SEPTEMBER/OCTOBER 1991

ECONOMIC PERSPECTIVES

A review from the
Federal Reserve Bank
of Chicago

Energy dependence and efficiency

Balancing act: Tax structure in the Seventh District

FEDERAL RESERVE BANK
OF CHICAGO

Contents

ECONOMIC PERSPECTIVES SEPTEMBER/OCTOBER 1991 Volume XV, Issue 5

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ISSN 0164-0682

Energy dependence and efficiency

Jack L. Hervey

World oil market fragility was demonstrated again last year following the August 2 invasion of Kuwait by Iraq and the subsequent United Nations imposed embargo on oil shipments from Iraq and Kuwait. Concern about the potential cutoff of Middle East oil brought back memories of long lines at gas stations, dim lighting in offices, lower thermostats on furnaces and reduced use of air conditioners. In public debate, issues of energy dependence, efficiency, and conservation were again in vogue. Developments in the Middle East from August 1990 through February 1991 serve as an effective reminder of the importance of energy in general and petroleum in particular to the industrial economies.

The intent of this article is two fold. In order to set the stage, it first reviews recent developments in the oil markets. Next, it surveys concepts of energy and oil-use dependence as well as energy and oil-use efficiency. It proposes measures of dependence and efficiency and uses these measures to compare developments in the world's six heaviest consumers of energy—Canada, France, West Germany, Japan, the United Kingdom, and the United States—during the period 1970 to 1988.

Recent developments

Following the U.N. embargo on oil shipments from Iraq and Kuwait, world crude oil production declined 6 percent in August, a reduction of 3.5 million barrels per day. However, initial fears of an oil shortage proved unfounded. Within days, other major oil exporters pledged to increase production to offset the 4.5 million barrels per day of lost Iraq and Kuwait oil. World crude oil production and prices are shown in Figure 1.

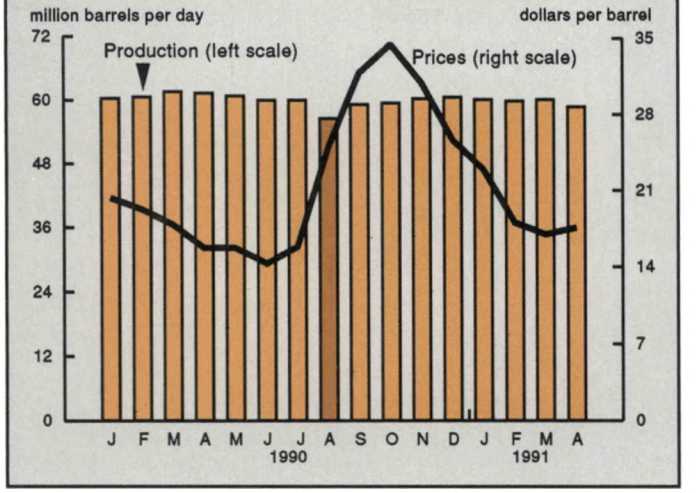
Nevertheless, oil prices soared, bringing on the fourth major price shock to world oil markets in less than two decades (counting the rapid decline in oil prices in 1986). Uncertainty in the markets intensified as multinational forces opposing the Iraqi move began to deploy in Saudi Arabia and the threat of military confrontation grew. Spot prices for crude oil peaked at over $40 per barrel in early October, up from $19 per barrel prior to the invasion of Kuwait.

By late November, oil production by the 11 remaining OPEC members, in particular Saudi Arabia, exceeded that of all 13 members of OPEC prior to the invasion, thus wiping out the Iraqi-Kuwaiti export deficit. World production returned to pre-August levels of 60-61 million barrels per day. In addition, world oil demand was slipping because of weakening economic conditions in oil importing countries and oil consumers' response to higher oil prices.

The author is a senior economist at the Federal Reserve Bank of Chicago. The author would like to express his appreciation to Kenneth Kuttner, Prakash Loungani, James Moser, and Steve Strongin for their helpful comments during the project and on earlier drafts of the paper. The views expressed herein, however, remain those of the author and do not necessarily reflect the views of the commentators or the Federal Reserve Bank of Chicago.

FIGURE 1

World crude oil production and prices



By mid-December, spot prices for crude had declined to well below $30 per barrel. Analysts were beginning to suggest that crude oil prices would once again drop to levels well below $20 per barrel during 1991, assuming a favorable resolution of the Persian Gulf situation.

With the initiation of the allied air offensive against Iraq on January 16, 1991, oil prices surged again, to more than $30 per barrel. However, it soon became apparent that oil production in the Gulf states would not be appreciably affected by the war, nor would shipping lanes in the area be disrupted. Oil prices promptly declined to the $20-$25 per barrel range.

The initiation of the land war by Coalition Forces on February 24 and its rapid conclusion contributed to a further easing of market tensions. Real economic factors once again dominated the market. Oil prices dropped into the $18-$20 per barrel range and day-to-day price variation decreased markedly.

The lesson learned from Kuwait

Soaring oil prices once again raised the issue of the economic dependance of the world's economies on energy, in general, and on petroleum in particular. This issue has been ignored, if not forgotten, by all but a few analysts and policy makers during the last half of the 1980s, a period during which nominal crude oil prices declined from around $30 per barrel to $10 per barrel before increasing again to settle in the mid-to-high teens.

Not surprisingly, public interest in energy conservation and a national energy policy subsided as soon as oil prices declined into the low twenties and high teens. Indeed, the oil price most often faced by the consumers, motor gasoline, was lower, when adjusted for inflation, at mid-year 1991 than prior to the 1973-1974 price shock.

Public officials' disinclination towards serious energy conservation measures is illustrated by Congressional response to an Administration proposal of a 12 cent per gallon gas tax as part of the 1990 tax bill. The Congress enacted a 5 cent per gallon increase in the gasoline tax, an increase motivated more by the desire to increase revenue than to promote conservation.[1] The Iraq and Kuwait episode illustrates the fact that the stability of the world oil market is fragile. That fragility grows out of at least two factors: 1) the dependence of the world's economies on petroleum as an energy source and 2) the mismatch between petroleum producers and consumers.[2]

In the United States, in particular, discussion about energy and oil usage focused on how dependent the economy is on oil and how inefficient the U.S. economy is in its use of energy and oil.

This raises the issue of what it means to say that a country is dependent on oil, or on energy in general. In fact, there are a number of different ways to measure how dependent a country is on energy in general, or on a particular energy source such as oil. In this article I discuss two measures of energy dependence—total requirements and per capita requirements—and compare the dependence of the six heaviest users of energy (Canada, France, West Germany, Japan, the United Kingdom, and the United States) according to these measures. Investigation into the sources of dependence requires a discussion of energy efficiency. Again, there are different ways to measure a country's energy efficiency. Four measures of efficiency are presented and compared for the six countries according to each measure of efficiency. Finally, in order to explain some of the differences in efficiency across countries, efficiency by economic sector is examined.

The next section deals with a discussion of dependence on energy in general, and on the major energy sources in particular.

An overview of energy dependence

The primary energy sources available to an economy are: 1) coal, 2) petroleum and petroleum products, 3) natural gas, 4) nuclear energy, 5) hydro-electric, geothermal, and solar energy (H-G-S), 6) solid fuels other than coal (for example, wood, peat, and incinerated garbage), 7) electricity (normally electricity is a derived or secondary energy form, however, some countries import electricity, in which case it then becomes a primary energy source to those countries), and 8) heat derived from public combined heat and power plants.[3] In the aggregate the last three categories are of minor importance, or, as in the case for the other solid fuels category, the data are inadequate, therefore these categories are not considered in the analysis.

An economy's overall dependence on energy or on a particular energy source, for example, petroleum, can be measured in several ways. This article specifically examines total energy utilized from all sources by the economy; energy requirements relative to population (for example, per capita energy requirements from all sources or per capita energy requirements derived from oil); and energy use by source (for example, oil) as a proportion of an economy's total energy requirements.

Energy consumption varies widely across economies. Table 1 presents total primary energy requirements (TPER) for the years 1970 through 1988 for the world's six heaviest energy users: Canada, France, West Germany, Japan, the United Kingdom, and the United States (see note 3 for an explanation of the source and makeup of these data, and a definition of total primary energy requirements). According to Table 1, as of 1988, the U.S. was by far the largest user of energy. With total energy requirements of 1,928 million tons of oil equivalent (Mtoe—see note 3 for a definition of Mtoe) U.S. requirements were nearly five times that utilized by the next largest user (Japan) and nine times that of the smallest users, France and the U.K. At the same time, the rate of increase for the U.S. compared favorably with that of the other 5 countries. Indeed, in 1988, U.S. TPER were only 1.5 percent above 1978 levels.[4] Only in the U.K. and Germany was the growth in TPER lower.

TPER falls short as a measure for comparing the relative energy dependence of different countries because it does not take into account factors which determine energy dependence, such as population, the size of the economy, the geographical size of the country, the type of goods produced, and the preferences and consumption habits of the population. For example, a country with a large population may have greater total energy requirements than a country with a small population without necessarily being more energy dependent, if per capita energy requirements are the same in both countries. A geographically large country that relies heavily on automotive transportation may be more energy dependent than a small country where the automobile is a lesser factor. Issues of economic size, population, geographic size, industrial composition and consumptions habits are addressed in more detail in the balance of the article. Here I turn to a consideration of per capita energy requirements for the six countries.

Per capita measures of total primary energy requirements are presented in Table 2 and Figure 2. They contrast sharply with the total requirements data in Table 1. U.S. per capita requirements for all energy remain high in comparison with those of Japan and the European countries but are substantially lower than for

TABLE 1

Total primary energy requirements
(Millions of tons of oil equivalent)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	1,579	268	237	208	155	154
1972	1,695	299	249	213	170	171
1974	1,721	335	258	212	179	184
1976	1,778	328	262	205	180	199
1978	1,900	347	272	209	191	211
1980	1,826	355	274	201	198	223
1982	1,707	337	252	193	187	213
1984	1,782	364	262	192	195	224
1986	1,793	369	270	205	204	233
1988	1,928	399	274	209	209	250

TABLE 2

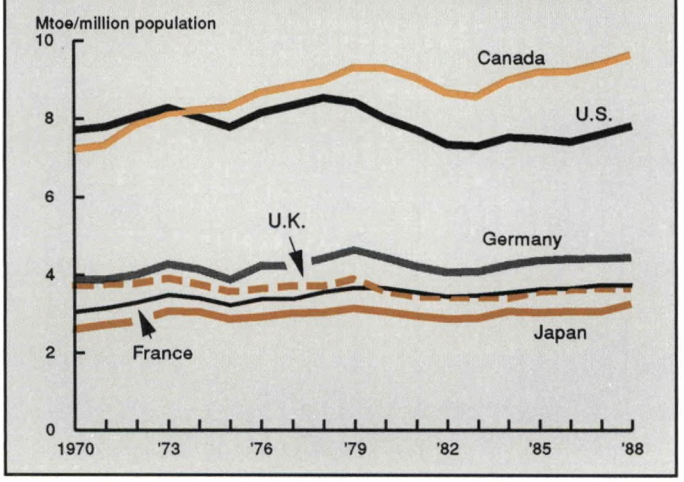
Total primary energy requirements per capita
(Millions of tons of oil equivalent/million population)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	7.7	2.6	3.9	3.7	3.1	7.2
1972	8.1	2.8	4.0	3.8	3.3	7.9
1974	8.1	3.0	4.2	3.8	3.4	8.2
1976	8.2	2.9	4.3	3.7	3.4	8.6
1978	8.5	3.0	4.4	3.7	3.6	9.0
1980	8.0	3.0	4.5	3.6	3.7	9.3
1982	7.3	2.8	4.1	3.4	3.4	8.6
1984	7.5	3.0	4.3	3.4	3.6	9.0
1986	7.4	3.0	4.4	3.6	3.7	9.2
1988	7.8	3.3	4.5	3.7	3.7	9.6

Canada. Most telling, changes over time as derived from the data in Table 2 indicate that the increase in per capita energy dependence in the U.S. during the 1970-1988 period compared favorably with the other countries. In 1988, U.S. per capita dependence for all energy increased less than 2 percent as compared with 29 percent for Canada, 23 percent for Japan, 20 percent for France, and 14 percent for Germany. Per capita requirements declined 2 percent in the U.K. Even more favorable is the per capita energy requirement performance of the U.S. during the last ten years of the period. By this measure the U.S. joined the U.K. in reducing its per capita overall energy dependence while energy dependence elsewhere continued to rise.

FIGURE 2

Per capita total energy requirements



I now turn to a discussion of energy dependence by energy source.

Petroleum

Before discussing the specific measures of oil dependence it is important to distinguish between an economy's overall dependence on petroleum and an economy's import dependence on petroleum. For example, a country may use little oil and produce none domestically, consequently importing all oil used. Such a country would have a low total dependence on petroleum but a high import dependence. Alternatively, an oil-rich country that has a high level of oil utilization may be a net exporter of petroleum. This country would have a high total dependence but no dependence on imports. The press and policy makers are often interested in import dependence because it has important implications for a country's national security and its international balance of payments.[5] However, for the reasons just given, import dependence should not be confused with overall dependence. In this article I restrict attention to overall dependence and do not address the issue of import dependence.

