates of growth

It is still possible for RZ's basic insight to be valid even if one of their joint assumptions, which is that U.S.-RIF^{adj}_{it} applies equally to firms classified as belonging to the same industries in other countries, is dropped. For instance, the sector of Chemicals and Allied Products contained in the BEA source includes the subsector for Drugs and Medicines which RZ (1998, p. 576) find to be the most financially dependent industry in their set-up. From their regression results, they expect this sector to grow 2.4 percentage points at an annual rate (compounded over 1980-90) faster in countries above than those below the median level of financial development. In this estimate, FD is represented by a, since discontinued, index of the quality of accounting standards. In the United States, the heterogeneous drugs and medicines sector includes biotech start-ups at one end and (re)producers of generic drugs at the other. The former have enormous advance external financing needs and many years to go before generating positive cash flow or being merged, often in distress, into other companies. The generic drug makers' path to positive cash flow is much shorter. In between these polar extremes from a cash-flow perspective are big-name drug MNEs in advanced countries which often pay substantial dividends and product-liability settlements and are cash-rich enough to engage in large stock buybacks to maintain leverage.

Now the industry with the same classification in India in the 1980s may well have consisted mostly of firms manufacturing drugs under license as well as generics. Then that industry could grow equally rapidly in India and the United States. The reason would be that the segment that would be most prevalent in India would be far less dependent on external finance, and hence on a high level of FD, for its growth than the median firm classified as belonging to the same sector in the United States. Even though RZ would not find such an outcome consistent with inferences derived from all their assumptions holding jointly, such a rejection could imply a Type I error from a broader perspective that takes account of international differences in the internal composition of sectors. The upshot of this discussion relating to GK_{it} is that neither acceptance nor rejection of the links to the sectoral structure of growth deduced from RZ's U.S.-based measure and their conjectures about its properties might yield the correct message: Test results, irrespective their statistical significance, could be inconclusive.

NIP/PK (nip_{it}) . This variable, with and without the use of weighting variable W_i, has a positive effect on the BSX_i representation, while having a negative effect in the

WSX_{it} (i.e., within-sector) representation of RIF^{adj}_{it}. *Between* sectors, a high rate of net interest payments in relation to the current cost of the net stock of fixed capital thus does not appear to imply low cash flow after interest payments as the Modigliani-Miller theorem would have suggested. It is as if credit had been lavished on those fairly slow-growing and relatively structure-intensive "old-line" (low δ_i) sectors with good cash flow that needed it least, except for the tax advantage of deducting net interest paid. The cross-correlation matrices in Table 4 strongly support this interpretation, especially for weighted data. In highly leveraged oligopolistic sectors, cash flow may be high but growth opportunities low − with leverage perhaps maintained at high levels through a program of special dividend distributions and stock buybacks. In that case the ratio variable RIF^{adj}_{it} could remain relatively high even after substantial interest payments by such sectors. Indeed, companies that earn a normal rate of return on invested assets but are not growing have to pay out their net (of depreciation and taxes) return in the form of interest and dividends unless they want to become net portfolio investors. Because dividends, as a use of cash flow, are included in CF, the RIF^{adj}_{it} values of dividend-paying companies with non-negative retained earnings making only replacement investments (only δ_{it} appears in the denominator of equation (6)) are bound to be above 1.

However, a rise in the interest burden within a sector could well be due to rating downgrades and liquidity problems affecting producers in a sector as their debt issues and interest rates on borrowing rise. Such a rise would be associated with a reduction in cash flow net of interest payments and hence of RIF^{adj}_{it}. Indeed, "pecking-order" models of financial structure long have described reliance on debt as a measure of last resort in a funding pinch when there is strong aversion to dilution of control through additional equity finance. This shows that the decomposition of variables into BSX_i and WSX_{it} deviations may have succeeded to some degree in separating equilibrium differentiations across sectors from within-sector disequilibrium effects of changes in the explanatory variable NIP/PK.

II/GO (for Δinv_{it}). As for DELTA, the highlighted ratios of $(SSB/SST)_i$ in Table 3 show that 80 percent or more of the total variation (sum of squared deviations) in this variable is due to between-sector, rather than within-sector, variations, thereby giving this variable a strong claim to being structural. The finding on this variable in Table 4 is that the higher the ratio of intermediate inputs in gross output, the lower is RIF^{adj}_{it}, more significantly in the WSX_{it} than the BSX_i representation. Our prior on the sign of the between-sector effect had pointed in the other direction. Pairwise correlation coefficients in Table 4 show that sectors with a high ratio of intermediate inputs in gross output grow more slowly, use less leverage, and have lower depreciation rates and poorer cash flow than sectors characterized by low II/GO. Within a sector, II/GO may well rise because the relative price of the value added by establishments in that sector has declined, because these establishments have been shedding functions on account of inefficiency and outsourcing, or for other reasons associated with a decline in RIF^{adj}_{it}. Hence a within-sector disequilibrium effect that is negative significant, as was found, may again be reasonable, but a negative between-sector effect was not expected.

DELTA (δ_{it}). The depreciation rate in a sector is another variable that may be deemed structural/technological. The expected effect of this variable is negative when RIF^{adj}_{it} is greater than 1, as holds on period-average in 18 out of the 21 sectors. Instead it is found to be positive significant according to the weighted results in part B of Table 4 although there are mixed and statistically insignificant signs on the unweighted results in Part A. High values of DELTA characterize high-tech companies intensively using equipment and software subject to rapid obsolescence. To the extent high-tech companies are also highly risky, they may have to depend on equity and venture-capital funding, rather than debt finance, at least in the start-up phase. But the surviving companies do not appear to display a high degree of dependence on this or any other external source of funds: In all, high values of DELTA are positively associated with high values of GK and low values of NIP/PK, but the pairwise correlation of DELTA with RIF^{adj}_{it} is around zero. The omission of investment in intangible assets (see Hall, 2001, and Cochrane, 2005, p. 74) from the denominator of RIF^{adj}_{it} could cause an upward measurement bias that is most severe in the high-tech, high-DELTA sectors, thereby masking the negative relation between DELTA and RIF^{adj}_{it} otherwise expected. According to a BEA (2006) study, for the economy as a whole, if R&D were included in the GDP as investment instead of as an expense, business investment would be 11 percent higher (in the last year of the study, 2002). But the effect in individual manufacturing sectors could be much larger.

In sum, there is some disappointment about the unexpected direction of between-sector effects on RIF^{adj}_{it} found for the variables II/GO and DELTA. These variables are most likely to represent fairly deep and universal characteristics of efficient production organization by establishment and of the most appropriate technology embodied in the composition of the stock of capital by sector. The results on GK and NIP/PK provide keener insights into the direction of effects, yet these variables relate specifically to U.S. growth and leverage patterns by sector. The fairly robust and consistently negative effect of GK on RIF^{adj} found in Table 4, especially within sectors, and irrespective of weighting, was strongly expected. Crediting GK_i with being one of the fundamental factors underlying sectoral differences in RIF^{adj}_i in the United States would disqualify its RIF^{adj}_i from being universally applicable if a new theory of comparative advantage, attempting to explain international differences in growth rates by sector upon opening up, is intended. The effects of $(NIP/PK)_{it}$ on RIF^{adj}_{it} being positive between, and negative within sectors, and the negative effect of $(II/GO)_{it}$ within sectors hinted that characteristic differences in long-run average values, construed as "equilibrium" differences in explanatory variable levels between sectors, and year-to-year changes in these levels within sectors can have quite different effects: Structures, or structural strengths and weaknesses, may be changing. Some of this distinctiveness can be captured by the decomposition technique here employed.

6. Interpretation of results and conclusion

Domestic financial development by itself and through its correlates, such as the general level of education, legal and institutional development, and technological sophistication, disproportionately benefits entities that make the greatest use of these national assets for production support.[19] So much is true without a doubt. Now such entities validly could be grouped by SIC manufacturing sector if the degree of dependence on external finance of these entities differed fundamentally by sector. Granting this just to proceed to a conclusion whose internal consistency is compelling, the next two assumptions are that local finance matters for economic growth and its importance by manufacturing sector is the same all over the world regardless of whether countries are open or closed to FDI and other capital inflows. If all this is so, it follows

[19] Wood (1995), for instance, showed the development of skills and analytical capabilities to be a key determinant of comparative advantage and manufacturing export performance.

necessarily that the level of domestic financial development helps determine the open-economy pattern of international specialization in manufacturing.

Any remaining logical problems then have to do only with differences between dynamic and comparative-static predictions. If developing countries open up to international trade and finance simultaneously, suppose that financial development grows most in countries with the lowest levels of FD, so that there is some international convergence in levels of FD. Then the expected effect of such joint liberalization on the sectoral structure of growth in manufacturing is unclear. The reason is that the dynamic Rybczynski effect of increasing the factor "finance" in those countries may trump the comparative-static effect of increased specialization in trade in sectors of their comparative advantage. These sectors are characterized by low values of DEF on account of the low level of FD, yet this comparative advantage, or the disadvantage in finance, is diminishing because FD is rising rapidly. Setting aside this difficulty by holding the level of FD, or relevant differences in FD between countries, constant, makes the internal logic of RZ's argument, granting its assumptions, unassailable.

