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In This Issue . . .

In the first article in this *Review*, "Free Trade and Environmental Policy: Are They Mutually Exclusive?" Alison Butler provides an introduction to the reasons for and the effects of domestic environmental policy. She then discusses the effects of environmental policy on international trade. Environmental policy, says the author, affects trade in two ways: either directly, through the price and amount of output produced of a traded good, or indirectly, through the effect of unwanted pollution transported across borders on relative prices, income and output in the affected country. The author highlights the difficulties of creating international agreements about the environment when countries have significantly different income levels or assimilative capacity to absorb pollution. The paper concludes with an examination of whether environmental policies are consistent with current international trade agreements.

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The rapid rise in foreign direct investment in the United States between 1977 and 1990 has generated much controversy. In the second article in this issue, "Foreign-Owned Companies in the United States: Malign or Benign?" Cletus C. Coughlin examines the factors potentially responsible for the sharp increase in this investment and the controversial economic effects of this investment.

The rise in foreign direct investment in the United States reflects the relatively rapid development of technology abroad that is being transferred to the United States. This transfer of technology allows resources in the United States to be more productive, not only in the industry affected directly by the investment, but also possibly in other industries because of external benefits.

Critics have raised numerous concerns that the behavior of foreign-owned firms might be detrimental to U.S. interests. Coughlin finds, however, that the major economic concerns do not stand up to scrutiny. For example, these firms are transferring more technology into the United States than out of the United States and their research and development activity is similar to that of U.S. firms. In addition, compensation for workers in foreign-owned firms is similar to U.S. firms, suggesting that foreign ownership is not replacing good jobs with bad ones. Finally, even though foreign-owned firms tend to import more than they export, their trading behavior is likely beneficial. The technology and other inputs imported by foreign-owned companies makes these companies more productive and, thus, generates gains for the U.S. economy.

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Central banks can direct their attention to a variety of goals, one of which in recent years has been to affect the foreign exchange value of its currency. In the third article in this issue, Michael T. Belongia ex-

plores "Foreign Exchange Intervention by the United States: A Review and Assessment of 1985-89."

The author first lays out the basic concept of foreign exchange intervention and illustrates its effects on the balance sheets of both domestic and foreign commercial and central banks, then to the consequent effects on the domestic and foreign money supplies. These mechanics suggest several hypotheses about the effects of intervention, which he then tests with newly released daily data for the United States. The results indicate that intervention, during isolated periods, seems to have significant, but small, effects on daily movements in the DM/dollar and yen/dollar exchange rates.

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Small rural banks often face strong seasonal patterns in their loans and deposits. This seasonality complicates the management of assets and liabilities at these institutions and is thought to constrain the volume of local lending. Since 1973, the Federal Reserve System has offered assistance to these banks through a seasonal credit program. In the fourth article in this *Review*, "Are Small Rural Banks Credit-Constrained? A Look at the Seasonal Borrowing Privilege in the Eighth Federal Reserve District," Michelle A. Clark examines the rationale for and use of this Federal Reserve program. She concludes with some observations on its role in light of recent financial innovations.

The author first outlines the purpose of the Seasonal Borrowing Privilege (SBP), then describes its administration and the pattern of borrowing since its inception. She then looks in closer detail at the pattern of program usage in the Eighth Federal Reserve District over the period 1984 through 1990. She finds that the usage of the SBP increased substantially over the period as the number of eligible institutions and awareness of the program increased. An analysis of loan and liquidity ratios for a group of banks prior to and during use of the SBP indicates that the program is achieving its desired objectives. Nonetheless, documented changes in the structure, branching status and location of program users in recent years suggest that borrowing banks may have alternative sources of credit beyond the SBP.

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In 1958, Paul Samuelson published a classic paper in monetary theory. His model fused general equilibrium ideas with an explicit demographic structure, and he was able to show how unbacked paper currency might be valued in such an economy. Unfortunately, there were some drawbacks, one of which was that a "time period" in the model, interpreted literally, would be decades long. Some economists felt that this time period problem invalidated Samuelson's theory of money, while others have continued to use the model, arguing that repair of the time period problem would not alter qualitative results.