As a group, the six countries increased their TPER supplied by oil from 1,270 Mtoe in 1970 to 1,377 Mtoe in 1988, an increase of 8 percent (refer to note 3 for definitions of TPER and Mtoe). The totals are derived from Table 3. Significantly, however, the absolute level of oil requirements in 1988 was down 11 percent from the average 1,540 Mtoe requirement during the peak period of 1978-1980. Further evidence indicating that dependence on oil declined is found in data presented in Tables 4 and 5. Here we see that in 1988 two measures of oil dependence, proportion of TPER supplied by oil and per capita oil requirements, respectively, were well below levels recorded during the high consumption period of the late 1970s.

TABLE 3

Primary energy requirements supplied by petroleum
(Millions of tons of oil equivalent)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	691	184	128	101	94	72
1972	771	219	140	111	114	78
1974	774	244	134	105	118	83
1976	824	232	139	92	116	89
1978	904	255	142	95	117	89
1980	792	235	131	82	111	89
1982	708	208	111	77	93	77
1984	724	214	111	88	86	72
1986	751	207	118	78	86	73
1988	791	226	116	79	86	79

The reduction in dependence on oil by the six countries combined, as compared with the late 1970s, is all the more interesting in the face of the increase in total primary energy requirements by these economies over the same period (see Table 1). Total energy requirements in the six countries combined increased 23 percent between 1970 and 1988 but only 4 percent during the latter half of the period—between 1978-1980 and 1988.

In an examination of the individual country data presented in Table 4, two patterns stand out. First, in each of the six countries, petroleum accounts for a major but declining proportion of total energy requirements. Second, throughout most of the 19 year period, oil accounted for a substantially smaller proportion of TPER in the United States than elsewhere—except Canada and to a lesser extent the U.K. At the same time, however, the decline in oil's proportional contribution to total energy requirements was markedly smaller in the United States than elsewhere.

As shown in Table 4, in 1970 the proportion of total energy requirements supplied by petroleum ranged from a low of 44 percent in the United States to a high of 69 percent in Japan. Eighteen years later the proportion of total energy requirements provided by oil was substantially reduced, ranging from a low of 32 percent in Canada to a high of 57 percent in Japan.

Indeed, the absolute dependence on petroleum, that is, the total amount of oil utilized by the economy, declined for three of the countries between 1970 and 1988: France, Germany, and the U.K. (see Table 3). In all six countries the TPERs supplied by oil were lower in 1988 than during the peak oil-use years of the late 1970s; ranging from down 13 percent for the U.S. to down 37 percent for France.

This reduction in the proportion of TPER supplied by oil and/or the reduction in the absolute contribution of oil to TPER occurred in the face of a continued expansion in overall energy requirements in these economies—with the exception of the United Kingdom, where TPER from all sources remained stable (see Table 1).

During the 1970-1988 period, less than half of U.S. energy requirements (ranging from 48 percent in 1978 down to 41 percent in 1988) were derived from oil, while in Japan well over half (ranging from 73 percent in 1972 to 57 percent in 1988) of energy requirements were supplied by oil (see Table 4).[6]

During much of the 1970s, the proportion of total energy requirements supplied by oil in

TABLE 4

Proportion of total energy met by petroleum
(Percent)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	43.8	68.8	54.1	48.8	60.5	46.9
1972	45.5	73.2	56.2	52.1	66.7	45.7
1974	45.0	72.7	51.8	49.6	65.6	45.0
1976	46.3	70.6	53.0	45.0	64.4	44.6
1978	47.6	73.4	52.4	45.5	61.1	42.3
1980	43.4	66.1	47.9	40.9	56.0	39.9
1982	41.5	61.7	44.3	39.9	49.6	36.1
1984	40.6	58.9	42.5	45.9*	44.3	32.3
1986	41.9	56.2	43.8	37.7	42.1	31.4
1988	41.0	56.6	42.5	38.1	41.2	31.5

*The downward trend was interrupted by increased oil use during a prolonged coal miners' strike in 1984.

TABLE 5

Primary energy requirements supplied by petroleum per capita

(Million of tons of oil equivalent/million population)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	3.4	1.8	2.1	1.8	1.9	3.4
1972	3.7	2.0	2.3	2.0	2.2	3.6
1974	3.6	2.2	2.2	1.9	2.2	3.7
1976	3.8	2.1	2.3	1.6	2.2	3.9
1978	4.1	2.2	2.3	1.7	2.2	3.8
1980	3.5	2.0	2.1	1.5	2.1	3.7
1982	3.1	1.8	1.8	1.4	1.7	3.1
1984	3.1	1.8	1.8	1.6	1.6	2.9
1986	3.1	1.7	1.9	1.4	1.6	2.9
1988	3.2	1.8	1.9	1.4	1.5	3.0

Canada, France, Germany, and the U.K. generally fell within the range circumscribed by the U.S. and Japan. During the late 1980s, however, the relative degree of reliance on oil as an energy source by these countries declined so that their use of oil as a proportion of total energy requirements became nearly equal to or, in some cases, less than that of the United States.

Thus, while the United States compared favorably in oil usage as a proportion of total energy requirements at the outset of the period, its economy did not progress as rapidly toward the replacement of oil with other sources of energy within the overall energy requirements composite as did the others.

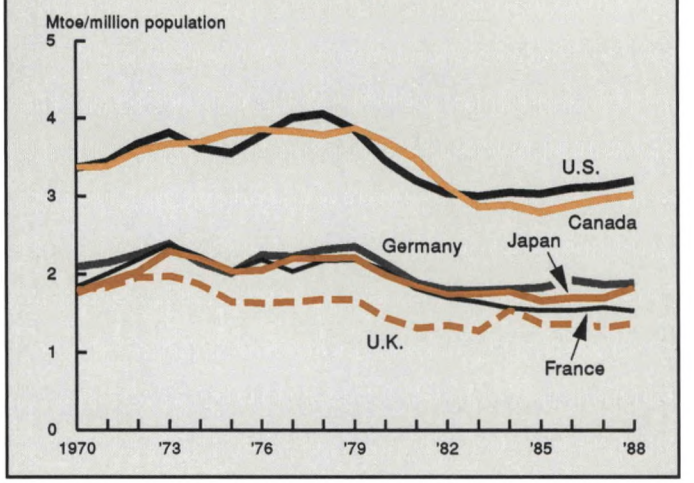
The per capita measure of oil dependence presents a rather different perspective. Per capita oil requirements, as shown in Table 5 and Figure 3, split the six countries into two packs. According to this measure, Canada and the United States appear as high oil dependent economies, as they did for total per capita energy requirements. Per capita oil requirements in the U.S. and Canada in 1988 (3.2 Mtoe/million population and 3.0 Mtoe/MP) were double that of France and the U.K. and were more than 50 percent larger than the per capita measures of 1.8 and 1.9 Mtoe/MP in Japan and Germany.

In sum, the per capita measure of oil dependence gives a somewhat different picture than does the measure of oil requirements as a proportion of total energy requirements. The proportional measure suggests that the dependence on oil relative to all energy sources is comparatively low for Canada, France, and the U.K. The relative oil dependence of the U.S., according to this measure, is in the middle of the six countries, and is especially high for Japan. However, the per capita measure indicates that the U.S. and Canada experience a comparatively high level of dependence on petroleum; substantially lower dependence levels are recorded in the other four countries. As discussed in more detail later, these high dependence levels for the U.S. and Canada are in part linked to their dependence on transportation and the related large geographical size of the countries. There is a common thread through both measures across countries, however. Dependence on oil, especially since the late 1970s, has declined.

The above discussion implies several conclusions for the issue of petroleum dependence. First, the response of the U.S. economy to the oil price shocks in the post 1973 period appears weaker than elsewhere. During the 1970-1973 period the U.S. economy relied proportionately

FIGURE 3

Per capita oil requirements



less on petroleum to meet its total energy needs than did any of the other five countries. In the aggregate, U.S. oil use accounted for 44 percent of U.S. energy requirements, well below an average (weighted by TPER by country) of 52 percent for the other five. By 1988, oil's share of total U.S. energy requirements had declined, but by only 3 percentage points, to 41 percent. The weighted average oil share of total energy requirements for the other five countries declined 8 percentage points, but at 44 percent remained above the U.S. figure, primarily as a result of the influence of Japan's continued heavy relative dependence on oil. However, in an absolute sense, that is, in terms of quantity of energy consumed, the U.S. and Canadian economies are heavily dependent on energy in total and on petroleum in particular. Per capita requirements for these two countries are consistently well above those for the other countries. The reduction in their dependence levels has been substantial, but they have a long way to go to attain levels comparable with the other countries. Indeed, the geographical size and the related dependence on transportation of the U.S. and Canada could effectively set lower limits on their dependence levels that are well above those of the other four countries.

Other energy sources

Apart from petroleum there are two other major hydro-carbon energy categories (coal and natural gas) and two nonhydrocarbon energy categories (nuclear and an agglomeration of hydro-electric-geothermal-solar) that constitute the remainder of primary energy sources for these economies. Given some reasonable adjustment period and favorable relative prices, these energy sources are potential substitutes for petroleum products in numerous industrial and power generation uses. The marginal cost of these other primary energy sources rose less rapidly than for petroleum during the decade following the initial 1973-1974 OPEC oil price shock. (In the U.S. this was partially due to government regulation.) Consequently, it is not surprising that over the period examined there was a relative movement away from oil utilization toward the alternatives. However, within this general pattern, there were substantial differences between countries and between energy forms.

Coal

During much of the 1970-1988 period, coal ranked second to oil as an energy source in the three European countries and Japan. Coal utilization for the six countries in total, like that for oil, increased during 1970-1988 while at the same time coal's relative importance as an energy source declined. However, the aggregated figures mask important individual country diversions from the overall trend.

Total energy requirements derived from coal declined in France, Germany, and the U.K. during the 1970-1988 period. As coal is primarily a power source for the generation of electricity, it is not surprising that the decline in coal energy requirements appears to parallel the increased use in these economies of natural gas and nuclear power. Coal remained an important energy source in Germany and the U.K., accounting for around 30 percent of their total energy requirements in 1988. Along with the absolute decline in coal use in France, Germany, and the U.K., the relative importance of coal as an energy source also declined (see Table 6).

In the U.S., Japan, and Canada, coal use increased progressively during the 1970-1988 period. In Canada, coal was relatively less

TABLE 6

Proportion of total energy met by coal
(Percent)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	18.5	23.0	37.9	42.7	23.9	11.1
1972	17.1	18.3	32.7	33.3	17.3	9.6
1974	18.1	18.4	32.8	32.1	16.5	8.1
1976	19.2	17.2	29.7	34.2	16.7	8.4
1978	18.8	13.4	27.4	32.3	15.8	8.5
1980	20.6	16.8	30.3	34.3	16.6	9.5
1982	21.7	19.1	32.5	33.2	16.0	10.8
1984	23.1	19.1	31.6	24.4*	13.2	11.9
1986	23.2	18.7	28.7	31.9	10.1	10.3
1988	23.5	18.5	27.1	31.7	9.2	11.0

*The sharp drop in share was due primarily to a prolonged coal miners' strike during 1984.

important as an energy source than in the European or Japanese economies. During the 19 year span, coal utilization increased apace with the increase in the economy's total energy requirements. Thus, in Canada, coal maintained a rather stable though comparatively low level share of total energy requirements—ranging between 9 percent and 11 percent of the total.

Coal's role as an energy source in the United States moved counter to the trend elsewhere. Indeed, coal was the only major hydrocarbon-based fuel to record an increased proportional contribution to U.S. energy requirements during the period—increasing from 19 percent to 24 percent of total energy requirements.

On a per capita basis, energy requirements supplied by coal increased during 1970-1988 in Canada and the United States, remained stable in Japan, and declined elsewhere. As an absolute measure, U.S. per capita dependence on coal remains well above that of any of the other countries—1.8 Mtoe/MP as compared with 1.2 Mtoe/MP in Germany, the second largest per capita dependent user of coal.

In sum, by 1988, coal still retained its position as the second largest energy source in Germany, Japan, and the U.K., and became the second largest source of energy for the U.S.

TABLE 7

Proportion of total energy met by natural gas
(Percent)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	31.6	1.1	5.0	4.9	5.3	19.0
1972	30.8	1.2	8.2	11.0	6.8	20.5
1974	29.0	2.0	12.2	14.2	7.9	20.1
1976	25.8	3.0	13.5	16.3	9.4	19.4
1978	24.2	4.5	15.2	17.7	9.9	19.3
1980	26.1	6.1	16.1	20.1	10.9	19.3
1982	25.2	6.7	14.9	21.1	11.3	19.9
1984	23.7	8.9	15.6	22.7	12.1	20.2
1986	21.7	9.6	15.2	23.0	11.9	20.1
1988	22.2	9.4	16.2	22.2	11.4	20.8

Natural gas

With the exception of the United States and Canada, natural gas was a distinctly minor factor in the overall energy package during the early 1970s. This probably was due, in large part, to the lack of known indigenous supplies and the lack of adequate transport facilities. As shown in Table 7, prior to the oil crisis of 1973-1974, natural gas accounted for 30 percent and 20 percent of total energy requirements in the U.S. and Canada, respectively.