The key questions examined in this paper relate to the validity of some of these assumptions. These are crucial for the construction of the test measure and the interpretation of its properties. We thus examined whether the manufacturing-industry sectors that stand to benefit most from opening up to trade in different countries could safely be predicted by using only data for their levels of FD and relying on U.S. firm data on DEF for all the rest. Confidence in the use of such a procedure to predict the structure of growth in different countries would be enhanced first if the data generated for the United States would also be macroeconomically representative for it. Yet agreement between the Compustat-based median-firm data of RZ and our BEA-based data for all establishments in a sector was found to be small. Secondly, confidence would be enhanced if structural/technological reasons for sectoral differences in RZ's DEF_i, or the present RIF^{adj}_{it}, could reliably be identified and judged to be intrinsic to these sectors.

Table 5 summarizes our results on identification. RZ attribute all structural/technological differences to unchanging between-sector effects by relying solely on one measure per sector obtained with decadal averaging. They then took the between-sector

Table 5. Percentage Decomposition of the Sum of Squares (SST) of RIF^{adj} Without and With Weighting by Sector

	Unweighted [1]	Weighted [2]
Between-groups effects, group = sector		
1. Total	70.9	69.4
2. –Identified	41.6	21.9
3. –Unidentified	29.3	47.5
Within-groups effects, group = sector		
4. Total	29.1	30.6
5. –Identified	9.7	7.9
6. –Unidentified	19.4	22.7
Total	100	100

Note: The source statements below identify entries in the table above by row followed by [column] number. The methodology used to separate within-group from between-group effects when sectors are unweighted (weighted equally) or weighted (weighted unequally) is explained in Appendix 3.

Sources

1[1] and 1[2]: Table 3, column 1. The entries in 4[1] and 4[2] are the complements (from 100).

2[1] and 2[2]: Product of (a) R^2 of 0.587 (unweighted) or 0.315 (weighted) shown in last column of Table 4 for regressions of deviations between sectoral and overall means and (b) the entries in 1[1] and 1[2], respectively. The entries in 3[1] and 3[2] contain the unidentified remainder of the total between-sector effects.

5[1] and 5[2]: Product of (a) R^2 of 0.333 (unweighted) or 0.257 (weighted) shown in last column of Table 4 for regressions with Time Fixed Effects of deviations of cyclically-adjusted RIF data from their respective sectoral means and (b) the entries in 4[1] and 4[2], respectively. The entries in 6[1] and 6[2] contain the unidentified remainder of the total within-sector effects.

effects found with U.S. data for the median firm by sector to be structural/technological within the United States and, as they further assumed, elsewhere. We examined whether we can substantiate the latter assumption just for the United States, on the data of which it was founded, by trying to attribute between-sector effects to some of the variables prominently involved in the construction of RIF^{adj}. As inferred from columns [1] and [2] in the top part of Table 5, BSX_i values of those variables are able to explain 59 percent (41.6/70.9) of the between-groups effects in RIF^{adj} unweighted, but this percentage drops to 32 percent (21.9/69.4) when weighting by the relative size of investment (CE_i) by sector. Hence up to two-thirds of the between-sector variation remains unexplained. Furthermore, what *is* explained, in particular by sectoral differences in the average rate of growth of the stock of capital, GK_i, itself, can not all be credited with being structural/technological, let alone universal. Nor were the signs found on more structural/technological variables like $(II/GO)_i$ and $DELTA_i$ consistently convincing.

To conclude, variables that can be viewed as likely candidates for structural differences between sectors fail to explain much of the variability in RIF^{adj}_{it}. This failure occurs despite the fact that RIF_{it}, as a measure constructed from data for all establishments contributing to activity in any sector, is bound to be more representative of conditions in that sector than measures based on sector medians by exchange-listed firm. Grouping manufacturing entities by the industrial classification of the sector in which they operate is not likely to yield a sectoral distribution by dependence on external finance that is firmly held in place by factors that are recognizably fundamental. Hence it is difficult to maintain the assumption that the DEF_i or RIF^{adj}_i measures calculated for the United States have information for the structure of growth in other countries via the nexus between sectors' financial dependence as revealed by U.S. DEF_i and each country's level of financial development.

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Appendices: **NOT FOR PUBLICATION**

Appendix 1. Short-Run Determinants of Output Used for Cyclical Adjustment

Overview

A monetary approach is used both to represent economy-wide aggregate-demand, or LM, disturbances and to anchor price expectations. These depend on a preset target level of the money supply, M, and enter into forward-looking wage contracts. The labor market clears ex ante as the nominal wage rate has been set in advance on the basis of rational expectations (consistent with expected fulfillment of the relevant first-order condition) for homogeneous labor employed in a competitive labor market. Ex post, however, aggregate manufacturing employment and output, and their breakdown by sector, deviate from expected levels. Temporary deviations from trend of two relative prices also influence sectoral output levels. This appendix then shows in several steps that the unexpected rate of deviation (D) from trend of an industry sector's output at time t is:

$$\mathrm{Dln}(Q_{it}) = (1-\beta_i)^{-1}[\alpha_i\, s_i\, (\mathrm{DlnL}_{mt}) - \alpha_i\, (\theta-1)\mathrm{Dln}(PGO_{it}/PGO_{mt}) - \beta_i\, \mathrm{Dln}(PII_{it}/PVA_{it})], \qquad \text{(A1)}$$

where PGO_{it}/PGO_{mt} is the price index of the sector's Gross Output relative to that of the entire manufacturing sector, and PII_{it}/PVA_{it} is the price index of the Intermediate Inputs used in sector i relative to the price index of its Value Added. Any deviation of s_i from its model value 1 indicates whether the cyclical sensitivity of demand for an industry sector's output is above or below average. Conceptually, the deviations of output from trend are linked to deviations in cash flow and RIF. Yet when cash flow (CF) in a sector responds to the short-run deviations identified in equation (A1), capital expenditure on fixed assets (CE) in that sector will show some of the same short-run sensitivity, albeit ─ on account of pre-commitment to lengthy investment projects ─ usually less. Hence the equation used for adjusting RIF_{it} uses the same explanatory variables as equation (A1).

Three-Factor Production Function

A CD production function $F_i(K_i, J_i, L_i)$ is adopted for industry sector i, where i, shown either as a subscript or in parentheses to optimize legibility, ranges over a unit interval from 0 to n=1. The goods and services inputs in that function are a beginning-of-period capital stock, K_i, of fixed assets and (raw, intermediate, work in progress, and finished-goods) inventories, as well as purchased inputs here called "intermediates," J_i, and labor, L_i. In the model, labor is homogeneous and the labor market competitive so that all workers earn the same nominal wage, W. Then with total factor productivity scalar A_i and with fixed input elasticities of output with respect to labor and intermediates, α(i) and β(i), the gross output of sector i at factor cost (excluding indirect taxes) is:

$$Q_i = A_i\, F_i(K_i, J_i, L_i) = A_i\, K_i^{\,1-\alpha(i)-\beta(i)}\, J_i^{\,\beta(i)}\, L_i^{\,\alpha(i)}. \qquad \text{(A2)}$$

Dixit-Stiglitz Aggregation and its Limiting Features

Using the final-sales method of aggregation, the Dixit-Stiglitz aggregate of total output is:

$$Q = \left[\int_0^n Q(i)^{(\theta-1)/\theta} di \right]^{\theta/(\theta-1)}, \ \theta >> 1, \tag{A3}$$

where the elasticity of substitution between any two products, θ, is required to be greater than 1 -- usually much greater.[20] The corresponding aggregate for the price level, P, is,

$$P = \left[\int_0^n P(i)^{(1-\theta)} di \right]^{1/(1-\theta)}, \tag{A4}$$

and Dixit-Stiglitz demand for product i is an inverse function of its price, P_i, relative to P and unit-elastic with respect to total gross income, Q:

$$Q_i = \left[\frac{P(i)}{P} \right]^{-\theta} Q. \tag{A5}$$

Adopting the Dixit-Stiglitz consistent aggregation scheme for model specification and coefficient identification poses certain difficulties for empirical work:

- Although both gross output and value added are reported by industry sector in the source followed, the factor incomes reported there, including gross returns to capital, refer, of course, to value-added in each sector. By contrast, the Dixit-Stiglitz aggregate refers to gross final output by sector that may contain inputs from other sectors.
- The imposition of identical elasticities of substitution of θ between the final sales of all industry sectors, coupled with unitary income elasticities of demand, may lead to over-determination in certain applications. Furthermore, equating the elasticity of substitution in consumption with the price elasticity of demand facing producers would imply that there is only one producer per variety.
- The Dixit-Stiglitz model implies that relative prices are determined by supply conditions while preferences are given. Hence, as shown by equation (A5), an increase in relative price always leads to some decrease in the relative quantity demanded and is not due to a shift in demand toward a sector's output.
- That equation also implies that any changes in aggregate demand that affect Q will change Q_i by the same percentage even though the cyclical sensitivity of demand is likely to differ by industry sector (and must be allowed to differ to avoid over-determination of the i equations of type (A12) estimated in the paper).