In the final article in this *Review*, "Samuelson's Model of Money with N-Period Lifetimes," James Bullard argues that reformulating the model to the point where a time period could be interpreted as a month or a quarter does not change the qualitative results, at least in a certain special case. In particular, the long-run equilibria of the model are unchanged, and the condition for paper currency to be valued is analogous to the condition in the original model. Bullard's argument is based on a relatively simple, but algebraically complicated, example in which solutions can be worked out explicitly.

Alison Butler

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Environmental Protection and Free Trade: Are They Mutually Exclusive?

Having to compete in the United States in a totally free market atmosphere with companies and countries who have yet to develop such environmental standards is inherently unfair. It puts us into a game where the unevenness of the rules almost assure that we cannot win or even hold our own.

James E. Hermesdorf, *Testimony to Senate Finance Committee on Trade and the Environment*, October 25, 1991.

COMMENTS LIKE THE ONE cited above are being heard with increasing frequency. In fact, protecting the environment has always had implications for international trade. In 1906, for example, the United States barred the importation of insects that could harm crops or forests. Similarly, the Alaska Fisheries Act of 1926 established federal regulation of nets and other fishing gear and made it illegal to import salmon from waters outside U.S. jurisdiction that violated these regulations. More recently, a U.S. law restricting the method of harvesting tuna to protect dolphins has been the subject of a trade dispute between the United States and Mexico.

In recent years, as global warming and other environmental concerns have multiplied, environmental issues have played an increasing role in trade negotiations, further complicating what are generally difficult negotiations. Negotiating environmental regulations multilaterally is especially problematic because of differences in preferences and income levels across countries. What's more, scientific evidence is not always conclusive on the effects of certain types of environmental degradation. Finally, environmental considerations can be used to disguise protectionist policies.

This paper examines the different ways environmental policy can have international ramifications and their implications for international trade and international trade agreements. A general introduction to environmental economics is given, followed by an analysis of the relationship between environmental policy and

international trade. The paper concludes with a discussion of the status of environmental considerations in multilateral trade agreements.

AN ECONOMIC RATIONALE FOR ENVIRONMENTAL POLICY

The environment is used primarily in three ways: as a consumption good, a supplier of resources and a receptacle of wastes.[1] These three uses may conflict with one another. For example, using a river as a receptacle of wastes can conflict with its use as a supplier of resources and as a consumption good.[2] When either the production or consumption of a good causes a cost that is not reflected in a market price, market failures that are termed "externalities" may exist.[3] Such market failures frequently involve the environment.

A. C. Pigou, in *The Economics of Welfare* (originally published in 1920), presented one of the classic examples of an externality. In the early 1900s, many towns in Great Britain were heavily polluted by smoke coming from factory chimneys. Laundered clothes hung outside to dry were dirtied by the smoke. A study done in the heavily polluted city of Manchester in 1918 compared the cost of household washing in that city with that of the relatively cleaner city of Harrogate. According to the Manchester Air Pollution Advisory Board:

> The total loss for the whole city, taking the extra cost of fuel and washing materials alone, disregarding the extra labour involved, and assuming no greater loss for middle-class than for working-class households (a considerable understatement), works out at over £290,000 a year for a population of three quarters of a million.[4]

Thus, a by-product of production—smoke—unintentionally had a negative effect on another economic activity—clothes-washing.

Why Do Externalities Occur?

Externalities exist when the *social cost* of an activity differs from the *private cost* because of the absence of property rights. In the preceding example, because no one "owns" the air, the factory does not take into account the extra washing costs it imposes on the citizens of the town. As a result, more pollution than is socially optimal will occur because the private cost of the smoke emissions to the firm (zero) is lower than the social cost (£290,000 a year). In general, if nothing is done about negative externalities, environmental damage will result as ecologically harmful products are overproduced and the environment is overused.

To eliminate externalities, the divergence between the social and private costs must be eliminated, either by assigning private property rights (that is, ownership rights) or by direct government regulation. The approach taken often depends on whether property rights can be assigned.[5] The advantage of assigning property rights to an externality is that it creates a market for that product and allows the price mechanism to reflect the value of the externality.