Elsewhere, the natural gas contribution to total energy requirements of the respective economies ranged from 1 percent in Japan to 5 percent in France and Germany. Increases in the importance of natural gas-derived energy from the mid-1970s to mid-1980s were substantial, in total volume as well as proportional terms. This was possible because supplies were made more plentiful in Europe by the opening of natural gas pipelines from the U.S.S.R. and the development of economically viable ocean going natural gas tankers during the 1970s. During the same period, natural gas use doubled in Canada, approximately keeping pace with total energy requirements. As a result, only marginal gains in the relative contribution of natural gas to total energy requirements occurred in Canada. In the U.S., natural gas use declined between 1970 and 1988, with a consequent sharp drop in the relative contribution of this energy form to total energy requirements.

Per capita dependence on natural gas increased in all countries but the U.S., where it declined by 33 percent between 1970 and 1988. Still, by comparison, the U.S. was highly dependent on natural gas. Only in 1984 did Canada surpass the U.S. as a country more per capita dependent on natural gas. In 1988, Canada's dependence level on natural gas stood at 2 Mtoe/MP. The United States followed with a dependence level of 1.7 Mtoe/MP. Of the six countries, Japan recorded the lowest dependence level with per capita requirements of 0.3 Mtoe.

Nuclear power

Nuclear energy is the only primary energy source to record a common pattern across countries over the time frame examined. Table 8 shows the proportion of total energy requirements met by nuclear energy. In each country, nuclear power recorded multiple gains during the 1970-1988 period, in terms of its total energy equivalents as well as in its proportion of total energy requirements.

TABLE 8

Proportion of total energy met by nuclear energy
(Percent)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	0.3	0.4	0.6	2.8	0.8	0.1
1972	0.8	0.8	0.8	3.1	1.9	0.9
1974	1.6	1.4	1.1	3.5	1.8	1.8
1976	2.5	2.5	2.1	3.9	2.0	2.0
1978	3.4	4.2	3.0	4.0	3.6	3.3
1980	3.3	5.7	3.6	4.1	6.9	3.8
1982	3.9	7.4	5.6	5.1	13.0	4.0
1984	4.4	9.0	7.9	6.3	21.9	5.2
1986	5.5	10.2	9.9	6.4	27.8	6.8
1988	6.5	10.0	11.8	6.8	29.5	7.4

The most dramatic of the increases was in France, where the nuclear power contribution to total energy requirements rose from less than 1 percent in 1970 to 30 percent in 1988. The gain in the nuclear share of total energy requirements in the other countries was less dramatic but nonetheless substantial. Except for the U.K., where nuclear power accounted for nearly 3 percent of total energy requirements in 1970, nuclear power generally accounted for less than 1 percent of total energy requirements in 1970. Apart from France, by 1988 nuclear power's contribution to total energy requirements ranged from less than 7 percent in the U.S. to 12 percent in Germany.

On a per capita basis, France also appears to be relatively dependent on nuclear energy. In 1988 it recorded the highest per capita dependence on nuclear power, at 1.1 Mtoe/MP. Canada, at 0.7 Mtoe/MP, and Germany, at 0.5 Mtoe/MP ranked well behind France in both per capita and relative dependence. The U.S., the U.K., and Japan round out the list in terms of their dependence on nuclear power.

Hydroelectric-geothermal-solar (H-G-S) power

The proportion of energy requirements met by H-G-S power is shown for each country in Table 9. A country's utilization of H-G-S energy is more heavily dependent on the natural resource base of the country than are the other energy forms. Within this category, hydroelectric energy was among the earliest energy forms harnessed. Despite new technologies utilized to extract geothermal and solar power, these energy sources have not yet made a widespread impact. For example, as of 1988, geothermal power is estimated to have accounted for less than 3 percent of U.S. total energy requirements.[7]

As shown in Table 9, of the six countries examined, only two—Canada and France—recorded appreciable gains in the absolute level of energy derived from H-G-S. Only Canada, which in fact relies heavily on hydroelectric power, recorded an appreciable increase in the share of its total primary energy supplied by this source—from 23 percent of the total in 1970 to 27 percent in 1988.

Canada's per capita dependence on H-G-S totaled 2.6 Mtoe/MP in 1988, 27 percent of its total energy requirements. Per capita dependence on H-G-S energy by the other countries was well below that of Canada. France ranked second with a dependence level of 0.3 Mtoe/MP, about 9 percent of its total energy requirements. Dependence levels for the remaining four countries were at 0.2 Mtoe/MP or lower. However, in Japan H-G-S energy accounted for about 6 percent of total energy.

TABLE 9

Proportion of total energy met by hydroelectric-geothermal-solar energy
(Percent)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	3.6	7.3	1.7	0.6	8.2	23.0
1972	3.7	7.2	1.2	0.5	6.5	23.7
1974	4.0	6.2	1.5	0.5	7.1	25.6
1976	3.6	6.6	1.2	0.6	6.1	23.9
1978	3.4	5.3	1.5	0.6	8.1	25.0
1980	3.5	6.4	1.5	0.6	8.0	25.1
1982	4.2	6.2	1.7	0.7	8.6	27.1
1984	4.2	5.3	1.6	0.7	7.8	28.6
1986	3.8	5.3	1.5	0.8	7.2	29.8
1988	2.7	5.4	1.7	0.7	8.4	27.4

In summary, energy consumption and energy dependence vary widely across countries and by source of energy. Among the major industrial countries, the U.S., along with Canada, recorded levels of dependence on total energy that are comparatively high, as measured by per capita requirements. U.S. per capita requirements are on the order of twice those in Western Europe and Japan. At the same time, however, the rate of growth in U.S. per capita energy requirements was generally lower than elsewhere.

Dependence on oil in per capita terms for the U.S. and Canada also stands out. In Mtoe per million population, the U.S. and Canada's oil dependence are considerably higher than the next most dependent country, Germany. To some degree this is likely due to the large geographical area of these two countries and the importance transportation plays in their respective economic activity (this issue is discussed in more detail below). It is interesting to note that Japan, an economy that recorded the lowest per capita dependence on total energy of the six countries, was the only economy of the six that in 1988 recorded a per capita dependence on oil equal to 1970 levels (still only 1.8 Mtoe/MP) although by this measure its oil dependence had declined from the higher levels in the late 1970s.

Only Canada and France moved significantly away from hydrocarbon energy forms during the period examined. Both developed a strong reliance on nuclear and H-G-S energy forms while the other four countries remained heavily dependent on the various forms of hydrocarbon energy.

Energy efficiency

Energy is a ubiquitous factor-input in any industrial/consumption oriented economy. An understanding of how well or how efficiently energy is utilized in the output of any economy is a key variable in examining the energy environment. Efficiency in the utilization of energy inputs, and differentials in energy efficiency across countries, may explain in part why one economy is more dependent on energy, or on certain forms of energy, than is another economy. It should also be expected to be a significant factor contributing to the overall and relative productivity of the economies.

The concept of efficiency is based on the relationship between the physical inputs in production and the resulting level of physical product. Measures of energy-use efficiency are easily enough derived where there are well defined inputs and outputs. Unfortunately, the physical product (output) of an economy is not so neatly defined. The closest such output measure is in the form of gross national product (GNP) or gross domestic product (GDP) adjusted for inflation to give real GNP:GDP.[8] Thus, given measures of aggregate energy inputs (total primary energy requirements) and economic output (real GDP) a technical efficiency measure can be defined as:

$$(1)\quad E_{i,t} = GDP_{i,t} / TPER_{i,t};$$

where $E_{i,t}$ is the technical efficiency level for country i, at time t; $GDP_{i,t}$ is gross domestic product valued in billions of home currency at constant prices for country i, at time t; and TPER is total primary energy requirements in millions of ton oil equivalents (Mtoe) for country i at time t.

Technical efficiency is adequate for a within-country measure of "home country" efficiency, but is clearly meaningless for analysis of relative changes in cross-country efficiency or in an analysis of relative levels of efficiency across countries. One problem is that cross-country currency exchange value is not taken into account in measures of technical efficiency. For example, the $2.3 billion per million tons oil equivalent (Mtoe) technical energy efficiency for the U.S. in 1988 cannot be meaningfully compared with the DM7.2 billion/Mtoe level for Germany. Energy efficiency, in particular, output, must be measured in common units in order to compare countries. However, finding a common base to use in computing energy efficiency measures raises a new set of problems.

This article examines four efficiency measures, the results of which are described below.

Technical efficiency level (TEL), or home country efficiency, as described above, is a measure of the relationship between an economy's output (in price adjusted GDP, valued in terms of the home country currency) relative to the economy's energy input (all energy forms are converted to oil equivalents).

The *technical efficiency ratio (TER)* removes the units of measure (that is, value of home country GDP per quantity of oil equiva-

lents used) from the technical efficiency level measure, and thus allows cross-country comparisons in terms of rates of change from some common base period. This ratio is derived from the index of a country's GDP divided by the index of its energy inputs. The base period is defined in the home country GDP index and the energy inputs index. Except where otherwise noted these indexes are set equal to 100 for the period 1970-1972. This measure suffers from the standard problems associated with indexes. In particular it is devoid of information about the level of efficiency (that is, the value of GDP output relative to the quantity of energy input) across countries. Further, it depends critically upon the countries' relative energy efficiency positions in the base year. The ratio reflects comparative developments in energy efficiency across countries as compared to their relative positions as of the base period. However, despite its shortcomings, this measure arguably provides the most meaningful basis for cross-country comparisons of energy efficiency.

Observed energy efficiency is obtained by converting TEL to a U.S. dollar base using annual average market exchange rates. I refer to this efficiency measure as "observed" because it is based on an observed exchange rate. The observed rate is the market exchange rate that is typically, though not necessarily appropriately, used to convert various countries' outputs to a common currency base as a means to facilitate cross-country comparisons.

Purchasing power parity (PPP) energy efficiency is calculated by converting the TEL to a U.S. dollar base using PPP exchange rate-based estimates of GDP. Because PPP rates are based on the relative real purchasing power of currency units, a relationship that changes slowly, period-to-period movement in PPP exchange rates is far more constrained than that of market exchange rates. Consequently, PPP energy efficiency should be less volatile than that for observed energy efficiency.

The last two measures of energy efficiency represent an attempt to express levels of energy efficiency across countries. Such measures would be useful, for example, in the analysis of cross-country productivity. This article presents efficiency measures based on these formulations but the severity of the limitations inherent in such measures merits more than cursory examination. To that issue I now turn.

One of the problems with the observed efficiency measure is that the wide fluctuation in exchange rates during the past 20 years has exerted a profound influence on the measure of efficiency, an influence that does not reflect changes in the relative output or the relative welfare across the economies. For example, during the period examined, the annual average for the German mark/U.S. dollar exchange rate ranged from 3.65 DM/$ in 1970 to 1.76 DM/$ in 1988. During 1988, the DM/$ exchange rate ranged from a low of 1.57 DM/$ to a high of 1.90 DM/$. If no change whatsoever had occurred in relative technical efficiency between the U.S. and Germany, the change in exchange rates would have implied a reduction in the level of U.S. observed energy efficiency by more than 70 percent between 1970 and 1988. Prima facie, this is not a plausible conclusion. A decrease in the energy efficiency level of that magnitude implies a concurrent deterioration in U.S. welfare relative to Germany. There is no evidence that such a shift in relative welfare occurred.

Another possible approach is to use an exchange rate that provides a ratio of exchange between two currencies such that a specified value of either currency would purchase the same bundle of goods in either country. Economists refer to this construction as the purchasing power parity (PPP) exchange rate.

The OECD estimates that in 1988 the GDP purchasing power parity exchange rate between the German mark and the U.S. dollar was equivalent to 2.44 DM/$, as compared with the annual average DM1.76/$ market rate. From an economic perspective, a PPP exchange rate would appear to be the theoretically correct rate to use when converting economic output measures of foreign countries to common dollar base. Economists agree that market rate deviations from PPP should be expected because PPP is a long-run concept, while the market rate is short-term. Still, the last time the DM/$ exchange rate approached 2.44 DM/$ was in January 1986, when the rapidly depreciating dollar "passed through" on its way down from the exchange rate highs reached during the first quarter of 1985.