[20] McCallum (2001, p. 149) settles on a value of 5. See Bennett T. McCallum, "Monetary Policy Analysis in Models without Money," *Federal Reserve Bank of St. Louis Review*, July/August: 145-160.

Model Disturbances and Assumptions

In long-run equilibrium, the rate of return on capital in any sector should be equal to the cost of capital required in the business- and market-risk class for that sector. In the short run, however, there are identifiable surprises that may affect cash flow and capital expenditures unequally so that their ratio, RIF = 1 - DEF, is affected. The short-run is here defined as the length of a business-cycle. The types of shocks considered that can have an effect on RIF in the short run are:

- An aggregate demand shock that is interpreted as a shock to the GDP-transactions velocity of money, e^v, where $v \sim N(0, \sigma_v^2)$, so that the shock process is stationary with 0 mean and the actual value of V is given as $V = e^v V^e$. Expected values are characterized throughout by the superscript e, while $e^v \equiv \exp(v)$. While a shock $v>0$ would be expected to lower interest rates and expand the economy in the short run, it would affect only the price level in the long run. Monetary policy is taken to refrain from attempting to fine-tune the economy and not to react immediately to current shocks to aggregate demand. Hence any cyclical instability observed in the economy can be attributed, for simplicity, to fluctuations in v that have not yet given rise to monetary-policy feedback.

- There are three relative prices in the model that may be subject to disturbances:

(a) the relative price of intermediate inputs used in sector i, P_{Ji}/P_i (written P_{IIi}/P_i in the text),
(b) the relative price of industry sector i's output (or value added) relative to the price index for manufacturing as a whole, P_i/P,
(c) the relative price of fixed capital goods inputs used in sector i, P_{Ki}/P_i.

The first two are subject to relative-price shocks in the short run. Such shocks will be identified simply by deviations in the logarithms of the respective explanatory variables from their trend values. For specific industry sectors, changes in relative input prices, identified under (a), may indicate productivity shocks and other supply disturbances. Changes in relative output prices (b) may reflect industry-specific demand factors in the short run and supply factors in both the short and the long run. Since the stock of fixed capital is taken as given in the short run as noted below, unexpected changes in the relative price of fixed capital inputs (c) do not affect the factor composition used in the short run.

Three basic modeling assumptions distinguish the short run from the long run:

1. In the short run, the beginning-of-period stock of capital whose services are used for this period's production is treated as a constant even though capital expenditures occur during the current period. Hence, unlike J_i and L_i, K_i is predetermined in the short-run, but not of course in the long-run analysis.

2. In the short run, the desired level of employment, L_i^*, as opposed to the actual level of employment during the contract period, L_i, is treated as constant while in the long run L_i^* changes (commonly grows). The modeling below also makes no allowances for changes in multifactor productivity, A_i, in the short-run, although

differential rates of multifactor productivity growth are among the factors that can contribute to changes in P_i/P even in the short run.

3. The nominal wage rate, W, equal to the expected marginal revenue (MR) product, is agreed upon in advance of the contract period on the basis of expectations (superscript e) about economy-wide productivity (A) and price-level developments (P) during that period (of one year). Beyond that timeframe, labor compensation rates are flexible and always set so that the labor market would clear ex ante at the intersection of labor demand and supply and yield the desired employment level of L*, that was determined in advance, if everything evolved as expected.

Aggregate Demand Shocks to Industry-Sector Employment

Aggregate demand is related in rudimentary fashion to real money balances M/P and to the demand for real balances that is inversely related to velocity, V. The nominal money supply, M, is exogenous while V is subject to spontaneous disturbances:

$$Q = AF(K, J, L) = V(M/P) \text{ , where } V = e^{v}V^{e},\ v \sim N(0,\sigma_v^2). \quad \text{(A6)}$$

The nominal wage rate that had been set in advance on the basis of rational expectations (consistent with expected fulfillment of the relevant first-order condition) for homogeneous labor employed in a competitive labor market is:

$$W = \alpha[(\theta -1)/\theta]P_i^e(A_i^e)F(K_i, J_i^e, L_i^*)/L_i^*, \quad \text{(A7)}$$

where $(\theta -1)/\theta = (MR^e/P^e)$ from equation (A5). This equation holds equally for total manufacturing in the aggregate so that:

$$W = \alpha[(\theta -1)/\theta]P^e(A^e)F(K, J^e, L^*)/L^*. \quad \text{(A7a)}$$

Taking expectations of equation (A6) assuming the level of M planned for the next period is already known, using the result to substitute the point estimate V^eM/Q^e for P^e in equation (7a), and then canceling $Q^e = A^eF(K, J^e, L^*)$ yields the wage-determination equation:

$$W = \alpha[(\theta-1)/\theta]V^eM/L^*. \quad \text{(A7b)}$$

The corresponding expected aggregate income shares are as follows:

1. The expected share of labor is $WL^*/P^eQ^e = \alpha[(\theta -1)/\theta]$.
2. Analogously, the expected share of intermediates is $(P_I/P)^e(J^e/Q^e) = \beta[(\theta -1)/\theta]$.
3. Hence if the expected share of capital is $(1- \alpha - \beta)\ [(\theta -1)/\theta]$, there is a fraction θ^{-1} still to be accounted for if the shares are to sum to 1
4. The monopolistic-competition component in the price, $(P^e - MR^e)/\ P^e = \theta^{-1}$ is statistically part of the return on capital and hence of cash flow. Conceptually, in the present framework, this component of the return is used to defray amortization of entry or franchise costs through the equivalent of an annual surcharge on value-added of $(P^e - MR^e)/\ MR^e = (\theta-1)^{-1}$.

When the gross monopolistic mark-up over marginal costs is $\mu = \theta/(\theta\text{-}1)$, the net mark-up is $\mu - 1 = (\theta\text{-}1)^{-1}$, while the net mark-up as a share of the price per unit of sector i's output is θ^{-1}. Hence the total return credited to capital, including the monopolistic component used for the amortization of a fixed amount of "franchise" capital not included in accounting measures of the stock of capital or of capital expenditures is:

$$(1- \alpha - \beta) [(\theta -1)/\theta] + \theta^{-1} = 1 - (1- \theta^{-1})(\alpha + \beta). \qquad \text{(A8)}$$

With W set, actual industry-sector employment, L_i, is demand-determined and thus given by the first-order condition:

$$W = \alpha[(\theta\text{-}1)/\theta] (P_i/P)P\ A_iF(K_i, J_i, L_i)/L_i\ . \qquad \text{(A9)}$$

Using equations (A2), (A6) and then (A5) to substitute for P and Q_i/Q, equation (A9) reduces to:

$$W= \alpha[(\theta\text{-}1)/\theta] (P_i/P)^{1-\theta}e^vV^eM /L_i\ . \qquad \text{(A9a)}$$

Hence, combining equations (A7b) and (A9a) and normalizing L* at 1 yields:

$$L_i = e^v(P_i/P)^{1-\theta}\ , \qquad \text{(A10)}$$

or, taking logarithms and then deviations (D) from trend over time, t,

$$D\ln(L_{it}) = v_t + (1\text{-}\theta)D\ln(P_{it}/P_t). \qquad \text{(A10a)}$$

Equation (A10a) shows that deviations in a sector's employment from trend are driven by aggregate demand disturbances, represented by velocity shocks, v, and by deviations from trend in the relative price of industry sector i's output, P_i/P, where $(1\text{-}\theta)<0$.

The result, that the unexpected rate of deviation of velocity from V^e is equal to the unexpected rate of deviation in aggregate employment, L, from L* is explained by P rising, and the real wage falling, at the rate $(1\text{-}\alpha)v$, given that W is preset. Hence labor input rises at the rate v (equation (A10)) and Q increase at the rate αv (equation (A2)), so that nominal output, PQ, rises at the rate $(1\text{-}\alpha)v + \alpha v = v$ as required by equation (A6) after substituting e^vV^e for V.

Because shocks to the relative price of intermediates and to the level of total factor productivity do not affect optimal employment in this simple model, aggregate demand shocks alone determine deviations of aggregate employment from the initially expected and desired level. The reasons for this independence are easy to explain:

(a) A uniform upward shock to the relative price of intermediate inputs (obtained from outside the manufacturing sector) in all manufacturing sectors lowers the marginal product of labor by the same rate by which it raises the price of output, P. Given W, the marginal product of labor and the real wage thus decline by the same amount at a given level of L. Hence there is no change in the quantity of labor demanded in the short run for which the money wage rate was preset, with labor committed to supply the amount employers wish to hire at that value of W.