Example of Assigning Property Rights

Suppose a chemical factory locates upstream from a small town and emits waste into the river as part of its production process. Suppose further that the town uses the river as its primary source of water. As a result of these emissions, the town must process the water before use. Clearly there is an externality associated with the firm's use of the water—it is no longer usable to the town without cost. If property rights to the river could be assigned to either the town or the firm, then the two parties could bargain for the most efficient level of pollutants in the water.

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[1]There are many definitions of what constitutes the environment and therefore what is environmental damage. Production pollution results from the act of producing a product. Consumption pollution arises when the act of consuming a product causes pollution. Deforestation reduces both the capacity of the earth to naturally process carbon dioxide and biological diversity. Elimination of a biological species also has environmental implications. Other things that have environmental consequences include product safety standards (such as limiting chemicals that can be used in agriculture) and soil erosion. This paper, unless otherwise noted, focuses on production pollution, the source of many trade-related disputes.

[2]For a more detailed discussion of these problems, see Siebert (1987).

[3]This paper focuses only on negative externalities. Positive environmental externalities occur when one use of the environment costlessly enhances another. For example, cleaning a river for recreational use could also increase its function as a supplier of fish.

[4]Pigou (1952), p.185, footnote 18.

[5]Even if they can, social mores or standards may prevent such an assignment. For example, people might be opposed to selling timber companies the property rights to all trees in national forests.

If property rights are assigned to the firm, the town pays the firm to reduce its pollution. The town's willingness to pay for reduced levels of pollution depends on the benefits it receives from cleaner water. Generally speaking, as the water becomes more pure, the additional (marginal) benefits to the town likely decrease. On the other hand, the firm's willingness to reduce pollution depends on the costs it incurs to reduce pollution by, for example, changing to a more costly production or waste-disposal method. Generally speaking, as the firm pollutes less, the additional (marginal) costs to the firm increase. The amount of pollution agreed upon will be such that the added benefits to the town of a further reduction in pollution are less than the added costs to the firm of the further reduction.

If property rights are assigned to the town, on the other hand, the firm pays the town to pollute. The firm's willingness to pay for the right to pollute depends on the benefits it receives from polluting. These benefits are directly related to the costs it incurs from using a more costly production or waste-disposal method. Similarly, the town's willingness to sell pollution rights depends on the costs it incurs from additional pollution. The amount of pollution agreed upon is where the additional benefits to the firm of increasing pollution are less than the additional costs to the town of additional pollution.

The Coase theorem proves that the equilibrium level of pollution is the same in the preceding cases. Furthermore, such an outcome is efficient.[6] Thus, when property rights are clearly defined and there is an explicitly designated polluter and victim, the efficient outcome is independent of how the property rights are assigned.

Limitations of the Coase Theorem

The key result of the Coase theorem, that the allocation of property rights does not affect the efficient amount of pollution, has limited application. If there are multiple polluters and/or many parties affected by the pollution, the outcome *can* depend on how property rights are assigned. Similarly, if there are significant transactions costs, such as measurement and enforcement costs, the Coase theorem may not hold.[7]

Assume, for example, that two towns are affected by the factory's emissions, one further downstream than the other. Suppose that the town further away from the chemical plant has lower costs associated with cleaning the water. In this case, the amount of compensation the towns would be willing to pay to reduce emissions by any given amount would differ. Thus, the allocation of property rights among the firm and the two towns would affect the outcome of their bargaining.

Suppose, instead, that more than one firm is polluting. Determining how much pollution is coming from each firm, along with ensuring that each firm lives up to any agreement, may be difficult and costly. If monitoring costs are high, the Coase theorem may not hold and the allocation of property rights again affects the choice of optimal emissions.

The lack of general applicability of the Coase theorem is not an indictment of using market-oriented incentives (which usually requires assigning property rights). Most economists believe that market-oriented solutions will lead to the most efficient use of resources because, rather than having the government attempt to estimate preferences, it allows the market mechanism to reveal them.

Government Regulation

Property rights are not always assigned because many uses of the environment are considered public goods. A pure public good is one that has two qualities: First, it is impossible or extremely costly to exclude people from the benefits or costs of the good (non-excludability). For example, even if a person does not contribute to cleaning the air, she still cannot be excluded from breathing the cleaner air. Second, the consumption of the good by one person does not diminish the amount of that good available to someone else (non-rivalry). For example, the fact that one person is breathing clean air does not reduce the amount of clean air others breathe. In this case, property rights cannot be assigned because rationing is impossible.