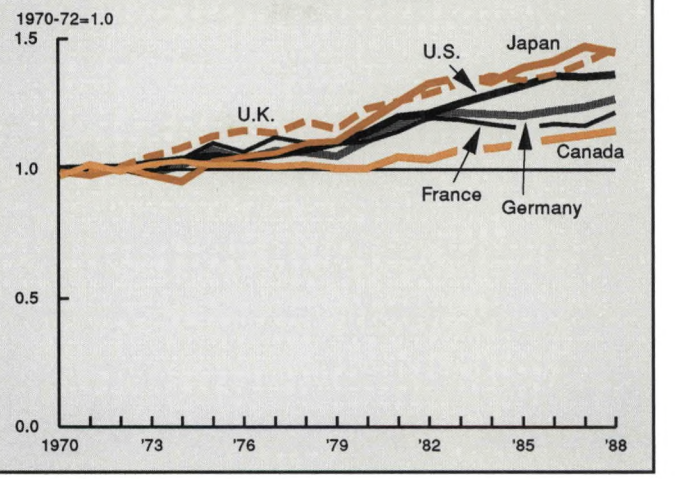
While it may be argued that the PPP rate is the theoretically correct rate over the long term, the market rate has seldom been even remotely in line with PPP rates. Market decisions are not

based on PPP based exchange rates. A firm's management does not look at the international competitive ability of its firm in terms of PPP exchange rates. It seems a reasonable question then whether efficiency measures based on PPP conversions are any more economically meaningful than observed efficiency.[9]

Clearly, if levels of energy efficiency are a vital consideration, the analyst is faced with an unpleasant choice of tools. As will be seen shortly, over the last decade, market exchange rate movements have overwhelmed technical efficiency changes. While some discussion of efficiency levels follows it is emphasized that it is not the intent of this paper to focus undue attention on such measures. Their inclusion is intended primarily to be illustrative of the difficulty in developing an economically meaningful measure of petroleum efficiency levels.

FIGURE 4

Technical efficiency ratios



Results

As shown in Table 10 and Figure 4, technical efficiency improved substantially in each of the six countries during the 1970-1988 period. Not surprisingly, most of the improvement occurred during the 1980s as changes in economic structures, prompted by the 1973-1974 and 1979-1980 oil price shocks, filtered through the economies. By 1988, technical efficiency gains in the six countries ranged from a low of 14 percent in Canada, relative to its 1970-1972 average, to a high of 39 percent in the U.K. Performance of the U.S. economy compared favorably with respect to the remaining countries; its technical efficiency ratio rose 31 percent from its 1970-1972 average—a more rapid gain than in France and Germany but slower than in Japan.

Table 10 shows that observed efficiency varied broadly across countries and illustrates the dramatic influence of movements in exchange rates. As can be seen in Figure 5, the impact of the dollar appreciation during the 1980-1985 period and the subsequent depreciation during 1985-1987 is clearly outlined in the data. Canada is the exception, where exchange rate movements were less pronounced.

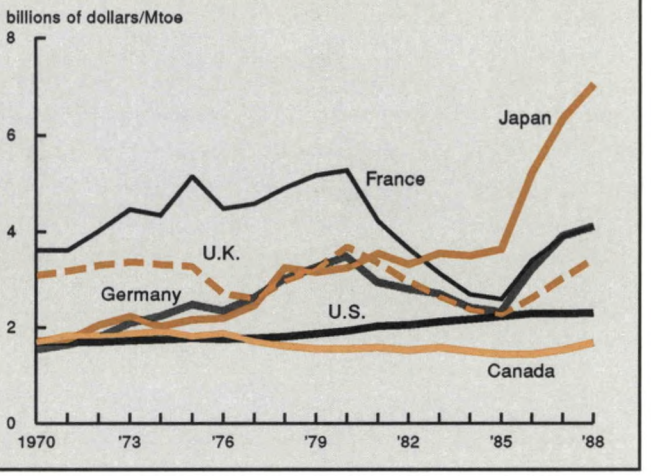
TABLE 10

Change in energy efficiency
(Efficiency levels in billions of dollar/Mtoe)

	U.S.	Japan	Germany	U.K.	France	Canada
Technical efficiency						
Percent change (1970 to 1988)	31	38	24	39	20	14
Observed efficiency						
1970 (level)	1.70	1.73	1.54	3.10	3.61	1.71
1988 (level)	2.31	7.05	4.13	3.43	4.11	1.71
percent change	31	141	99	10	13	0
PPP efficiency						
1970 (level)	1.70	2.42	1.71	4.53	4.21	1.67
1988 (level)	2.31	4.35	2.97	3.18	3.27	1.67
percent change	31	59	55	-35	-25	0

FIGURE 5

Observed energy efficiency levels

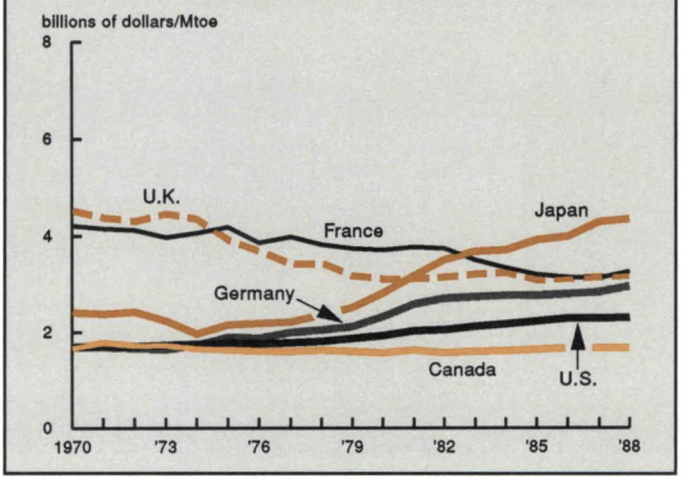


Observed efficiency levels in four of the countries (Canada, Germany, Japan, and the U.S.) began the period in relatively close proximity—$1.5 to $1.75 billion GDP/Mtoe. On the other hand, the French and the U.K. economies recorded substantially higher observed efficiency levels in 1970; $3-$3.5 billion GDP/Mtoe. By 1988, observed efficiency levels for the six countries diverged broadly, ranging from $1.7 billion/Mtoe for Canada and $2.3 billion/Mtoe for the U.S. to $7.1 billion/Mtoe for Japan.

As expected, PPP efficiency levels show change over time that is considerably less dramatic than the fluctuations recorded in the observed efficiency measure (see Figure 6 and Table 10).[10] The level of energy efficiency for the U.S. remained well below that of the other countries (except Canada) during most of the period. The rate of gain in U.S. energy efficiency based on PPP compares favorably with Canada, France, and the U.K. and lagged behind that of Germany and Japan, though not so severely as when the common valuation measure of output was based on the prevailing exchange rates. Indeed, the most dramatic development coming out of the PPP based data is the deterioration in energy efficiency levels in France and the U.K.

FIGURE 6

PPP energy efficiency levels



Energy efficiency by economic sector

Here to fore the discussion has focused on energy utilization by whole economies. Different sectors of an economy might be expected to be more or less dependent on energy and more or less efficient in their use of energy. Large efficiency gains in certain sectors might be expected to positively influence the competitiveness of those sectors relative to other sectors, or relative to similar sectors in other countries. The limited data available suggest, not surprisingly, that efficiency differentials exist across sectors of an economy as well as across countries.

This article focuses upon two different types of comparison. First, it looks at two broad economic sectors defined as "industrial" and "nonindustrial." The second comparison examines a sector classification defined by "all transportation" and "nontransportation."

The industrial/nonindustrial sector analysis examines three countries—Germany, Japan, and the United States—for the period 1974-1988. The industrial sector includes a broad aggregation of manufacturing, construction, and mining and quarrying. The nonindustrial sector includes all other sectors of the economy. This particular sector and country breakdown is used to facilitate the construction of efficiency

measures, as GDP (output) and energy consumption (input) data are available by these aggregate economic sectors.

Efficiency measures are calculated as the ratio of the dollar value of gross domestic product generated by industrial and nonindustrial sectors to total energy consumption by these two sectors. As in the earlier discussion, comparisons are based on measures of technical efficiency levels (TELs) and dollar output measures using prevailing exchange rates and PPP exchange rates, which yield measures of observed energy efficiency and PPP energy efficiency, respectively.

Within countries, GDP output by sector, valued in the home currency relative to units of energy consumed by the sector, indicate an interesting diversity in efficiency trends. It was expected that TELs (the technical efficiency level) would be higher in the industrial sector than in the nonindustrial sector. This pattern did indeed emerge, but did not hold universally.

In the United States the nonindustrial sector recorded a TEL of $1.8 billion/Mtoe, slightly higher but probably not significantly different from the $1.7 billion/Mtoe recorded for the industrial sector. By 1987, the TELs for both sectors were identical at $2.5 billion/Mtoe.

In Germany, the industrial sector began the period with a TEL of DM6.0 billion/Mtoe, well below the DM7.3 billion/Mtoe for the nonindustrial sector. However, rapid efficiency gains in industry during the late 1970s and early 1980s pushed Germany's industrial TEL to DM9.2 billion/Mtoe, substantially higher than the DM7.8 billion/Mtoe TEL for the nonindustrial sector.

Among the most interesting developments were the relative sector levels and changes in technical efficiency derived from the Japanese data. In 1974, industry's TEL stood at Y493 billion/Mtoe, far lower than the nonindustrial Y1,106 billion/Mtoe. By 1987, nonindustrial TEL still remained above that of industry, but industry's dramatic increase in energy efficiency brought its TEL to Y1,092 billion/Mtoe compared with Y1,266 billion/Mtoe for the nonindustrial sector.

One result which met the expectation of higher industrial TELs in each of the three economies was the more rapid rates of gain in energy efficiency in the industrial sector as compared with the nonindustrial sector. The most rapid TEL gains in industry occurred in Japan, up 80 percent, and Germany, up 42 percent, as compared with a gain of 36 percent for U.S. industry. Higher energy costs could be expected to stimulate increased efficiency in that sector, relative to the nonindustrial sector. The industrial sectors in Japan and Germany account for a somewhat larger proportion of GDP, 42 and 36 percent respectively, in 1974 as well as in 1987, than in the United States where industry's proportion dropped from 33 percent in 1974 to 30 percent in 1987. It remains puzzling, however, as to why the industrial TELs in Germany and especially Japan compared poorly with nonindustrial TELs in the early 1970s.

Another interesting development is most easily seen in a graph of the technical efficiency ratio (TER). Recall that this ratio is the index of the home country GDP divided by the index of energy input. In this case the base period is 1974, the first year of the data set. TERs for the industrial and nonindustrial sectors in the U.S., Japan, and Germany for the period 1974-1988 are shown in Figures 7 and 8. Figure 7 shows that in the nonindustrial sector the U.S. performed relatively better than the economies of either Japan or Germany. U.S. technical efficiency in this sector rose 31 per-

FIGURE 7

Technical efficiency ratios (nonindustrial sector)

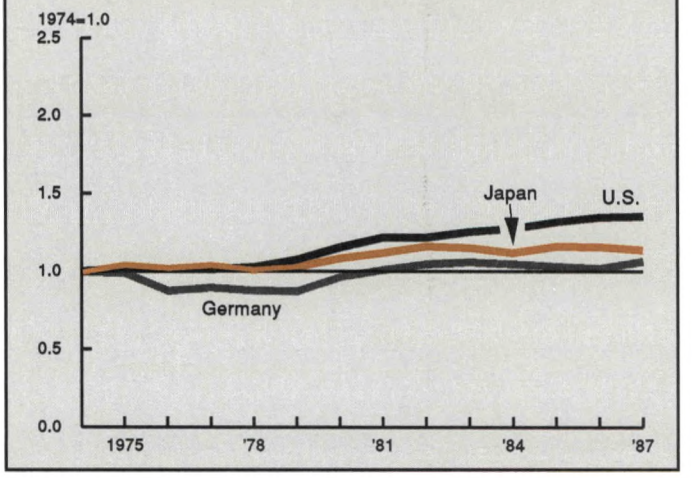
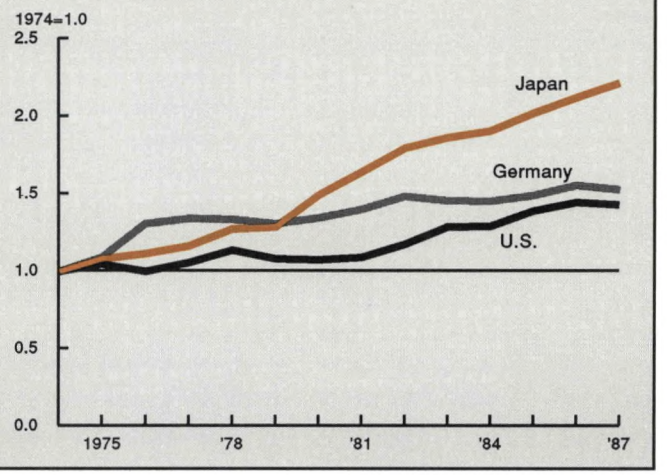


FIGURE 8

Technical efficiency ratios (industrial sector)



cent between 1974 and 1987 while nonindustrial energy efficiency in Japan and Germany rose 13 percent and 7 percent, respectively.

As shown in Figure 8, the TERs for the industrial sector indicates that in this case the U.S. did not fair so well relative to gains in Japan and Germany. The TER for U.S. industry rose 35 percent compared with 31 percent for the nonindustrial sector. The ratio's gain in Germany was somewhat greater (42 percent) and in Japan substantially greater (80 percent). The United States' overall TER, buoyed up by gains in the nonindustrial sector, showed a gain (up 32 percent) about midway between Japan (47 percent) and Germany (19 percent).