(b) A uniform unanticipated rise in multifactor productivity raises the marginal product of labor at the same rate by which it lowers the price level at a given level of L. Hence the real wage rises at the same rate as the marginal product of labor, leaving no change in the amount of labor demanded in the short run.

Intermediates, Output, and Supply Disturbances

Having obtained equation (A10) to determine L_i , we next have to find the amount of intermediates, J_i, used in production by manufacturing sector i for given K_i and relative price P_{Ji}/P_i from the first-order condition:

$$P_{Ji}/P_i = \beta_i A_i(K_i^{1 - \alpha(i) - \beta(i)} J_i^{\beta(i) - 1} L_i^{\alpha(i)}).$$

The solution for J_i is:

$$J_i = [\beta_i(P_i/P_{Ji})A_i K_i^{1 - \alpha(i) - \beta(i)} L_i^{\alpha(i)}]^{1/(1-\beta(i))}. \quad \text{(A11)}$$

The solutions for L_i and J_i from equations (A10) and (A11), in conjunction with the pre-given levels of K_i and A_i and with the aggregate demand shock v and relative prices P_{Ji}/P_i and P_i/P thus allow Q_i to be determined from equation (A2) as subject to unexpected change in the short run solely in v, P_i/P and P_{Ji}/P_i. Taking the logarithm of the resulting expression for Q_i and then the relative differences of all variables from their trend values (or from their stationary value, as with V^e) yields:

$$Dln(Q_{it}) = (1-\beta_i)^{-1}[\alpha_i(s_i\, v_t) - \alpha_i(\theta-1)Dln(P_{it}/P_t) - \beta_i Dln(P_{Jit}/P_{it}], \quad \text{(A12)}$$

where any deviation of s_i from the value of 1 in this model (or more than 1 according to Okun's Law) allows for the demand for an industry sector's output to be of above-average or below-average cyclicality (equation (A5) imposes the same sensitivity on all sectors). Solving equation (A10a) for the entire manufacturing sector allows replacing v_t in equation (A12) by $Dln(L_t)$, the rate of deviation in employment in manufacturing from trend. Furthermore, the price index of a sector's intermediate inputs, $P_{Ji} \equiv PII_i$, enters into the price index of its gross output, P_i, but not into the price index of its value added, PVA_i. To prevent joint effects from input price shocks on both the numerator and denominator, $Dln(PII_{it}/PVA_{it})$ was substituted for $Dln(P_{Jit}/P_{it})$ in equation (A1) to obtain better resolution in the equations for cyclical adjustment reported in the text.

Equations (A1) thus shows that an industry sector's output may be disturbed in the short run by the macroeconomic analogue of income (aggregate demand) and price (aggregate supply) disturbances, specifically by:

- aggregate demand shocks that raise total manufacturing employment above trend if positive ($dlnL>0$) with a model coefficient that is identified as s_i-times a fraction that is equal to the share of labor over the share of value added in gross output, $\alpha_i/(1-\beta_i) < 1$.
- deviations in the relative supply price of the sector's output from trend that, if positive, lower Q_i on account of their adverse effects on the quantity demanded with a model coefficient greater than absolute 1 on account of $\theta>>1$, and

- deviations from trend in the supply price of intermediate inputs relative to value added, that, if positive, also lower Q_i because margins become squeezed when the relative price of materials inputs increases. The absolute value of the model coefficient on this term is greater than 1 if the share of value added is less than one-half and hence the share of intermediate inputs, β_i, greater than half.

The Cyclical Adjustment of RIF_{it}

The estimating equation derived from equation (A1), which is equation (1) in the text, displays all the advantages of rigorous modeling in that it fully identifies the coefficients of the reduced form with structural parameters from the production and demand functions specified earlier. Yet the modeling is much too uniform to do justice to conditions in each sector. First, since corporate profits tend to lead and corporate investment and employment tend to lag the business cycle, RIF might show countercyclical tendencies in some sectors relative to employment deviations from trend in total manufacturing. For instance, when employment and investment in manufacturing are still unduly depressed in the early stages of "jobless recoveries," profits and cash flow may already have recovered nicely well before investment. Hence RIF_{it} could be higher in the early than in the late stages of recoveries in some sectors.

In addition, the Dixit-Stiglitz specification, while providing modeling discipline, tractability, and coefficient identification, unrealistically limits the set of product-market disturbances to those stemming from the supply side. If instead of figuratively just moving along negatively sloped (factor and product) demand curves, demand, and not supply, is actively disturbed in a sector, expected signs would change. For instance, if the demand for the finished goods of a sector making heavy use of intermediate inputs (II or J) that are in inelastic supply increases, so may $Dln(PII_{it}/PVA_{it})$ *and* RIF_{it}. A shift in final demand towards a sector's gross output may also raise $Dln(PGO_{it}/PGO_{mt})$, the price index of its gross output relative to that of total manufacturing (m) at time t, and again raise RIF_{it}, and not lower it as equation (A5) instead would predict.

Hence in adjusting the RIF_{it} data, separately for each sector, for their particular "cyclical" income and price effects, acceptable coefficients are distributed over a broader range than that admitted by the model with unchanging preferences and uniform parameters. Indeed, some positive and some negative significant values are found among each of the three regression coefficients in separate estimates for each of the i =1,…21 sectors over t = 1,…21 years. Accepting all this, the cyclically-adjusted data, RIF^{adj}_{it}, are the solution for RIF_{it} that is obtained from equation (1) in the text after setting all three temporary deviations (D…, in bold letters) to zero.

Appendix 2. Data Sources, Industry Classifications, and the Construction of RIF, DEF, and of Explanatory Variables for the 21 Manufacturing-INDUSTRY Sectors

I. Data Sources and Construction

I.A. BEA Data Sources

The homepage of the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce, http://www.bea.gov, provides four main selections of U.S. Economic Accounts, among them *National* and *Industry*. There are 21 manufacturing sectors, identified in Tables A1 and A2 of this appendix, for which data are reported in some of the tables in each of these two main databases and in a supplementary database, *FAWeb*. The tables used to obtain data on gross fixed capital formation and to construct cash flow in all 21 sectors are identified below. These data are used to construct the dependent variables RIF and DEF, where RIF = 1 - DEF. Additional, explanatory, variables are obtained from these databases first to construct values of cash flow by industry sector that are free of temporary or cyclical disturbances affecting that sector and secondly to explain time-series cross-section differences in the ratio of this adjusted cash flow measure to gross fixed capital formation by industry. That ratio represents the degree of reliance on internal finance, RIF, and it is adjusted for temporary disturbances to obtain the equilibrium measure, RIF^{adj}, whose differences by industry sector and over time are subject to panel analysis. Names used in the body of the paper either for variables serving to adjust RIF for temporary deviations or to help explain systematic differences in the adjusted values of RIF, RIF^{adj}, by industry sector are highlighted in what follows to facilitate looking up their derivation. The operator + is used in the click sequences below to indicate the items selected from successive menus of the three databases to reach the data used in this study.

(1) NIPAWEB National (http://www.bea.gov/bea/dn/nipaweb/index.asp) + Gross Domestic Product + Interactive NIPA Tables + List of All NIPA Tables. Tables 6.17B (through 1987) and 6.17C (from 1987): Corporate Profits Before Tax by Industry, and Tables 6.18B and 6.18C: Taxes on Corporate Income by Industry.

(2) INDUSTRY (http://www.bea.gov/bea/dn2/gdpbyind_data.htm) + GDP by Industry + Interactive Tables + GDP-by-Industry Data 1947-1997 + Historic SIC Data + GDPbyIND_VA_SIC (open XLS) + tab 72SIC_Components_of_VA (value-added data for 1947-1987 on 1972 SIC basis) or tab 87SIC_Components_of_VA (value-added data for 1987-1997 on 1987 SIC basis; data on this basis are not available beyond 1997).

Unlike in NIPAWeb above, value-added and its components are not attributed simply to the pre-dominant SIC classification of the corporation that produced them but imputed to the line of business of each of the corporation's or proprietor's establishments in the GDP-by-Industry database followed. Hence there is no disagreement between the cash flow data derived from this database and the data on gross fixed capital formation, taken from FAweb, which are also reported on an establishment basis as noted below.

Data on gross output (GO), intermediate inputs (II) and value-added (VA) totals are also available from this source from worksheets 72SIC_VA,GO,II and 87SIC_VA,GO,II together with the respective chain-type price and quantity indexes. Details are given in the Section I.B.

(3) FAWEB http://www.bea.doc.gov/bea/dn/FAweb/Index2002.htm + Standard Fixed Assets Tables + Section 3: Private Fixed Assets by Industry + Table 3.7ES: Historical Cost Investment in Private Fixed Assets by Industry.