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[6]See Coase (1960). An (Pareto) efficient outcome is one in which no one can be made better off without making someone else worse off. This type of economic efficiency, however, provides no information or guidance regarding equity issues. For a graphical analysis, see Nicholson (1985).

[7]For a discussion of the limitations of the Coase theorem, see Baumol and Oates (1988).

While few uses of the environment are pure public goods like air, many have enough features of non-excludability and non-rivalry to make assigning property rights virtually impossible. The functions of the environment that are public goods, such as breathable air and clean water, are summarized by the term *environmental quality*.

Regulating environmental quality is difficult because the government first needs to determine the public's demand for environmental quality before deciding the efficient level of pollution. The *free-rider* problem that occurs with public goods makes this determination especially difficult. When people cannot be excluded from use, they have an incentive to understate their willingness to pay for environmental quality because they can gamble that others will be willing to pay. Similarly, if they are asked their preferences and know they will not have to pay, people have an incentive to overstate their desire for a given public good. The degree to which free-riding is a problem depends on the size of the non-rival group affected. The larger the group, the greater the free-rider problem.[8]

For the purposes of this paper, we will assume that to determine the "true" value of public goods, the government measures the costs of pollution reduction and the benefits of pollution abatement accurately.[9] Using a cost-benefit approach, the optimal outcome is where the marginal cost of pollution reduction equals the marginal benefit of pollution abatement.[10]

It is important to recognize that the socially optimal level of pollution is generally not zero. Achieving zero pollution would require an extremely low level of production or an extremely high cost of pollution control. In determining the optimal amount of pollution, both the costs to individuals and industry need to be taken into account.[11]

Example of Government Regulation of the Environment: An Emissions Tax

Recall the previous example of a firm emitting pollutants into a river. Suppose the government decides to regulate the industry because there are too many polluting firms on the river to define property rights adequately.[12] After determining the socially optimal level of pollution, the government imposes a per-unit tax on emissions to reduce pollution to the optimal level.[13]

What happens to production? Figure 1 shows the supply and demand curves for the industry's output. The effect of the tax is to shift the supply curve the distance AB (the additional per-unit cost of output given the new tax).[14] The price rises from P_1 to P_2, and the quantity of output falls from Q_1 to Q_2, which is the output level associated with the efficient emission level.[15] Emissions are reduced and environmental quality improves.

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[8]How to avoid this problem is the source of vast literature in economics and is not discussed in detail here. For a discussion of the free-rider problem in valuing public goods, see Browning and Browning (1983), or any other public finance textbook.

[9]Significant problems face governmental agencies trying to determine the optimal amount of environmental quality. For a discussion of these issues, see Baumol and Oates (1988), Siebert (1987), and Anderson and Blackhurst (1992). For an evaluation of how successful current methods are in the United States, see OECD (1991).

[10]For a more detailed study of cost-benefit analysis, see Mishan (1971).

[11]While it is difficult for many people to think of placing a monetary value on health and life, in reality it is done all the time. For example, though many lives are lost in cars each year, people are not willing to pay the "costs" of outlawing cars to save those lives. For an excellent discussion of this issue, see Blackhurst (1977), footnote 18.

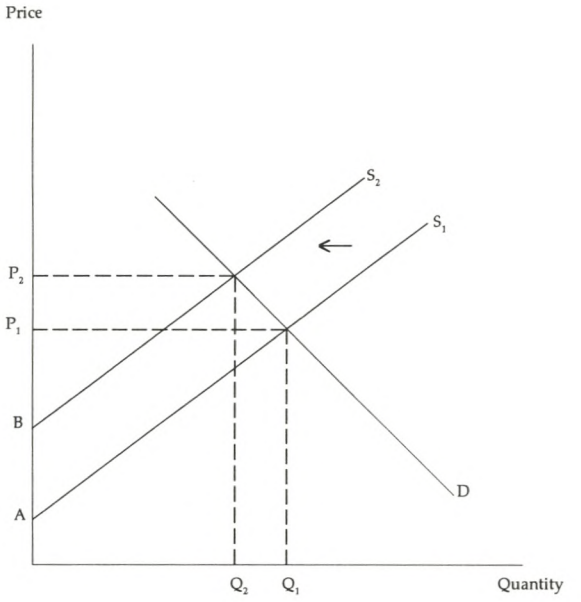
[12]For simplicity, we assume all firms on the river produce the same product and constitute the entire industry. This analysis can be generalized, but it greatly complicates the graphical analysis.