Measures of observed and PPP efficiency levels for the industrial and nonindustrial sectors were subject to the same dominating influences of exchange rate movements noted earlier. Throughout, the PPP based and observed efficiency levels for industrial and for nonindustrial sectors in Japan and Germany were well above efficiency levels in the United States, indicating prima facie that the U.S. lost ground in energy efficiency in the industrial sector as well as in the nonindustrial sector. However, two-thirds of the gain in observed energy efficiency in Japan's industrial category and nine-tenths of the gain in its nonindustrial category, for example, were due to changes in market exchange rates. Exchange rate movements had a similar effect on Germany's observed efficiency measures for industrial and nonindustrial sectors. Once again, exchange rate movements dominate the data.

As noted earlier, a country's physical size and the dispersion of its population may affect energy efficiency. In particular, one would expect a country with a comparatively high level of economic activity in a small geographic area to have a comparatively high level of energy efficiency, due to lower energy expended on transportation. That is, countries with greater population densities should be more energy efficient, other things being equal. As shown in Table 11, the U.S. and Canada have substantially smaller population density per square mile than the other countries in the sample. This may explain in part why the U.S. and Canada fair relatively poorly on energy efficiency measures compared to the other countries. In order to investigate this hypothesis, we examine the development of energy efficiency

TABLE 11

Selected demographic characteristics
(1988)

	U.S.	Japan	Germany	U.K.	France	Canada
Geographic area, (000) sq. mi.	3,615.1	144.0	96.0	94.2	212.8	3,851.8
Population, millions	246.3	122.6	61.4	57.1	55.9	26.0
Population density per sq. mi.	68.1	851.5	639.5	606.0	262.5	6.7

in the transportation vs. nontransportation sectors over the 1970-1988 period.

Two formulations of the data are examined: Both are modifications of previously discussed measures—technical efficiency and the per capita utilization measure used above in the energy dependence section. This analysis relies on OECD data that facilitate a breakdown of energy consumption by source of energy into total transportation and nontransportation sectors.[11] Because transportation relies primarily on oil, rather than all energy, oil is used as the energy source measure. The reader should be aware that the data limitations cited in note 11 mean that the technical efficiency measures constructed here are not comparable with those constructed in earlier sections of the paper.

The TERs for the transportation/nontransportation sectors shown in Figures 9 and 10 and Tables 12 and 13, respectively, suggest some interesting relationships. First, gains in oil efficiency in the transportation sector were well below those for nontransportation. This is not surprising because the opportunity for the substitution of alternative energy sources is greater for nontransportation than for transportation. Figure 9 also indicates that these ratios tended to remain closely bundled until the 1979-1980 oil price shock, after which the ratios for the U.S., Canada, and to a lesser degree Japan, broke from the pack.

A somewhat surprising result was that three of the six countries (France, Germany, and the U.K.) recorded TERs for transportation that declined and one country (Japan) recorded a transportation efficiency ratio that increased only modestly. During the 1970-1988 period, percentage changes in the transportation TERs ranged from a decline of 13 percent for Germany to an increase of 27 percent for Canada. The gain in the U.S. TER was 20 percent.

FIGURE 9

Technical efficiency ratios (transportation sector)

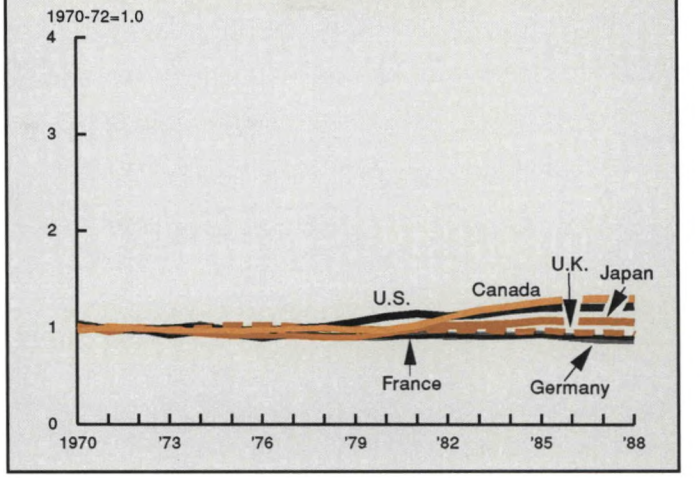
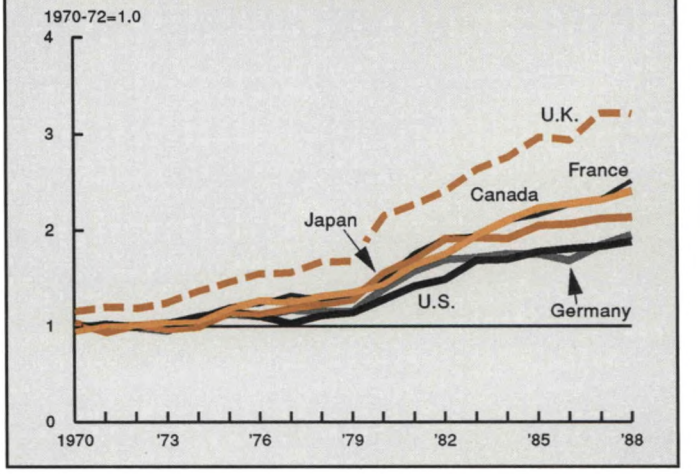


FIGURE 10

Technical efficiency ratios (nontransportation sector)



In those countries where gains were recorded the data suggest that it took the transportation sector some time to adjust to the initial shock of higher oil prices in 1973-1974 and the subsequent shock in 1979-1980. The major gains occurred post-1980.

The pattern of change in the TERs for the nontransportation sector was markedly different from that of the transportation sector (see Figure 10). All six of the countries recorded substantial gains in oil efficiency in nontransportation—gains ranged from 64 percent in the U.S. to 117 percent in the U.K. One might expect that the heterogeneous nature of this sector, with its greater diversity of potential energy

TABLE 12

Technical energy efficiency ratio for the transportation sector
(1970-1972 average=1)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	1.02	1.03	1.04	1.02	1.04	0.98
1972	0.99	1.00	0.98	0.98	0.97	1.00
1974	1.01	0.95	1.02	1.02	0.95	0.98
1976	0.97	0.92	0.99	1.03	0.88	0.99
1978	1.01	0.91	0.91	1.00	0.90	1.01
1980	1.12	0.94	0.92	0.97	0.91	0.98
1982	1.12	1.02	0.92	0.98	0.92	1.11
1984	1.18	1.04	0.92	0.96	0.91	1.22
1986	1.21	1.07	0.91	0.95	0.91	1.30
1988	1.22	1.06	0.88	0.93	0.89	1.30

TABLE 13

Technical energy efficiency ratio for the nontransportation sector
(1970-1972 average=1)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	0.98	1.04	1.01	1.17	1.01	0.96
1972	1.00	1.02	0.99	1.20	0.99	1.02
1974	1.11	1.00	1.08	1.37	1.11	1.06
1976	1.11	1.13	1.11	1.56	1.24	1.28
1978	1.12	1.24	1.16	1.68	1.29	1.32
1980	1.28	1.56	1.39	2.16	1.48	1.45
1982	1.49	1.92	1.70	2.42	1.92	1.77
1984	1.70	1.92	1.76	2.76	2.10	2.11
1986	1.81	2.07	1.70	2.94	2.27	2.28
1988	1.89	2.14	1.96	3.22	2.51	2.42

sources and substitutability, contributed to the progressive improvement in the efficiency ratio throughout the period.

The second approach to examining the geographical size/transportation issue looks directly at the geographical size component of the economies. The per capita consumption measures used in the energy dependence discussion earlier is modified to incorporate country size. The modification is accomplished by constructing a standard population density series for each country across the 1970-1988 period. This results in two series per country—oil consumption relative to density for the transportation sector and oil consumption relative to density for the nontransportation sector.

The data indicate that low population density does appear to go hand-in-hand with high oil consumption. Both the U.S. and Canada recorded much higher consumption to density figures than did the other countries (see Tables 14 and 15) These data also indicate that oil consumption in transportation, relative to population density, increased through out the period in France, Germany, Japan, and the U.K. On the other hand, the U.S. and Canada recorded declines in consumption relative to density in transportation from the late 1970s, although the data showed an up-tick in 1988.

In the nontransportation sector the geographical size of the U.S. and Canada also appear to dominate the data. The data for the U.S. does indicate a decline in oil consumption relative to population density, albeit from comparatively high levels. The U.K. and France also recorded reductions in oil consumption relative to population density.

In short, it would appear that geographic size does influence an economy's level of oil use efficiency in the transportation sector, and also in the nontransportation sector.

Conclusion

Dependence on energy is a fact of life for the world's economies. How dependent and on what energy forms that dependence relies is not universally alike. On the contrary, there appear to be substantial differences across countries in their level of aggregate dependence, the form of that dependence, and how they have responded to changes in the energy environment following the 1973-1974 oil shock.

While oil continues to dominate the energy picture in each of the six countries, each of the countries has reduced its relative dependence on oil, at least from those periods of highest dependence in the late 1970s. But it is also the case that the alternative energy sources toward which

TABLE 14

Oil consumption by transportation sector relative to population density

(Millions of tons of oil equivalent/population density)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	6.11	0.05	0.05	0.05	0.09	5.25
1972	6.65	0.05	0.05	0.05	0.10	5.68
1974	6.67	0.05	0.05	0.05	0.11	6.28
1976	7.06	0.06	0.05	0.05	0.12	6.47
1978	7.34	0.06	0.06	0.06	0.13	6.57
1980	6.34	0.07	0.07	0.06	0.13	6.90
1982	6.44	0.07	0.06	0.06	0.13	5.87
1984	6.62	0.07	0.07	0.06	0.14	5.77
1986	6.73	0.07	0.07	0.07	0.14	5.77
1988	7.07	0.08	0.08	0.07	0.15	6.21

TABLE 15

Oil consumption by nontransportation sector relative to population density

(Millions of tons of oil equivalent/population density)

Year	U.S.	Japan	Germany	U.K.	France	Canada
1970	15.25	0.23	0.23	0.20	0.43	14.54
1972	15.54	0.25	0.24	0.20	0.45	15.54
1974	15.02	0.27	0.24	0.20	0.45	16.63
1976	14.79	0.26	0.25	0.19	0.42	16.96
1978	15.03	0.25	0.25	0.19	0.45	17.39
1980	14.30	0.24	0.25	0.17	0.44	17.56
1982	12.71	0.22	0.22	0.17	0.39	16.18
1984	13.03	0.24	0.23	0.16	0.40	16.60
1986	12.40	0.23	0.24	0.17	0.39	16.69
1988	13.18	0.25	0.23	0.17	0.38	17.42

these economies have shifted tend to be hydrocarbon fuels, specifically coal and natural gas. The U.S. increased its relative dependence on coal. Germany, Japan, the U.K., and to a lesser degree France, increased their relative dependence on natural gas. Indeed, as of 1988, hydrocarbon fuels continued to provide 85 percent to as much as 92 percent of total fuel requirements in Japan, Germany, the U.S. and the U.K. (in 1970, hydrocarbons provided well over 90 percent of fuel requirements in each of these countries).

Only in France and Canada do nonhydrocarbon fuels constitute a conspicuous portion of their economies' energy sources. In 1988, for example, nuclear and H-G-S energy provide 38 and 35 percent, respectively, of France's and Canada's energy requirements. France in particular has moved well away from dependence on hydrocarbon fuels toward nuclear power during the period examined. Not only did it maintain a comparatively low per capita total energy requirement but it also maintained a comparatively low reliance on oil and hydrocarbon fuels in general. In relative terms, Canada moved well away from hydrocarbon fuels as a general category, but because of its high per capita total energy requirements, the highest of the six countries, its dependence on oil remained high.

An economy's reliance on energy depends on numerous factors. Central to how an economy responds to shocks in prices or the availability of its energy resources is how efficient the economy is in energy utilization. Standard technical efficiency measures indicate that each of the six economies have recorded substantial overall gains in technical efficiency. In the U.K. the efficiency ratio for GDP-to-energy input stood 39 percent higher in 1988 than in 1970. In the U.S., which ranked third in overall efficiency gains behind Japan, technical efficiency was up 31 percent.

As one would expect, these gains are not uniform across sectors within an economy and the pattern of gains across sectors varies considerably between countries. Gains in technical energy efficiency in U.S. industry were only modestly greater (up 35 percent between 1974 and 1987) than for the nonindustrial sector (up 31 percent). In Japan and Germany, technical energy efficiency gains in industry were dramatically larger (up 80 percent and 42 percent, respectively) than in the nonindustrial sector (up 13 percent and 7 percent, respectively). This differential in technical efficiency gains could be expected to be a factor in maintaining or enhancing international competitiveness by

reducing energy input costs, thus possibly helping to offset the adverse competitive implications, for Germany and Japan, of the dollar's depreciation in foreign exchange markets.