BEA staff (Michael D. Glenn and David B. Wasshausen) directed us to this site, not identified on the BEA public website menu. It has time-series data (last revised September 25, 2002) for 1947-2001, consistently presented in the 1987 SIC format, for Historical-Cost Investment in Private Fixed Assets by Industry on an establishment basis. This variable, known as capital expenditures, **CE**, constitutes the denominator of RIF.

The distribution of CE is also used to construct weights reflecting the relative importance of industry sectors. The annual share of each sector's CE in the combined total for all 21 sectors, averaged over 10 years, 1980-89, yields the weighting variable $\mathbf{W_i}$.

Additional Tables used from FAWEB (2002) to explain variations in $\mathbf{RIF^{adj}}$ are:

(a) Table 3.1ES Current-Cost Net Stock of Private Fixed Assets by Industry
(b) Table 3.2ES Chain-Type Quantity Indexes for Net Stock of Private Fixed Assets by Industry
(c) Table 3.4ES Current-Cost Depreciation of Fixed Assets by Industry.

The ratio (c)/(a) provides estimates of the underlying depreciation rate by industry sector (**DELTA**). Section I.F(a) explains why use of these current-cost data yields the proper "economic" measure of the depreciation rate. Calculating the appropriate underlying rate of growth of the net stock of capital is more complicated because this rate is more variable, both cyclically and structurally. To deal with both of these issues, we used the geometric average of the index values in (b) for three successive years, t-1 through t+1 (centered on t), divided by the geometric average of t-5 to t-7 (centered on t-6) index values, with the resulting ratio of geometric means taken to the power 1/6, to obtain our estimate of the underlying annual average rate of growth of capital (**GK)** leading up to a time period centered on time t. Thus, only a third of the data used in the construction of this underlying growth rate are updated each year.

The data in (a) are used as denominator of the explanatory variable **NIP/PK**. Its numerator, NIP, consists of Corporate and Noncorporate Net Interest and Miscellaneous Payments that are among the components of VA in the INDUSTRY database. The SIC conversion factors from the SIC72 to the SIC87 basis described at the end of this section were applied to the data before 1987 for this component before dividing by the Current-Cost Net Stock of Private Fixed Assets by Industry, PK.

SIC Conversion Factors. The components of value added by industry up to and including 1987 (overlap year), and hence cash flow by industry, are available only on the 1972 SIC (establishment) basis as explained under INDUSTRY above. To achieve compatibility with the fixed-investment data by SIC87 industry sector, cash-flow data prior to 1987 were converted by applying conversion factors to industry sectors equal to the ratio of cash flow reported by SIC87 sector to cash flow reported by the comparable or identical SIC72 manufacturing-industry sector in the overlap year, 1987. The resulting conversion factors, shown in the first column of Table A1, are 1 for most sectors, meaning that the industrial classification content assigned to those sectors had not changed.

An alternative procedure would have been to match the 1972 SIC cash flow data to 1972 SIC investment data through 1986, but BEA staff advised against trying to use old 1972 SIC investment data because such data had not participated in a number of benchmark and related retroactive revisions made after the adoption of SIC 1987, nor is this data available electronically. Hence we brought the cash flow data through 1986 to the 1987 SIC basis instead and related them to the investment data on the same SIC basis.

I.B. Dealing with Data Missing in Two Manufacturing-Industry Sectors

Among the explanatory data needed to adjust measures of cash flow in sector i for identifiable deviations from equilibrium are disturbances in two relative prices. The first is the relative price of each manufacturing sector's gross output ($\mathbf{PGO_{it}}$) to that of total manufacturing ($\mathbf{PGO_{mt}}$). The second is the relative price of each sector's intermediate inputs ($\mathbf{PII_{it}}$) relative to the price of its value added ($\mathbf{PVA_{it}}$).

Chain-type price indexes identified as GOPI, IIPI, and VAPI in the INDUSTRY source described are available only from 1977 on (on the SIC72 basis) but not until 1987 (on the SIC87 basis) for two sectors, "electric and electronic equipment" and "instruments and related products." For these two sectors, current dollar values of GO and II are also not available until 1987. To be able to work with identical complete data sets, the missing data for GOPI and IIPI were generated for the two sectors by fitting an exponential time trend to the price index data reported annually for 1987-1997 on the SIC 1987 basis. The estimated trend rate of growth was then used to extend the data series backward to 1977 from the predicted (rather than actual) 1987 value implied by the regression estimate with time trend (1987=0, 1997=10) fitted to the log-transformed data. However, to extend the share of intermediates in gross output, **II/GO**, from 1987 backwards to 1977 for the two sectors, we simply kept their 1987 value for the earlier years for lack of a clear trend from 1987 on.

I.C. Estimating Taxes on Corporate Profits and Proprietors' Income by Industry Sector Classified on an Establishment, Rather than Firm, Basis

For the entire period used here, 1977-1997, income taxes by industry sector, that are reported only for corporations, had to be estimated for corporations and proprietors when establishments (by establishment-SIC), and not entire firms (by firm-SIC), are assigned to industry sectors.

The INDUSTRY source uses the establishment basis. While this is essential if structural and technological characteristics are to be attributed to industry sectors or their "external" financing needs, no allocation of income taxes (as opposed to taxes on production and imports, less subsidies) has been attempted in this source. In Tables 6.18B (used for 1977-87) and 6.18C (used for 1987-1997) of NIPAWEB for corporation income taxes, and in Tables 6.17B (for 1977-87) and 6.17C (for 1987-97) for corporate profits without inventory valuation adjustment (IVA) and capital consumption adjustment (CCA), identical values are reported for all sectors in the overlap year 1987. This is because the allocation of firms (as opposed to establishments within firms) by industry sector has not changed from SIC72 to SIC87. We therefore estimated income taxes on corporate profits and proprietors' income in each sector by multiplying the tax liabilities reported in Tables 6.18 by the ratio of the sum of INDUSTRY Corporate Profits and Proprietors' Income, both without IVA and CCA, to the corporate profits, also without IVA and CCA, reported in Tables 6.17 identified above. This ratio or adjustment factor thus was calculated only for total manufacturing each year and then applied to the tax liabilities of each of its sectors in the corresponding year to assure macroeconomic consistency.

The alternative, of using the tax and profits data available on a firm-SIC basis to obtain a tax rate that can then be applied to the sum of corporate profits and proprietors' income reported on an establishment-SIC basis to estimate the tax liabilities of that INDUSTRY sector, had to be rejected. The reason is that, because profitable firms paying taxes are combined with unprofitable firms in the tax and income aggregates reported by sector, such a rate would bear no relation to a statutory income tax rate. Indeed it could be very high, when the sector as a whole has close to zero net income even though it contains a number of tax-paying firms, or negative if the sector is making losses in the aggregate in a particular year. Hence it is not valid to use one set of tax revenue and net income data by sector to obtain a tax rate that can be applied to another set of net income data, not even in the same sector.

I.D. Constructing Cash Flow from the INDUSTRY Database

The components of VA listed in the INDUSTRY database yield an estimate of cash-flow before taxes on proprietors' income and corporate profits from which such taxes, estimated as described in the previous section, must still be subtracted to approximate the concept of cash flow used by RZ. Specifically:

Gross Value Added
- Wage and Salary Accruals
- Supplements to Wages and Salaries
- Taxes on Production and Imports, less Subsidies

= Gross Operating Surplus
- Corporate and Noncorporate Net Interest and Miscellaneous Payments
- Business Current Transfer Payments

= Cash Flow before Income Taxes, where

Cash Flow before Income Taxes is the sum of :
Proprietors' Income without IVA
-- IVA
Corporate Profits before Tax without IVA
-- IVA
Capital Consumption Allowances, Corporate
Capital Consumption Allowances, Noncorporate Business

From these Components of Value Added in the INDUSTRY Source, the matching estimate of corporate and noncorporate income taxes is subtracted to obtain cash flow by industry sector on the establishment basis.

I.E. Deviations from the Rajan and Zingales Measure of Cash Flow and of DEF

(a) Unlike the estimate used by RZ (1998, p. 564), this measure of cash flow does not add (subtract) decreases (increases) in inventories, decreases (increases) in receivables, and increases (decreases) in payables into the measure of cash flow. For details of RZ's treatment see also *Standard & Poor's COMPUSTAT (North America) User Guide* 3/99, Chapter 4: Financial Statements, p. 12: Operating Activities – Net Cash Flow Format Code 7, data item #308. "Effective for fiscal years ending July 15, 1988, the SFAS #95 requires U.S. companies to report the statement of Cash Flows (format code = 7)" (p. 11).