[13]This analysis assumes that the cost of reducing pollution per unit is the same across firms in this industry. One problem with imposing a per-unit tax, however, is that the cost of reducing pollution can vary significantly across firms. One innovative approach to finding the most efficient way to reduce pollution to a given level is the trading of emission permits. In this case, the government decides the maximum amount of each type of pollutant that can be emitted overall and distributes permits to firms, allowing them each a certain level of polluting emissions. The permits can be traded among firms, which allows firms to use firm-specific information to set their own level of pollution. This enables firms for which installing pollution controls is relatively inexpensive to sell emission permits to firms that find it more expensive to install pollution-reduction devices. For a discussion of the theory of emission trading, see Tietenberg (1990) and Nicolaisen, Dean and Hoeller (1991). For a discussion of the effectiveness of emission trading in the United States, see OECD (1991).

[14]This assumes that the per-unit emissions tax increases the cost of production proportionately.

[15]Other means of reducing pollution, such as a tax credit for pollution reduction, may not result in lower output in the industry.

Figure 1
The Effect of an Emissions Tax on Industry Price and Output



THE TRADE-RELATED ASPECTS OF ENVIRONMENTAL QUALITY

Pollution can have international effects in two ways. First, it might be localized within national boundaries but, through the impact of environmental policy, affect a country's international trade. On the other hand, pollution may be transported across borders without the consent of the countries affected (so-called transfrontier pollution). These two types of environmental damage have different effects on international trade and, therefore, are discussed separately.

Why Do Countries Trade?

Countries trade because of differences in comparative advantage. The idea of comparative advantage suggests that, given demand, countries should export products that they can produce relatively cheaply and import products for which they have a relative cost disadvantage. Traditional international trade models ignore externalities such as non-priced uses of the environment.

By not explicitly including the environment as a factor of production, the costs associated with using the environment are ignored. More recent economic models have extended the definition of factors to include *assimilative capacity,* that is, the capacity of the environment to reduce pollutants by natural processes. The degree to which the environment will be affected by its use or by the production of ecologically harmful products depends on its assimilative capacity. The higher the assimilative capacity, the less the environmental damage caused by the emission of a given amount of pollutants. Assimilative capacity can differ across regions and countries and thus is an important factor in determining the effects of environmental use on trade.

Traditional trade models also ignore the non-priced use of the environment as a consumption good. This underestimates the value consumers may place on the environment and therefore the cost of using the environment for other functions. These two factors can be significant in determining a country's comparative advantage.[16]

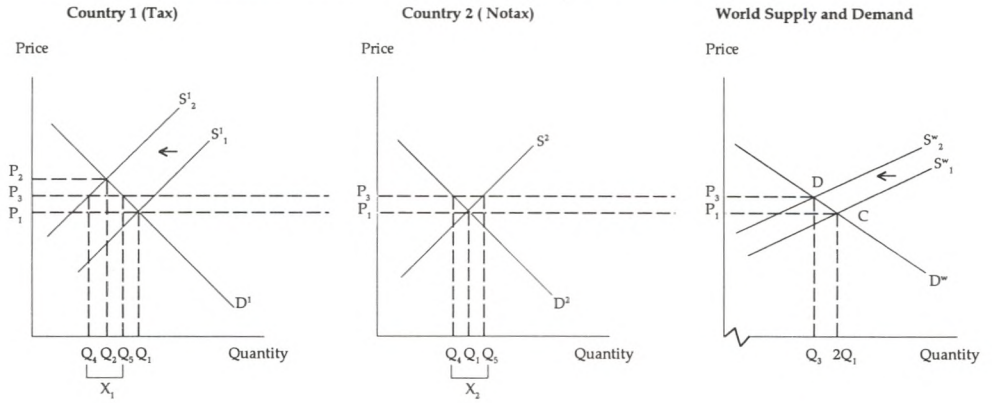
Why Would Countries Choose Different Levels of Environmental Quality?