Several points stand out from this examination of energy dependence and efficiency: The major industrial economies continue to be heavily dependent on oil and other hydrocarbon fuels. Among those countries, Canada and France have made substantial strides in shifting their dependence to nonhydrocarbon fuels. In the aggregate, energy is more efficiently utilized than it was prior to the 1973-1974 oil shock. The gains in energy efficiency in the U.S. have been spread rather evenly across the industrial and nonindustrial sectors of the economy. The efficiency gains in Japan and Germany were primarily in the industrial sectors of the two economies.

Much work remains to be done concerning the issues of energy dependence and efficiency. Because of the problems noted above concerning the measurement of efficiency levels in cross-country analysis, there is need for further work concerning the measurement of efficiency, as well as further study of the impact of geographical size on energy utilization and the impact of prices, environmental concerns, and government polices on energy use and efficiency.

FOOTNOTES

[1]Currently, the Congress is considering an omnibus energy production and conservation bill, the major focus of which is to promote increased domestic oil production (and reduced dependence on foreign oil) by relaxing drilling restrictions in Alaska and in offshore areas. Also under consideration are measures to decrease oil consumption through administrative auto mileage requirements and another token increase in the gasoline tax of 5 cents per gallon.

[2]One might assert that this fragility is also due to an apparent lack of appreciation by policy makers of their economies' dependence on energy, especially petroleum, for continued economic viability. This is exemplified by a lack of will in some countries, especially the U.S., to apply significant economic disincentives (e.g., gasoline taxes) to the consumption of energy and oil. The preference instead is for administrative distortions to the market place.

[3]Measures of energy utilization used in this study draw on the Organization for Economic Cooperation and Development (OECD) definition of domestic "Total Primary Energy Requirement" (TPER) and "Total Final Consumption" (TFC). Where a common energy unit is required in the analysis the OECD's common energy unit, "tons of oil equivalent," usually measured in millions (Mtoe) is used.

During any given period, TPER is defined as the sum of a country's internal production of all energy resources, plus imports, less exports, less international marine bunkers, plus or minus inventory changes of these resources. This measure differs from TFC primarily in that TPER includes energy used in the transformation process, e.g., coal to electricity, and distribution losses as in the transmission of electricity. Energy forms also differ between TPER and TFC. Nuclear or solar energy contribute toward fulfilling a country's energy requirements, TPER, but are not used directly in consumption, TFC. Nuclear or solar energy is consumed in the form of electrical energy, and thus does not appear directly in energy consumption.

The OECD defines a "ton of oil equivalent," where ton refers to a metric ton (2,204.6 U.S. pounds), as equal to 10^7 kcal. of energy. All energy forms, be they petroleum, nuclear power used to generate electricity, or electricity consumption itself are converted to the common unit "t.o.e." In this article units will be reported in millions of ton oil equivalent (Mtoe).

[4]Percentage changes throughout the article are reported on a logarithmic basis.

[5]Import dependence has implications for a country's international balance-of-payments. The larger the oil import requirement needed to sustain the economy, the greater the real resources required to finance the importation of oil. Other things remaining the same, a lower standard of living results for the oil importing country than if the oil could be sourced at equal cost domestically.

Import dependence is also a concern for national security. The greater a country's dependence on imported oil the less independent it is from the political or economic whims of its foreign oil suppliers. It is clear that in the current political/economic environment, energy and petroleum security is vital. From a near-term perspective, it may be undesirable to be dependent on the political or economic whims of foreign oil producers, however, one must also be aware of longer-term security issues.

Arguably, a nation's energy sources would be more secure the less its dependence on foreign supplies. During 1989-1990, 40-45 percent of U.S. petroleum consumption was derived from foreign sources. On the other hand, in an environment of limited and relatively high cost domestic supplies and relatively inexpensive foreign supplies the utilization of imports serves to conserve and prolong those limited domestic supplies, should a real emergency develop. U.S. petroleum independence in the near-term—the relatively more rapid depletion of domestic supplies—risks the possibility of becoming more heavily dependent on

foreign supplies in the future, barring major technological innovation, such as, for example, economically viable solar or fusion power. From an energy security perspective then, it is not a clear cut decision that reduced import dependence now is preferable to necessarily greater dependence later. This is an argument that policy makers must not continue to ignore.

[6]It is interesting to note how the region of source has changed over time. From 1973 to 1988 the proportion of total oil consumption by the six countries that was derived from the Persian Gulf states generally declined: For Japan, from 74 percent to 55 percent; for France, from 84 percent to 28 percent; for the U.K. from 66 percent to 15 percent; for Germany, from 49 percent to 9 percent; and for Canada, from 19 percent to 4 percent. The U.S. share increased from a comparatively low level of 6 percent to 9 percent.

[7]American Gas Association (1990), p. 124.

[8]Gross domestic product is used as the measure of a country's output in order to obtain a more consistent data series. GDP is the more commonly used output measure abroad. GDP differs from GNP in that GDP excludes net factor income from abroad. In U.S. national income statistics, for example, most of the net factor income from abroad is in the form of U.S. firms' corporate profits from abroad—profits earned abroad are not part of U.S. GDP, but are included in GNP.

[9]Other economists, for example, Summers and Heston (1984), have done extensive work that has focused on developing meaningful measures of real national product across countries.

[10]Organization for Economic Cooperation and Development (1991).

[11]OECD data are available for energy and oil consumption by transportation (air, road, and rail). An important restriction in the transportation case is the lack of contribution to GDP by sector data, as was the case for industrial/nonindustrial sectors—that is, contribution to GDP by the transportation sector and contribution to GDP by the nontransportation sector. The technical efficiency measures, therefore, do not refer specifically to this sector. Rather, they are a hybrid that relates total GDP output to energy inputs for transportation/nontransportation.

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Balancing act: Tax structure in the Seventh District

Richard H. Mattoon

State and local governments are facing their toughest fiscal situation since the recession years of the early 1980s. As tax revenues throughout the country fall below projections, state and local governments are grappling to find the right course between spending cuts and tax increases. Owing to budget problems of its own, there is little hope that the Federal government can help the states in these recessionary times.

As state and local governments begin to examine their expenditure and revenue options, it would be wise for policy makers to bear in mind what constitutes a good tax system, as well as the major advantages and disadvantages of the tax sources available to state and local governments.

Many analysts have described what they believe the objectives of a good tax structure should be. While the criteria developed share many common concerns, no two lists are exactly alike. Depending on which aspect of the tax structure receives emphasis, goals can conflict and blueprints for tax policy can become muddled. However, keeping well-defined criteria at the forefront can help focus the tax policy debate and can force policy makers to be explicit in recognizing the trade-offs that occur in selecting one tax over another.

This article will begin by reviewing the criteria often cited for establishing a good tax structure. Against these criteria, it will examine the tax structure of the five Seventh District states—Illinois, Indiana, Iowa, Michigan and Wisconsin—focusing on their utilization of the property, income and general sales tax. Finally, it will review the tax options now under consideration to relieve state and local fiscal pressure.

Criteria for judging a good tax structure

Requirements for a good tax structure can be distilled from a large body of analysis and thought.[1] Criteria often include the following:

- The distribution of the tax burden should be equitable, with everyone paying a fair share.
- Interference with the operation of efficient private markets by taxes should be minimized. In particular, taxes should not distort economic choice by placing excess burdens on individuals.
- Taxes can, however, be used to correct inefficiencies in the private sector in situations where markets do not behave efficiently.
- The tax structure should help stabilize the national economy while providing adequate revenue growth.
- The tax structure should permit efficient and nonarbitrary administration and should be comprehensible to the taxpayer.
- Administration and compliance costs should be reasonable.

The author is a regional economist at the Federal Reserve Bank of Chicago. The author thanks William Testa for guidance and comments on previous drafts.

In order to design tax systems, state policy makers often need more detailed guidelines which incorporate strategies specific to state and local government.[2] In this regard, Robert Kleine and John Shannon have developed the following guidelines of taxation.

- Revenue sources for taxation should be diversified. In particular, they should balance the three principal tax bases available to state and local government: income, property and sales taxes.
- Revenue sources should be stable and taxes should be moderate. This includes using broad tax bases with minimum volatility and insuring that expenditures and state revenues grow at consistent and reasonably parallel rates.
- Taxation should be fair and equitable. That is, the tax structure should be progressive enough to protect the lowest income members of society from bearing a disproportionate share of the tax burden.
- There should be state fiscal equalization preventing property tax disparities from creating local fiscal disparities in funding for education and other programs. Specifically, this calls for state government to take a "senior" role in the state and local fiscal system and assume at least 50 percent of the cost for education, health and hospitals, and all of the cost of nonfederal public welfare. In lieu of picking up these costs directly, the state should offer revenue sharing so that communities can fund these programs without sole reliance on the property tax.
- Changes to the tax structure should be politically accountable. Tax increases should be the product of deliberate legislative action and not inherent structural features of the tax system which permit automatic tax hikes. To cite two examples, "bracket creep" for income taxes and changes in assessment practices for property taxes often permit governments to raise revenues without approval from either taxpayers or their representatives. In contrast, indexing income taxes and adopting truth in property tax laws can help safeguard residents from automatic tax increases.
- There should be property tax equity, defined as uniform assessments both within and between towns.
- State and local governments should strive for tax competitiveness. Tax rates and policies should avoid creating an image of a poor business climate. Each state should be cautious that its tax policies do not provide incentives for desired companies to invest in lower tax jurisdictions.

Neither of these lists exhaust the possible criteria for designing a good tax system and it is impossible to meet all of these criteria simultaneously. In trying to meet the goal of one aspect of the tax system, trade offs with other goals are bound to occur; compromises must be made. For example, offering tax incentives to business may undermine revenue stability. Many states have created special tax incentives in order to attract and retain business and to create a "competitive tax climate." In doing so, states narrow the base on their business taxes, often making the revenue performance of the tax more volatile and thereby undermining revenue stability. Similarly, those sales tax policies that exempt "necessities," such as food and clothing, are usually intended to promote tax fairness. In doing so, the revenue stability of the tax system may again be reduced by narrowing the tax base. Furthermore, some of the goals of a good tax system are ill-defined or not universally accepted. Having everyone pay their fair share is a goal of tax equity; however, not everyone agrees on what constitutes a fair share. Should a person's fair share be based on their ability to pay or on the benefit they receive from the public services provided by taxation?

Given that it might not be possible to satisfy all of the objectives listed above simultaneously, the purpose of reviewing lists such as these is to provide the framework for examining what specific needs and pitfalls should be considered when trying to reform or modify a state's tax structure. Revenue systems are reformed because one feature of the system has fallen out of line. Too often, in the process of re-alignment, other important features are neglected.

Currently, revenue adequacy is the one goal of taxation which is of most immediate interest to policy makers. Many states are finding that revenues are not adequate. None of the three major state and local tax bases (property, sales, income) appear to be easy targets for revenue expansion to relieve the currently

strained state and local fiscal condition. Yet states are largely limited to the property, sales and income tax bases which have traditionally been the focus of major tax changes.

Seventh District focus

The District's revenue structure

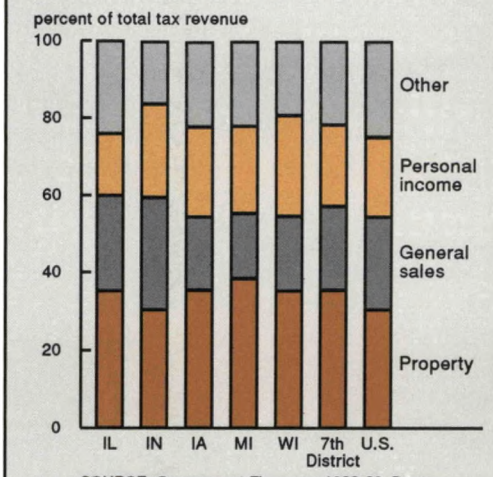
Seventh District states have established a fairly conventional tax structure, raising the bulk of their tax revenues from property, sales and income taxes. District states differ somewhat from the rest of the nation in that they rely on property taxes for a greater proportion of revenue. Income and sales tax bases grew faster during the 1980s than the property tax base. As a result, District tax revenues grew more slowly during the 1980s than the rest of the nation.

The property tax

Table 1 compares the District with the U.S. on property tax reliance. The Advisory Commission on Intergovernmental Relations (ACIR) tax effort index reported in the Table is designed to measure a state's tax effort relative to the U.S. (see Box for details). Table 1 shows that, as measured in terms of effective tax rate, share of personal income and the ACIR tax effort index, District states tend to utilize the property tax more heavily than the national average. It is therefore not surprising that in terms of revenue raised, the property tax comprises the largest share of state and local tax revenues in the District states, as shown in Figure 1.

FIGURE 1

Distribution of state/local tax revenue by source



SOURCE: Government Finances: 1988-89, Bureau of the Census.

Table 2 compares the growth of the property, sales and income tax revenues for District states and the U.S. during the 1980s. From 1981 to 1989, real property tax revenues in the District grew by only 15 percent while sales and personal income tax revenues were up more than 25 percent, in spite of the fact that the District attempts to tax property more vigorously than the other tax bases. At the national level, property tax revenues were the slowest growing revenue source with receipts up 31 percent while sales and income were up 40 and 49 percent, respectively.