(b) The RZ measure was constructed for listed corporations by summing the annual COMPUSTAT data for capital expenditure (CE) and cash-flow (CF) over the entire decade of the 1980s before estimating DEF rates (by subtracting CF from CE and then dividing by CE) by use of these ten-year aggregates. RZ chose the median of the resulting corporate values in any industry sector to represent the DEF of that sector. Conceptually it is preferable to average annual estimates of DEF over these ten years to derive a representative value for the sector. The reason is that working with ratios of 10-year aggregates of nominal values tends to give more weight to the more recent than the more distant years on account of continuing growth and inflation. However, experimentally constructing measures of DEF on either basis for the 11-year period 1987-1997 showed that the correlation between the resulting industry-sector DEF measures -- one based on working with 11-year aggregates to obtain the sector's characteristic DEF measure and one averaging 11 annual DEF estimates to derive such a measure -- turned out to be 0.9992.

(c) The basis for industrial classification used by RZ is the firm rather than the establishment. Hence all the, possibly quite diverse, operations of a firm in a variety of sectors are attributed to its largest sector of operation. This detracts from the viability of any "structural" or "technological" interpretation that can be put on observed differences in the dependence on external financing of the firms assigned to a particular industry sector. For instance, firms may contain establishments with very different "external" funding needs so that there may be large financial transfers between establishments that are internal to the firm. Indeed firms may be configured in part to achieve greater financial autarky through averaging between establishments operating in different sectors. While use of the data provided on an establishment basis by the BEA appears conceptually superior for the purposes at hand, it does introduce an element of incomparability with the RZ data.

(d) RZ used the accounts of the median firm to characterize conditions in the manufacturing industry sector to which it has been assigned. Since such a sector inevitably can contain only a few large, but many small firms, the median firm, outside a few strictly oligopolistic sectors is likely to be small. Hence the median firm may not be representative of the aggregate financing conditions for all the firms in an industry sector. Results may be sensitive to industrial organization and conglomeration of the firms in the sector, and to its concentration ratio which, unless dictated by economies of scale at the establishment level, may not be a deeply structural characteristic. Being comparatively small and specialized, the median firm may, however, fit better with an establishment concept than with a firm concept of industrial classification because large and diversified firms may dominate the aggregate financing pattern observed in their sector.

I. F. BEA Definitions and Differences in Industrial Classification by Corporation or other Legal Form, and by Establishment

BEA Definitions, from http://www.bea.doc.gov/bea/dn/FAweb/Articles/Intro.html, are used here that relate to the valuation of investment and the definition of establishment:

(a) "Historical-cost valuation measures the value of fixed assets in the prices of the period in which the assets were purchased new." Aggregate measures of historical-cost investment thus are identical to nominal gross fixed investment in the GDP accounts. "Current-cost valuation measures the value of assets in the prices of a given period, which are end-of-year for stocks and annual averages for depreciation." Current-cost estimates of depreciation thus differ from historical-cost estimates of depreciation (without capital consumption adjustment) which are a component of value added in that they represent replacement-cost estimates of the BEA-economic (rather than business or tax-accounting) depreciation of fixed capital assets valued at current-period prices.

(b) "Establishments, as defined for the purposes of the SIC, are economic units, generally at a single physical location, where business is conducted or where services or industrial operations are performed."

Comment: In the *Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations* of the U.S. Census Bureau (e.g., Quarter 4, 2000, p. x), "a reporting corporation is initially classified into the SIC division accounting for more gross receipts than any other SIC division... For the most part, after a corporation is assigned to a division, it is further classified by the two-digit SIC major group accounting for more gross receipts than any other two-digit group within the division." The identification of corporations by SIC group in NIPA accounts such as "corporate profits by industry," and of listed corporations in Compustat, follows the same scheme. Unless all establishments of a corporation are assigned to the same classification because the corporation is not vertically integrated and not horizontally conglomerated, classifications by establishment and by corporation do not agree.

I.G. BLS Data Source: Employment in Manufacturing

The only non-BEA data source used in this paper is the Bureau of Labor Statistics (BLS) (http://data.bls.gov). It provides data for total manufacturing employment: Manufacturing, All Employees, Thousands, Not Seasonally Adjusted, Annual, Series ID: CEU3000000001. The data was used to generate deviations of the logarithm of employment from its estimated trend value for 1977-1997, where the exponentially declining trend in total manufacturing employment was estimated from 1976 (t=0) to 1998 (t=22). These deviations, $\mathbf{DlnL_{mt}}$, are meant to characterize cyclical conditions in the manufacturing sector as a whole that might help explain short-run fluctuations in RIF in cyclically-sensitive manufacturing industry sectors. $DlnL_{mt}$ is used together with the relative-price deviations $\mathbf{Dln(PGO_{it}/PGO_{mt})}$ and $\mathbf{Dln(PII_{it}/PVA_{it})}$ to adjust the annual values of RIF for temporary disturbances.

II. Statistical Comparisons of RZ data of DEF with Our Data

II.A. Correspondences of Industrial Classifications

RZ data by sector are for the median publicly listed corporation in each manufacturing-industry sector, with the entire operations of a firm assigned to just one sector using the International Standard Statistical Classification (ISIC), Revision 2 (Rev. 2). Our data are for all corporations and proprietorships with establishments operating in a particular sector classified by SIC87, or converted to that classification. Hence the first task is to map the data reported on the ISIC (Rev. 2) basis into the U.S. 1987 SIC classification. This is done for RZ's "all" and "mature" companies in Tables A2 and A3, respectively. Table A4 compares the RZ measures, which represent averages for 1980-89, reclassified to the SIC 1987 basis, to our measures for that same period as well as the earlier periods, 1976-1986 and 1987-1997, to gain insights into the intertemporal stability of these measures. Finally, Table A5 reports correlations of the various unweighted and weighted RZ measures and our measures which were obtained as annual averages of the ratios estimated for each year rather than as the ratio of decadal firm aggregates, as in RZ.

II.B. Correlation Results with Unweighted Data

The first panel in Table A5 shows that the "internal" correlation between RZ's measures of DEF for "all" and "mature" companies is 0.475. The correlation of our aggregate measure is much higher with RZ's "mature companies" than with the "all companies" measure, -- 0.53 compared with 0.24 in a precise time match: "Mature" companies undoubtedly have by far the largest weight in our complete industry-sector aggregates.

II.C. Correlation Results Using Investment-Weighted Data by Sector

Because annual fixed investment in private assets by industry forms the denominator of RIF and DEF, it is appropriate to weight by the amount of such investment in each sector to examine whether correlations found with equally weighted ("unweighted") data are representative of macroeconomic relations for those sectors. Weighting is especially necessary because the investment shares of the 21 sectors distinguished in Table A1 can differ by a factor of as much as 75 for 1980-89 and by even more in other periods. For instance, the average annual share in 1987-1997 of Leather and Leather Products is 0.001 while that of Chemicals and Allied Products is 0.148. Using the square-root of the average annual weights for the middle period, 1980-89, as weights here, Table A5 shows correlations between our and the RZ measures to be slightly *negative* in a precise time match in the second panel of Table A5. The positive correlations between RZ's measures and ours that were found with unweighted data in Table A5 thus do not apply to those manufacturing sectors in which the bulk of investment occurs. On the other hand, the positive "internal" correlation between the two *weighted* RZ measures rises to

Table A1. Conversion Factors and 10- or 11-Year Averages of Annual Investment Weights for 1987 SIC U.S. Manufacturing Sectors

	Conversion Factor	Weights 1976-1986	1980-1989	1987-1997
Column:	1	2	3	4
Lumber	1.009	0.027	0.022	0.019
Furniture	1	0.008	0.009	0.009
Stone Clay Glass	0.932	0.034	0.030	0.026
Primary Metals	1	0.070	0.057	0.049
Fabricated Metal	1.001	0.052	0.050	0.047
Machinery	1.019	0.105	0.103	0.088
Electric Machinery	0.989	0.092	0.104	0.109
Motor Vehicles	1	0.069	0.067	0.070
Other Transpo. Equip.	0.947	0.042	0.050	0.038
Instruments	1.097	0.039	0.047	0.049
Misc. Manufactures	1	0.010	0.009	0.009
Food & Beverages	1	0.084	0.085	0.089
Tobacco	1	0.008	0.009	0.005
Textiles	1	0.022	0.022	0.022
Apparel	1	0.010	0.009	0.008
Paper	0.996	0.065	0.069	0.072
Printing	1	0.044	0.053	0.055
Chemical Products	1	0.132	0.123	0.148
Petrol. & Coal Prod.	1	0.052	0.046	0.042
Rubber & Plastics	1.086	0.032	0.035	0.045
Leather Products	1	0.002	0.002	0.001
Sum	--	1	1	1

Table A2. RZ's "All Companies" Estimate of Manufacturing Industries' Dependence on External Finance (DEF) Extended from ISIC Rev. 2 to US-SIC 1972 and 1987 Using 1987 Investment Weights in Total U.S. Manufacturing