Assimilative capacity is one of the principal factors affecting a country's choice of environmental quality. In general, assimilative capacity is lower in industrialized countries because of the effects of past pollution. Less-industrialized countries often have greater assimilative capacities and thus can tolerate a higher level of emissions without increasing pollution levels. Population density and geography also affect a country's assimilative capacity. For example, the introduction of a polluting industry in a sparsely populated area, all else equal, will likely not affect the assimilative capacity of that area as much as it would in a densely populated area.

Other factors can also affect a country's willingness to accept environmental degradation.

[16]Recently some have suggested that the United Nations change its system of national accounts to take into account environmental resources. This can be particularly important for countries like Costa Rica that have large environmental resources (see "Wealth of Nature," January 18, 1992). A different system of national accounting could take into account the costs of irreversible environmental destruction, so that, for example, the costs (as well as the benefits) of rapid deforestation are accurately reflected in measures of output growth and wealth.

Figure 2
The Effect of an Emissions Tax on Industry Price and Output in a Two-Country World



For example, poor countries may put a higher priority on the benefits of production (such as higher employment and income) relative to the benefits of environmental quality than wealthy countries. As income levels increase, however, demand for environmental quality also rises.[17] Thus, countries with similar assimilative capacities might choose different levels of environmental quality. As the example below demonstrates, environmental policies that result from differences in countries' preferences and income levels can have significant trade effects.

Environmental Policy When Pollution Is Within National Boundaries

How does environmental policy affect trade? Recall that, in the emissions tax example, the higher production costs that resulted from the tax caused the price of the industry's output to increase and the quantity produced to fall. Assume there is a chemical industry in another country producing the same product with the same level of emissions. For simplicity, assume that, prior to the implementation of environmental controls, each industry produced just enough to meet its home demand, and the price was the same in both countries. As a result, trade did not occur.[18] Suppose, because of different preferences, income levels or assimilative capacity, it is optimal to impose environmental controls in one country but not in the other. What happens to price, output and environmental quality in the two countries?[19]

The answer depends in part on whether the two countries can trade. If trade does not occur, the effect is the same as in the previous example. As figure 1 shows, in the country where pollution controls were imposed, the price will rise to P_2 and the quantity of output will fall to Q_2, while in the other country nothing changes. Figure 2 shows the effect of an emissions tax on price and output in the two countries when trade occurs.[20] The reduction in supply of the chemical in the taxed country (Tax) will reduce the world supply of that product, causing the world supply curve to shift upward to the left. At the new world equilibrium D, the price, P_3, is lower than the autarkic (no trade) equilibrium price in Tax (P_2), but higher than the autarkic equilibrium price in the other country, Notax (P_1). At P_3, consumers in Notax demand Q_4, but firms are willing to supply Q_5. The distance X_2 is exactly equal to the distance X_1, which measures the difference between what firms in Tax are willing to supply at P_3 (Q_4) and what consumers demand at that

[17]See, for example, Grossman and Krueger (1991).

[18]This example generalizes to the case where trade occurs before the implementation of environmental controls.

[19]This section assumes that each country is large enough to affect the world price. If the country with the emissions tax was a small country, it could not affect the world price. As a result, the effect on output in that country would be greater than in the example above.

[20]This assumes prices are in the same currency, so all exchange rate effects are ignored.

price (Q_5). As a result, Notax exports the quantity X_2 of the chemical to Tax.

What is the effect on other economic variables? Consumption of the chemical falls in Notax, even though output rises. In general, because of the increased production in Notax, there will be an increase in pollution emissions in that country. How much the pollution *level* actually increases in Notax (if at all) depends on the assimilative capacity and the method of production used in that country. Whether the people in Notax are better off at the potentially higher level of pollution that resulted from increased production depends on that country's willingness to accept higher pollution for higher income.

Pollution declines in Tax. If the assimilative capacity is higher in Notax, world pollution will likely be lower after environmental controls are implemented. The effect on world employment is ambiguous and depends on certain country-specific variables. The terms of trade will deteriorate for the country with the emissions tax.