Before discussing the advantages or disadvantages of the relative reliance on property taxes for District states, it is necessary to keep several caveats in mind. It is very difficult to make meaningful generalizations about how the property tax burden uniformly affects any individual state due to the wide variation in local property tax administration. Given the local nature of the tax, the property tax burden can be significantly different from town to town and can reflect differences in the level, quality and efficiency of town services, variation in the local price of providing services, assessment practices,

TABLE 1

Property tax comparisons for the District and the U.S.

	Effective tax rate* 1987	Share of personal income 1988	ACIR index 1988
Illinois	1.59	3.8	129
Indiana	1.28	3.2	103
Iowa	1.96	4.5	152
Michigan	2.26	4.7	157
Wisconsin	2.27	4.5	147
U.S.	1.16	3.5	100

*Effective tax rate reflects the estimated taxes on a FHA insured single family home mortgage.

SOURCES: *State Policy Data Book 89*, Table D-40, Brizius & Foster. *States in Profile, 1990*, Table D-9, Brizius & Foster. *1988 State Fiscal Effort*, 1990, Advisory Commission on Intergovernmental Relations.

TABLE 2

Real tax growth by type of tax: 1981-1989
(Percent change)

	Property	General sales	Personal income	Total tax
Illinois	15.6	19.5	19.1	13.2
Indiana	9.7	31.1	109.1	34.9
Iowa	4.7	27.1	20.4	13.8
Michigan	12.8	20.6	29.2	19.5
Wisconsin	30.2	46.2	7.6	25.6
U.S.	31.4	39.9	49.9	32.49
District	15.0	25.5	27.6	19.58

SOURCE: *Government Finances: 1980-81, 1988-89,* Bureau of the Census.

and other factors. Simply noting that the average property tax burden for a given state is high fails to recognize the extremely varied distribution of this tax burden.

Determining the ultimate burden of the property tax is also an issue of dispute. Originally, tax theory held that property tax was passed on to tenants and consumers of property. As such, the effect of the tax showed up in either the tenants' rent or in the price of a property. In practice, this made the property tax regressive with respect to income since lower income households tend to devote a larger share of their income to housing. For this reason, many tax analysts held that reliance on the property tax should be held in check due to its regressive sting.

However, more recent theory has held that the property tax is actually a tax on capital. As such, its incidence is reflected in a reduced return on capital investment which ultimately is also borne by labor. Labor is affected because the reduction in capital stock caused by the property tax reduces labor output. The effect is even more pronounced when there are differentials in property taxes between jurisdictions. Here a distinction must be made between the effect the tax has on land vs. its effect on capital. While land is immobile, capital is not. Consequently, differentials in property tax rates will induce capital to move to locations with lower tax rates, thereby increasing the return on capital. This will cause investment funds to flow out of high tax jurisdictions and into low tax jurisdictions until the return on capital investment is equal in both jurisdictions. This will leave the high tax town with a diminished share of capital stock, which can be a major concern for a town's economic growth and development.[3]

The District's reliance on the property tax probably has little to do with the debate over who bears the burden of the tax. High property tax reliance is usually related to a variety of other factors which relate taxes to the funding of public services rendered rather than to who bears the tax burden.. If there is a political preference for local governments funding a large share of public education expense or other local programs, the property tax burden will be higher. For example, in Illinois, the existence of thousands of special districts and other governments explains why the state's reliance on the property tax is higher than the U.S. average. Also, property tax reliance is often a product of historical factors. Agricultural states tend to rely on property taxes because, historically, the property tax was a good way to relate the tax burden to the ability to pay. In an agrarian economy the more farm land held, the greater the ability to produce income.[4]

Critics often attack the property tax on several grounds. The first criticism is that it serves as a poor proxy for judging an individual's ability to pay the tax if the tax is viewed solely as a tax on the consumption of housing. The property tax is often claimed to be "horizontally inequitable" in the sense that individuals with equal incomes or wealth rarely have an equal property tax burden due to variations in their housing consumption. For example, two houses may be assessed and taxed at identical rates and yet disparities in the incomes of the owners can make the burden of the tax minimal on one owner and heavy on the other. For example, the tax burden is often heavy for senior citizens on fixed incomes who find that property taxes consume a larger and larger fraction of income over time.

Another criticism is that the multiplicity of taxing districts and variations in tax structure often provides incentives for avoiding the tax. In states where mobile personal property such

The Advisory Commission on Intergovernmental Relations Representative Tax System

The Representative Tax System (RTS) was created by the Advisory Commission on Intergovernmental Relations (ACIR) in an effort to allow comparisons of state and local tax capacity and effort between states. RTS measures the amount of revenue that would be raised if a state applied national average tax rates to 27 different tax bases within the state's boundaries. The figure arrived at through this process defines the hypothetical tax capacity of a given state. It is important to note that the RTS is a hypothetical measure that assumes all states utilize all 27 tax bases and that all states tax at the same rate.

Tax effort in the RTS attempts to determine a state's relative utilization of its tax base. Tax effort is the ratio of actual state tax collections to the state's hypothetical tax capacity. A tax effort above 100 indicates that the state's utilization of the tax is above the U.S. average. For example, Wisconsin's 1988 tax effort score for the personal income tax was 157. This indicates that the state imposes a tax burden which is 57 percent above the national average. Conversely, a score below 100 indicates that the state's utilization of the tax is below the U.S. average. For example, Michigan's sales tax effort of 76 means that the state's sales tax effort was 24 percent below the U.S. The RTS provides a basis for standard comparisons among states.

as automobiles is taxed, there is an incentive to register cars in towns with low tax rates even if the owner resides in a higher tax town. A further criticism is that gaps in the property assessment cycle can distort the relative value of both personal property and new construction, forcing both to bear an unfair share of the tax load. This occurs when personal property and new construction assessment reflect current value while real property assessments are allowed to lapse for several years in between revaluations. In some states the gap between real property revaluations can be as much as 10 years.

Evidence suggests that high property taxes can also serve as an obstacle to business and economic development, since the property tax can often be the largest tax faced by a business. A recent Wisconsin study found that the property tax constituted 47 percent of the state and local total tax liability for a group of six manufacturing industries.[5] This out-distanced the corporation business tax which comprised 35 percent of total state and local tax payments. The view that high property taxes impede economic development is supported by economic theory, which holds that differentially high property taxes will tend to increase the cost of capital, thereby encouraging new investment to seek lower tax jurisdictions.

Finally, high property tax reliance can create fiscal disparities between communities. Goals of equity and fairness can be undermined when property poor towns are forced to provide the bulk of their local services through the property tax.

The primary defense of property taxation tends to be founded more on political than economic grounds. Because property tax growth is relatively inelastic, or unresponsive to swings in economic activity, it supplies a steady but sluggish revenue source for local governments. This steady growth can be a stabilizing factor for local governments in bad economic times.

The relative stability of the property tax has proven to be an advantage during the recent recession. National Income and Product Account data placed the property tax as the fastest growing revenue source when measured from the first quarter of 1990 to the first quarter of 1991. Specifically, property tax revenues have grown by 6.5 percent while sales and income tax revenues have increased by only 2.7 and 3.8 percent, respectively. Recessionary effects which are impacting sales and income tax returns are less likely to cut into property tax gains. Since property tax assessments often lag because of administrative features, this tax source continues to grow as updated assessments reflect past gains in property values even though current values may have stabilized or declined. This administrative lag can often stabilize government spending in the early periods of a recession and generally reduce

reliance on faster growing but more volatile tax bases such as income and sales.

In summary, the District's reliance on property tax suggests a choice of slower but more stable revenue growth, more costly investment in property from a tax perspective and an overall tax structure that is probably more regressive with respect to income than is the case for the U.S. as a whole. Further, while the property tax may have the advantage of increasing local government accountability by requiring that more services be performed at the local level, it reduces the redistributive role of state government by reducing the potential revenue raising capacity of state government.

The general sales tax

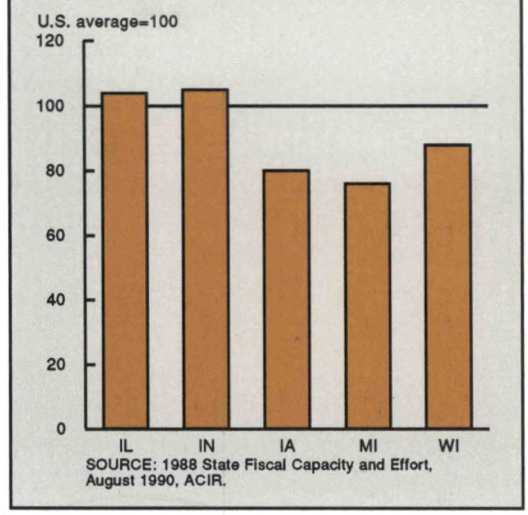
District wide reliance on the sales tax varies significantly. While both Indiana and Illinois draw 25 and 29 percent of total state and local revenues from the sales tax, the remaining three District states all draw less than 20 percent. This variation is also evident in the relative burden of the tax as a percentage of personal income. In Indiana, the sales tax is 3.1 percent of personal income, in Illinois it is 2.6 percent and in Wisconsin it is 2.5 percent. In Iowa and Michigan the percentage falls to 2.1 percent. When viewed relative to the U.S. average, only Indiana exceeds the national figure of 2.8 percent. This variation occurs despite the fact that state sales tax rates among the five District states are quite similar, ranging from 4 percent in Michigan to a high of 6.25 percent in Illinois.[6]

The significant difference in reliance has come about because states differ in authorizing localities to levy their own sales tax. Iowa, Illinois and Wisconsin all permit other governmental units to levy a sales tax in addition to the basic state sales tax rate. In Chicago, for example, the total sales tax rate levied by all overlapping governments is 8 percent. Meanwhile, just over the state line in Indiana, the rate is 5 percent. Such disparities can create an incentive for people to avoid additional sales taxes by crossing state borders to make purchases.

Even in the ACIR tax effort figures, District states rank very low nationally on the sales tax effort index (see Figure 2). Only Indiana and Illinois at 105 and 104 respectively are above the national average. When compared to the very high property tax effort scores for

FIGURE 2

Sales tax effort: 1988



SOURCE: 1988 State Fiscal Capacity and Effort, August 1990, ACIR.

District states, it is clear that the District provides something of a break with respect to consumption taxes. This reduced reliance does not arise because of any smaller tax base in the District. Rather, it most likely reflects differing exemption policies for certain goods (all five District states exempt manufacturing machinery and materials as well as food and prescription drugs from the sales tax) rather than lower spending tendencies by District residents.

Low reliance on the sales tax is perhaps the most unusual aspect of the District's tax structure. Nationally, the sales tax is consistently seen as the most popular tax in surveys of taxpayers. Much of this popularity is due to administrative features of the tax. The relatively small amount of the tax attributable to the purchase price of a good makes the tax less visible on all but the largest purchases.

In addition to its relative popularity, the sales tax is fairly easy to administer even though sales tax audits are necessary and often expose significant fraud. The sales tax also has the added advantage of being an exportable tax in that it is paid by those nonresidents such as tourists and conventioners who make purchases within the state.

One problem often noted with the sales tax is that it is not progressive. That is, if a wealthy person and a poor person buy the same good, the tax bite as a share of income is much greater for the poor person. Attempts to correct this feature and reduce the regressivity of the

tax by exempting food and other necessities often fail because the tax break tends to provide relief to both income groups. As a further drawback, exemptions of necessities, such as food, increase the volatility of the tax base by making the base more reliant on "big ticket" consumer goods such as cars.

Further, the relative regressivity can be capricious, because it is greatly influenced by an individual's particular consumption and savings habits. This feature is moderated to some extent because it is possible to escape some of the sales tax burden by lowering the level of consumption and increasing savings. Indeed, some analysts favor this tax because it encourages national savings. But low income individuals have much less latitude in their consumption vs. savings decisions. Much of the decision to consume is based on the relative need for a product. The more price inelastic the demand for a product, the more regressive the sales tax. For goods that are price elastic, such as luxuries, the seller of the product may have to absorb some of the tax burden.[7] Necessities are relatively price inelastic, consequently the buyer must absorb all of the tax burden.

By underutilizing the sales tax, District states generally forego revenues from the least politically objectionable tax source. Their gain may be greater revenue stability because they are less reliant on this relatively more volatile base. Furthermore, by permitting local sales taxes, the states provide local governments with an option for revenue diversification which can lessen the dependence on the property tax. However, taxpayers find it easy to avoid the local sales tax by making purchases in lower tax jurisdictions, thereby affecting shopping location decisions.