Industry Classifications					RZ-DEF		
SIC72	*SIC87*	*Rev. 2*	*Manufacturing Sector*	*%Weight*	*Rev. 2*	*SIC72*	*SIC87*
		311	Food Products (P.)	5.622	0.14		
		313	Beverages	1.533	0.08		
20	*20*	*311-313*	*Food and Kindred P.*			*0.127*	*0.127*
21	21	314	Tobacco Manufactures	0.593	-0.45	-0.45	-0.45
		321x	Textile Manufacturing	1.374	0.40		
		3211	Spinning, Weaving	1.598	-0.09		
22	*22*	*321*	*Textile Mill Products*			*0.137*	*0.137*
23	23	322	Apparel from Fabrics	0.625	0.03	0.03	0.03
		323	Leather Products	0.075	-0.14		
		324	Footwear	0.052	-0.08		
31	*31*	*323+324*	*Leather & Leather P.*			*-0.115*	*-0.115*
24	24	331	Lumber & Wood Prod.	1.738	0.28	0.28	0.28
25	25	332	Furniture and Fixtures	0.815	0.24	0.24	0.24
		341x	Paper and Paper Prod.	2.285	0.18		
		3411	Pulp, Paper(board)	4.807	0.15		
26	*26*	*341*	*Paper & Allied Prod.*			*0.160*	*0.160*
27	27	342	Printing & Publishing	6.268	0.20	0.20	0.20
		3511	Basic Ind. Chemicals	4.079	0.25		
		3513	Synthetic Materials	2.428	0.16		
		352x	Other Chemicals	2.234	0.22		
		3522	Drugs and Medicines	2.234	1.49		
28	*28*	*351+352*	*Chemicals & Allied P.*			*0.476*	*0.476*
		353	Petroleum Refining	2.599	0.04		
		354	Petroleum & Coal P.	0.391	0.33		
29	*29*	*353+354*	*Petr. Ref. and Related*			*0.078*	*0.078*
		355	Rubber Products	0.906	0.23		
		356	Plastic Products	3.598	1.14		
30	*30*	*355+356*	*Rubber & Plastics P.*			*0.957*	*0.957*
		361	Pottery, China	0.106	-0.15		
		362	Glass and Products	0.994	0.53		
		369	Other NM Mineral P.	2.095	0.06		
32	*32*	*361+2+9*	*Clay Glass Concrete P.*			*0.199*	*0.199*
		371	Iron & Steel	2.834	0.09		
		372	Nonferrous Metals	1.856	0.01		
33	*33*	*371+372*	*Primary Metal Indus.*			*0.058*	*0.058*

Table A2 cont'd

Industry Classifications					RZ-DEF		
SIC72	*SIC87*	*Rev. 2*	*Manufacturing Sector*	*%Weight*	*Rev. 2*	*SIC72*	*SIC87*
34	34	381	Fabricated Metal P.	4.367	0.24	0.24	0.24
		382x	Machinery ex. Electr.	6.890	0.45		
		3825	Office & Computing	2.805	1.06		
35	*35*	*382*	*Machinery ex. Electr.*			*0.626*	*0.626*
		383x	Electric Machinery	2.771	0.77		
		3832	Radio, TV, Commun.	5.954	1.04		
36	*36*	*383*	*Electr. and Electronic*			*0.954*	*0.954*
		384x	Transportation Equip.	4.727	0.31		
		3841	Shipbuilding &Repair	0.520	0.46		
371	371	3843	Motor Vehicles & Eq.	10.166	0.39	0.39	0.39
372-379	*372-379*	*384x+3841*	*Transportation Equip. ex. Motor Vehicles*			*0.325*	*0.325*
38	38	385	Prof. and Sci. Equip.	4.759	0.96	0.96	0.96
39	39	390	Other Manuf. Product	0.807	0.47	0.47	0.47
			Subtotal + weig. avg.	97.505	0.419		
incl. in 20	incl. in 20	3121+ 3122	Animal Feeds & Food Prod. n.e.c.	0.461	NR		
in 28	in 28	3512	Fertilizers and Pestic.	2.036	NR		
			Effect of Rounding	-0.002			
			Total	100			

Notes: Suffix x (column 3) indicates that data refer to a 3-digit class minus any 4-digit class(es) shown below it. Classes not appearing directly in RZ but obtained by combination of their data are shown in italics. The concordances in the first three columns between US-SIC 1972 and 1987 and, in turn, ISIC Rev. 2 are approximate. The weights in column 5 are derived from the 1987 distribution of U.S. manufacturing investment (totaling $78,299 million) by up to 4 digits shown in OECD, Industrial Surveys – ISIC Rev. 2, Vol. 2003 release 01. The RZ-DEF (Rev. 2) data in column 6 are taken from Rajan and Zingales (1998, 566-67) where data with a combined weight of 2.5% are not reported (NR). The DEF data in the last two columns are constructed as weighted averages of the RZ estimates shown in col. 6. By definition, DEF = 1 - RIF.

Table A3. RZ's "Mature Companies" Estimate of Manufacturing Industries' Dependence on External Finance (DEF) Extended from ISIC Rev. 2 to US-SIC 1972 and 1987 Using 1987 Investment Weights in Total U.S. Manufacturing

Industry Classifications					RZ-DEF		
SIC72	*SIC87*	*Rev. 2*	*Manufacturing Sector*	*%Weight*	*Rev. 2*	*SIC72*	*SIC87*
		311	Food Products (P.)	5.622	-0.05		
		313	Beverages	1.533	-0.15		
20	*20*	*311-313*	*Food and Kindred P.*			*-0.071*	*-0.071*
21	21	314	Tobacco Manufactures	0.593	-0.38	-0.38	-0.38
		321x	Textile Manufacturing	1.374	0.14		
		3211	Spinning, Weaving	1.598	-0.04		
22	*22*	*321*	*Textile Mill Products*			*0.043*	*0.043*
23	23	322	Apparel from Fabrics	0.625	-0.02	-0.02	-0.02
		323	Leather Products	0.075	-1.33		
		324	Footwear	0.052	-0.57		
31	*31*	*323+324*	*Leather & Leather P.*			*-1.019*	*-1.019*
24	24	331	Lumber & Wood Prod.	1.738	0.25	0.25	0.25
25	25	332	Furniture and Fixtures	0.815	0.33	0.33	0.33
		341x	Paper and Paper Prod.	2.285	0.10		
		3411	Pulp, Paper(board)	4.807	0.13		
26	*26*	*341*	*Paper & Allied Prod.*			*0.120*	*0.120*
27	27	342	Printing & Publishing	6.268	0.14	0.14	0.14
		3511	Basic Ind. Chemicals	4.079	0.08		
		3513	Synthetic Materials	2.428	-0.23		
		352x	Other Chemicals	2.234	-0.18		
		3522	Drugs and Medicines	2.234	0.03		
28	*28*	*351+352*	*Chemicals & Allied P.*			*-0.052*	*-0.052*
		353	Petroleum Refining	2.599	-0.02		
		354	Petroleum & Coal P.	0.391	0.16		
29	*29*	*353+354*	*Petr. Ref. and Related*			*0.004*	*0.004*
		355	Rubber Products	0.906	-0.12		
		356	Plastic Products	3.598	NR		
30	*30*	*355+356*	*Rubber & Plastics P.*			*-0.12*	*-0.12*
		361	Pottery, China	0.106	0.16		
		362	Glass and Products	0.994	0.03		
		369	Other NM Mineral P.	2.095	0.15		
32	*32*	*361+2+9*	*Clay Glass Concrete P.*			*0.113*	*0.113*
		371	Iron & Steel	2.834	0.09		
		372	Nonferrous Metals	1.856	0.07		
33	*33*	*371+372*	*Primary Metal Indus.*			*0.082*	*0.082*

Table A3 cont'd

Industry Classifications					*RZ-DEF*		
SIC72	*SIC87*	*Rev. 2*	*Manufacturing Sector*	*%Weight*	*Rev. 2*	*SIC72*	*SIC87*
34	34	381	Fabricated Metal P.	4.367	0.04	0.04	0.04
		382x	Machinery ex. Electr.	6.890	0.22		
		3825	Office & Computing	2.805	0.26		
35	*35*	*382*	*Machinery ex. Electr.*			*0.232*	*0.232*
		383x	Electric Machinery	2.771	0.23		
		3832	Radio, TV, Commun.	5.954	0.39		
36	*36*	*383*	*Electr. and Electronic*			*0.339*	*0.339*
		384x	Transportation Equip.	4.727	0.16		
		3841	Shipbuilding &Repair	0.520	0.04		
371	371	3843	Motor Vehicles & Eq.	10.166	0.11	0.11	0.11
372-379	*372-379*	*384x+ 3841*	*Transportation Equip. ex. Motor Vehicles*			*0.148*	*0.148*
38	38	385	Prof. and Sci. Equip.	4.759	0.19	0.19	0.19
39	39	390	Other Manuf. Product	0.807	-0.05	-0.05	-0.05
			Subtotal + weig. avg.	97.505	0.097		
incl. in 20	incl. in 20	3121+ 3122	Animal Feeds & Food Prod. n.e.c.	0.461	NR		
in 28	in 28	3512	Fertilizers and Pestic.	2.036	NR		
			Effect of Rounding	-0.002			
			Total	100			

Notes: See Table A2.