The personal income tax

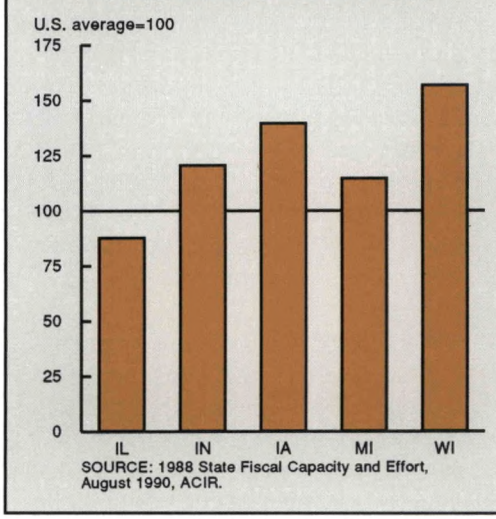
The District tends to be slightly above the national average in utilizing the personal income tax. When measured as a share of state and local revenues, the District tends to draw on the personal income tax more heavily than the U.S. as a whole. This is also reflected in the burden of the personal income tax as a percentage of income. The U.S. average for state and local personal income taxes as a percentage of income is 2.1 percent. District states above the average include Indiana at 2.3 percent, Michigan at 2.5 percent, Iowa at 2.6 percent and Wisconsin at 3.3 percent. Only Illinois at 1.7 percent is significantly below the average.

With the exception of Illinois, with its low reliance on the personal income tax (this will change given the recent tax surcharge which raised the income tax rate from 2.5 to 3 percent), the District tends to conform fairly closely to the ACIR criteria of raising a quarter of revenues from this source. However, it does so by imposing a slightly higher tax burden on residents relative to the nation. Both the tax as a share of personal income numbers and the ACIR effort index reflect a relatively high burden for this tax (see Figure 3).

Differences in reliance among District states arise primarily from differences in the tax structure. Three states—Illinois, Indiana and Michigan—have flat rate income taxes which range from 3 percent in Illinois to 3.4 percent in Indiana and 4.6 percent in Michigan. Iowa and Wisconsin have graduated rate income taxes, with Iowa's tax consisting of nine tax brackets ranging from a tax rate of .4 percent to 9.98 percent, and Wisconsin's consisting of three brackets ranging from 4.9 percent to 6.93 percent. All five states use some variant of federal adjusted gross income as a starting point for the tax base. As a group, none of the District states can be characterized as having generous deductions or tax credits in arriving at state taxable income. Both Illinois and Indiana permit only a $1,000 standard deduction against individual income before levying their flat rate tax. Iowa and Wisconsin provide limited tax credits.

FIGURE 3

ACIR income tax effort: 1988



SOURCE: 1988 State Fiscal Capacity and Effort, August 1990, ACIR.

Iowa's credit is $20 for the filer and $15 for each dependent while Wisconsin limits its tax credit to $50 per dependent. Michigan provides the most generous standard deduction at $2,000. The impact of these limited deductions and credits is to make the income tax more regressive in District states, particularly in those with low standard exemptions and flat rate tax structures, than in those states with progressive rate tax structures or large personal exemptions.[8]

There are several advantages to raising revenues through income taxes. It is considered the best tax in terms of progressively relating the tax burden to one's ability to pay. And assuming that the tax uses a fairly broad measure of income, it is also horizontally equitable, that is, it treats equally-situated individuals the same. Tax compliance costs are also lessened through conformance with the federal income tax base guidelines. The tax is highly productive as a revenue source. As personal incomes rise the tax base grows. As such it can provide a substantial revenue source for the states. Also, because most states choose not to index the income tax base, state income tax revenues can grow through bracket creep in which increases in personal income push tax payers into higher tax brackets even if their inflation-adjusted incomes have not increased significantly. Since three of the District states utilize flat income tax rate structures, bracket creep is less of an issue within the District.

One disadvantage of the personal income tax is that as it reduces disposable income, it can serve as a drag on spending and investment. A relatively higher income tax burden can mean that people will adjust their spending and savings habits in order to absorb the tax. This behavior is likely because the income tax in most cases cannot be transferred or shifted to another party. As such, the District's slightly heavier burden on income taxes may tend to reduce both consumption and savings. Furthermore, the preference toward flat tax rates with limited deductions erodes much of the progressive structure usually associated with income taxes.

Exportability

Tax exportability—the ability to levy taxes in such a way that the burden is borne by out-of-state residents—is quite understandably a desirable goal from the point of view of the state levying taxes.[9] The advantage for a state in having a significant share of its tax base exportable is that it lessens the tax burden on state residents. Three states noted for having highly exportable tax bases are Alaska, Nevada and Hawaii. Alaska is able to export a great deal of its tax burden through severance taxes on the sale of oil. Because oil deposits are mostly owned by large multi-national companies, which are in turn owned by non-Alaska residents, severance tax incidence falls on out-of-state residents. A 1980 study[10] found that Alaska was able to export 36 percent of its tax burden largely because of the severance tax. The same study found that Nevada was able to export over 20 percent of its tax burden through the sales taxes on gambling by out of state residents. Hawaii exports taxes by taxing spending by tourists.

By comparison, Seventh District states are not so blessed. At present, there is no large industry generating profits for out-of-state residents which can be tapped by the tax system. Very little of existing revenue vehicles are able to export the burden. This is due in part to the District's relatively heavy reliance on property taxes, which are usually not exportable, and the light reliance on sales taxes, which are the most exportable. The 1980 study found that while the average rate of tax exportation for the U.S. was 9.6 percent, the range in the District states was 7.7 percent in Illinois, 6.5 percent in Michigan, 5.8 percent in Indiana, and 5.4 percent in both Iowa and Wisconsin.

In a sense, taxes can also be exported to the federal government when states take advantage of the so-called federal offset permitting deductions from the federal income tax for selected taxes paid to states and municipalities. In particular, income and property taxes are currently eligible as a deduction for those who itemize deductions on federal returns. District states fare better with respect to federal tax exportation because they rely heavily on property and income taxes. In 1980, the national average for the federal offset of state taxes was an estimated 7.1 percent. Among District states, the value of the offset was greater in all states except Indiana; 7.5 percent in Illinois, 5.6 percent in Indiana, 7.3 percent in Iowa, 9.2 percent in Michigan and 10.2 in Wisconsin. Sales tax deductions were phased out following the 1986 Tax Reform Act and are no longer a source of

federal tax exportability. With the elimination of sales tax deductability, the size of the offset has undoubtedly declined but, given the District's lesser reliance on sales taxes, the decline has probably been less precipitous than in high sales tax states.

One final trend which also affects the relative value of the federal tax offset is the recent popularity in state and local governments of user fees and special charges. While these have the advantage of diversifying revenue sources and directly relating the cost of providing a service to the beneficiary, they have the disadvantage of not being deductible from federal taxes. User fees and charges often replace revenues from deductible sources, such as property and income, which in turn reduces the value of the federal offset.

Options for raising tax revenues

States are now facing the largest revenue gap since the 1981-82 recession. Then, most states initially tried to avoid major tax increases. Nevertheless, states entered FY83 with record tax increases. At the beginning of FY83, 16 states raised their income tax, 11 raised their sales tax and 5 raised both. Furthermore, 10 states had a stated goal of trying to increase revenues by 15 percent that year.[11]

While states are today looking at similar options, fears of developing a less competitive tax climate than neighbors have many states attempting to raise revenues through means other than raising major tax rates. Some states, motivated by their current fiscal problems, are reducing tax rates that are perceived as being too burdensome, and replacing these taxes with new ones. For example, Tennessee and Connecticut considered instituting state income taxes and using the money raised to role back the sales tax rate. In Tennessee's case, the state sales tax rate could be cut from 5.5 to 4 percent and in Connecticut from 8 percent to 4.25 percent. The belief is that a more balanced tax system will ultimately be of greater benefit to the states' residents while also enhancing economic development.[12]

In a turnaround of trends from the 1980s, a number of states with progressive rate income taxes are considering raising the top marginal tax rate on individual income taxes. Proposals to do so have been offered in California, Delaware, Montana, Maine, and New York. For example, a legislative package in California proposed raising the top bracket marginal tax rate from 9.3 to 11 percent. While these proposals have received some popular support, others have criticized them on the grounds that higher income individuals tend to be more mobile, so that high marginal rates may encourage the wealthy to leave, thereby diminishing the tax base.[13]

The sales tax is the remedy most frequently considered by states to relieve fiscal pressure. Two kinds of changes are being considered. Rather than increasing the tax rate, most states are looking at ways to eliminate tax exemptions for certain items such as snack food and magazines, thereby broadening the tax base. California recently added a number of snack foods to its sales tax base, although problems defining what constitutes a snack food are being encountered. Alternatively, states are considering an extension of the sales tax base to include services. Service taxation is still an area where states have been moving cautiously. A broad-based taxation of services has yet to emerge although certain professional and personal services are increasingly being taxed.

Service taxation has been defended on several grounds. According to one argument, the purchase of services is a form of consumption just like the purchase of tangible property. There is no reason to treat the choice of one type of consumption differently from another. Consequently, according to this argument, service taxation is a matter of tax equity as well as neutrality. It is unreasonable to penalize those who consume tangible goods rather than services, thus encouraging service purchases rather than goods.

As a practical matter, services have not been taxed because of difficulties in administering the tax. Because some services, such as housekeeping and lawn cutting, are very informal, it is difficult to imagine that a tax on such services could be easily imposed and easily collected. However, other services, particularly those involving the repair and maintenance of tangible personal property, are particularly vulnerable targets for sales taxes. Subscription services such as cable television are also a frequent target for the same reason. From a practical point of view, service taxation is not without advantages. The rapid growth in service activities and in service consumption makes this a particularly attractive potential tax base. Increased service taxes can broaden and

reduce the volatility of sales taxes which have grown dependent on big ticket durable goods purchases.

Objections to service taxation are based on the fear that this is such a huge pool of revenue that it will not only relieve current fiscal pressures, but further encourage government spending. Another objection is that service taxation should not apply to many of the services purchased by business because this would be a form of double taxation, i.e. the physical output (which embodies the service) is ultimately taxed once it is sold. According to this argument, just as most states try to limit taxes imposed on parts used in the manufacturing process to avoid double taxation, services used by businesses should receive similar treatment. Finally, perhaps the strongest objection is based on tax competitiveness. States are very sensitive about taxing those services that are perceived as footloose. Such taxation might also put home state service companies at a competitive disadvantage when competing against out-of-state businesses.[14]

One final area that is receiving considerable attention (but limited action) is property tax reform. Several states (for example, Illinois, Michigan and Kansas) have proposed reducing property tax burdens using either tax caps or roll backs in property assessments.[15] While these proposals are popular with voters—Michigan voters will again try to put an initiative on the 1992 ballot to roll back assessments by 20 percent—cash strapped state governments have trouble identifying sources of funds to replace these lost local revenues.

The consequences for tax reform measures

When examining the tax structure of a given state or local government it is important to realize that the effect of raising $100 million in revenues through an increase in the sales tax is not the same as raising 100 million through the income tax. For District states, concern about revenue sources is increased by the tight fiscal situation facing its governments and the resulting adjustments to state fiscal systems.

In recent tax developments, many of the District states have attempted to reduce dependence on property taxes. Wisconsin has passed property tax relief measures and Illinois has increased its personal income tax in order to pay for a larger share of education spending, thereby reducing the need for the local property tax to fund these expenditures. Furthermore, Illinois has considered capping property tax assessment growth at 5 percent per year. Michigan's new governor proposed raising state sales and/or income taxes in order to reduce property tax dependence. If the trend to reduce property taxes continues, the result will be a larger role for state government in the District.

In the short run, if District policy makers are forced to raise revenues, they need to consider the tradeoffs suggested by the varying theories of taxation presented here. If a state's interest lies in sparking capital investment, then encouraging increases in local property taxes is probably a bad idea as such a measure could, if unaccompanied by services benefitting local business, increase the cost of capital. If, on the other hand, legislators want to increase tax stability, then broadening the tax base of the sales tax by reducing exemptions or taxing services could provide a valid avenue. In any case, the ability to export tax burden outside the state's boundaries is another consideration. Given the tenuous position of state and local economies, revenue raising decisions must be made with care. Adjusting the tax rates of major revenue sources in an ad hoc manner fails to recognize the interaction between taxes and economic activity. District policy makers need to understand both how the current tax structure effects the economy and how proposed changes may improve or hinder future economic activity.

FOOTNOTES

[1]See Musgrave and Musgrave (1976), pp. 210-211.

[2]See Kleine and Shannon (1986), pp. 33-36.

[3]For more on the incidence and theory of the property tax see Phares (1980), P. Mieszkowski (1972), and Musgrave and Musgrave (1976), Chapter 19.

[4]See Fisher (1969), Chapter 4.

[5]Wisconsin Department of Revenue (1990).

[6]The Council of State Governments (1991), Table 6.17. Note also that the Illinois state government only collects sales tax revenues based on a fixed tax rate. Revenues

above this percentage are distributed to various other governments in Illinois, such as special districts, municipalities, etc. Also, Iowa's tax rate is 4 percent; in Wisconsin and Indiana the tax rate is 5 percent.

[7]Musgrave and Musgrave (1976), chapter 20.

[8]Council of State Governments (1991), Tables 6.19 & 6.20.

[9]Phares (1986), chapter 5.

[10]Phares (1986), chapter 5.

[11]Snell (1991).

[12]State Legislatures (1991).

[13]State Budget and Tax News (1991).

[14]John Mikesell (1986).

[15]State Budget and Tax News (1991).

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