Table A4. Reclassified RZ DEF Measures and Our Measures of DEF, Various Periods, for 1987 SIC U.S. Manufacturing Sectors, and their Weighted Average

	1980-1989 RZ Def		DEF		
	All Co's	Mature Co's	1976-1986	1980-1989	1987-1997
Column:	1	2	3	4	5
Lumber	0.28	0.25	-2.151	-2.850	-3.460
Furniture	0.24	0.33	-0.835	-0.980	-1.000
Stone Clay Glass	0.199	0.113	0.011	0.094	-0.355
Primary Metals	0.058	0.082	0.112	0.099	-0.137
Fabricated Metal	0.24	0.04	-1.054	-1.269	-1.589
Machinery	0.626	0.232	-0.667	-0.736	-0.902
Electric Machinery	0.954	0.339	-0.278	-0.654	-1.806
Motor Vehicles	0.39	0.11	-1.251	-1.720	-1.421
Other Transpo. Eq.	0.325	0.148	1.449	1.050	1.120
Instruments	0.96	0.19	-0.040	0.568	1.003
Misc. Manufactr.	0.47	-0.05	-2.280	-3.235	-4.133
Food & Beverages	0.127	-0.071	-0.670	-0.822	-0.727
Tobacco	-0.45	-0.38	-1.465	-1.061	-5.023
Textiles	0.137	0.043	-0.265	-0.152	-0.199
Apparel	0.03	-0.02	-2.272	-2.303	-2.197
Paper	0.16	0.12	-0.131	-0.212	-0.229
Printing	0.2	0.14	-1.477	-1.121	-0.952
Chemical Products	0.476	-0.052	-0.602	-0.905	-1.159
Petrol.&Coal Prod.	0.078	0.004	1.230	1.075	0.565
Rubber & Plastics	0.957	-0.12	-0.234	-0.169	0.106
Leather Products	-0.115	-1.019	-2.653	-4.357	-6.755
Weighted Average	0.370	0.078	-0.518	-0.658	-0.934

Notes: The data in columns 1 and 2, reclassified from 36 ISIC Rev. 2 sectors to 21 1987 SIC sectors, are obtained from Tables A2 and A3, respectively. To obtain the weighted average shown in the last row, weighting is by the square-root of the capital expenditure weights by sector (W_i) shown in the fourth column of Table 2 in the text and, more rounded, in the third column of numbers in Table A1, with the square-root weights, $W_i^{0.5}$, normalized to 1.

Table A5. Correlation Matrices for RZ's and Our Average Annual Measures of DEF for Various Time Periods

(1) Correlation of RZ measures of DEF and our measure for 1980-89

	AVG8089	*RZ-DEF*	*RZ-MAT*
AVG80-89	1		
RZ-DEF	0.2396	1	
RZ-MAT	0.5346	0.4750	1

(1a) Correlation of same measures weighted by investment share*

	WAVG889	*WRZDEF*	*WRZMAT*
WAVG889	1		
WRZDEF	-0.1108	1	
WRZMAT	-0.0561	0.6119	1

(2) Correlation of our measures of DEF, 1976-86 and 1987-97, with RZ's

	AVG77-86	*AVG87-97*	*RZ-DEF*	*RZ-MAT*
AVG77-86	1			
AVG87-97	0.8684	1		
RZ-DEF	0.2760	0.4055	1	
RZ-MAT	0.4587	0.6542	0.4750	1

Glossary:

RZ-DEF	Rajan and Zingales' measure of Dependence on External Finance for "All" Companies
RZ-MAT	Same measure for "Mature" Companies only
AVG80-89	Average of annual values of our measure of DEF^{adj}
WAVG889	1980-1989 --weighted
AVG77-86	Same measure for 1977-1986
AVG87-97	Same measure for 1987-1997
W (Prefix)	Using weighted variables

*Mean deviants of individual observations that are weighted by the square-root of W_i -- where W_i is the average annual investment share in each sector for 1980-89 -- yield products entering into the calculation of (co)variances that are weighted by W_i.

0.612, from 0.475 for the unweighted measures, showing that the DEF measures for "all" and "mature" companies correlate more closely for large than for small sectors.

II.D. Intertemporal Correlations

Examining correlations between non-overlapping annual averages of our DEF data for 1977-1986 and 1987-1997 shows a correlation of 0.87 in the third panel of Table A5 indicating a *fairly high degree of intertemporal consistency*. Nevertheless, the correlation between the earlier (1977-1986) measure and RZ's two measures is far lower than with the later (1987-1997) measure, 0.46 compared with 0.65 for "mature" and 0.28 compared with 0.41 for "all" companies. Because certain data used in parts of this study, such as the chain-type price indexes for gross output, intermediate inputs, and value added, are available only from 1977 on, and other data, such as the components of value added on the SIC87 basis, are not reported past 1997, this study deals with a maximum of 21 (1977-1997) annual observations.

Appendix 3. The Weighting Variable and its Applications and Transformations

The weighting variable, W_i, is shown in column 4 of Table 2 in the text. Introducing weights complicates understanding of the decompositions of the Sum of Squared Total (SST) deviations, where grouping is either by sector (i) or time (t), into their within-sector (SSW) and Between-Sector (SSB) deviations. Because SST(i) must equal SST(t) since grouping affects only the decomposition of SST, not its total value, it follows that SSW(i) + SSB(i) = SSW(t) + SSB(t).

The text box on the next page explains the decomposition for any variable, generically called X_{it}, when weighting by sector (i). As shown near the bottom of that box, the weighting variable on the individual variables, W_i, is transformed automatically to w_i for use on the sum of squares in the statistical program.[21] This transformation is designed to equate the sum of these weights, with each w_i repeated T times, to the total number of observations, which in this case is N = TS = 441, where S = 21 sectors and T = 21 years (1977-97). This sum of weights then is the same as in the "unweighted" case where $w_i = 1$ for all *i* at any *t*, allowing direct comparisons between "unweighted" and "weighted" results reported in Table 3 in the text.

[21] The program is LIMDEP, version 8.0, by William H. Greene, Econometric Software, Inc

Decompositon of the Sum of Squared Deviations, SST, of X_{it}

$$SST(i) = SST(t) = \sum_{i=1}^{i=S}\sum_{t=1}^{t=T} w_i[X_{it} - \sum_t\sum_i (W_i X_{it})/(T\sum_i W_i)]^2;\ \mathrm{S} = 21, \mathrm{T} = 21.$$

$$\textit{Within Groups} \rightarrow SSW(i) \neq SSW(t)$$

$$SSW(i) = \sum_{i=1}^{i=S}\sum_{t=1}^{t=T} w_i[X_{it} - \sum_t (W_i X_{it})/(\sum_t W_i)]^2, \text{ where } \sum_t (W_i X_{it})/(\sum_t W_i)] = \overline{X_i},$$

$$SSW(t) = \sum_{t=1}^{t=T}\sum_{i=1}^{i=S} w_i[X_{it} - \sum_i (W_i X_{it})/(\sum_i W_i)]^2.$$

$$\textit{Between Groups} \rightarrow SSB(i) \neq SSB(t)$$

$$SSB(i) = \sum_{i=1}^{i=S}\sum_{t=1}^{t=T} w_i[\overline{X_i} - \sum_t\sum_i (W_i X_{it})/(T\sum_i W_i)]^2$$

$$= T\sum_{i=1}^{i=S} w_i[\overline{X_i} - \sum_t\sum_i (W_i X_{it})/(T\sum_i W_i)]^2.$$

$$SSB(t) = \sum_{t=1}^{t=T}\sum_{i=1}^{i=S} w_i[\sum_i (W_i X_{it})/(\sum_i W_i) - \sum_t\sum_i (W_i X_{it})/(T\sum_i W_i)]^2,$$

$$= S\sum_{t=1}^{t=T} w_i[\sum_i (W_i X_{it})/(\sum_i W_i) - \sum_t\sum_i (W_i X_{it})/(T\sum_i W_i)]^2.$$

Transformed sectoral weights are $w_i = W_i(S/\sum_i W_i)\ \therefore\ \sum_i w_i = S$,

where W_i is the weighting variable, and N = TS = 441= the total number of observations and the sum of their weights.

If all sectors (and years) are weighted equally, $w_i = 1$ for every sector *i* through each of *T* years and :

$$\sum_i (W_i X_{it})/(\sum_i W_i) = \overline{X_t},$$

$$\sum_t\sum_i (W_i X_{it})/(T\sum_i W_i) = \overline{X}, \text{ and}$$

$$\overline{\mathrm{X}} = \sum_{i=1}^{i=S} \overline{X_i}/S = \sum_{t=1}^{t=T} \overline{X_t}/T.$$