If the new level of emissions in each country is optimal given preferences and income, both countries are better off by trade. The taxed country is able to consume more at a lower price than in the autarkic case, while the value of total output rises in Notax. If measures of national income or wealth accurately reflected environmental damage, they would increase in both countries.

Does Environmental Protection Distort Trade?

One concern is that environmental regulation unfairly discriminates against domestic firms when they compete with firms in a country that has lower environmental standards. In the example discussed above, an externality existed in Tax but, by assumption, not in Notax. As a result, introducing environmental controls eliminated a distortion that previously existed. This changed the flow of trade, but caused all the costs of using the environment, both as inputs in production and as consumption items, to be reflected in market prices. Thus, assuming that environmental quality was not socially optimal before protections were enacted, pollution-intensive sectors in Tax were actually receiving an implicit subsidy from those who had been incurring the external costs of pollution.

The difficulties in trying to determine the optimal amount of environmental quality within a country, as discussed above, are substantial. The optimal level of environmental quality in one country is unlikely to be optimal in another, particularly if the two countries have significantly different income levels. Attempting to impose one country's environmental standards on another by using import restrictions does not allow countries to capitalize fully on their comparative advantage.[21] As discussed later, it is also illegal under current international trading rules.

Environmental Policy When Pollution Crosses National Boundaries

The previous section discussed the international effects of environmental policy when environmental damage is contained within national borders. Many other uses of the environment cause environmental damage across borders, such as acid rain, which results from sulphur dioxide emissions, or worldwide, such as ozone depletion, which results primarily from chlorofluorocarbons (CFCs). Transfrontier pollution may occur in essentially four ways:[22]

1. A firm's production takes place in one country, but pollutes *only* in another.
2. Both countries have firms whose production processes pollute, but each country's pollution is experienced *only* in the other country.
3. Pollution occurs as a result of production in one country but the effects are felt in *both* countries.
4. Both countries pollute, and the pollution generated by each is felt in *both* countries.

[21] If Tax puts trade restrictions on imports of chemicals from Notax because of the lack of emission restrictions in Notax, both countries would be worse off. If, for example, a tariff was levied against imports from Notax, the earnings in Notax from exporting the chemicals would be lower. Consumers in Tax would pay a higher price and import a lower quantity as a result of the tariff. For a detailed discussion of the effects of tariffs on trade, see Coughlin, Chrystal and Wood (1988). For a discussion of the possible application of trade and policy measures in relation to environmental problems, see Subramanian (1992).

[22] See Lloyd (1992).

If pollution is of form 1 or 2, in the absence of an international agreement, the polluting country has no incentive to curtail its polluting activities by implementing an environmental policy. If, instead, pollution is of the form 3 or 4, pollution may be regulated domestically. Without taking into account the pollution in the other country, however, these controls will not likely be optimal internationally. In the absence of a globally optimal international agreement, domestic policymakers have less incentive to take into account the costs imposed on a foreign country than if the costs were borne domestically. Thus, from a global perspective there will be excessive use of the environment.

International Policy in the Presence of Transfrontier Pollution

Suppose, as in case 1, the river being polluted by the chemical firm runs directly into another country and all the towns affected are in the foreign country. How is an appropriate policy determined? Previously, we assumed that a country weighed the costs and benefits of pollution, given its preferences for environmental quality, its income level and its assimilative capacity. Unfortunately, in the case of transfrontier pollution, this is no longer sufficient. In this case, domestic policymakers will be less concerned with the costs imposed on a foreign country than those borne domestically. In addition, the desired level of pollution could differ significantly between the two countries because of their preferences and income levels. Other issues contribute to the difficulties in negotiating an international agreement on pollution control. For example, should the polluter pay to reduce emissions or should the residents of the country affected by the pollution pay to induce the firm to reduce emissions?

In the early 1970s, countries belonging to the Organization of Economic Co-Operation and Development (OECD), the multilateral organization of the industrialized countries, adopted the Polluter Pays Principle (PPP) to deal with purely domestic pollution.[23] This principle requires that the polluter bear the cost of pollution-reducing measures. This approach, however, provides no guidance about how to determine environmental damage or what to make the polluter responsible to pay for. For example, should a polluter be responsible for damage that has already occurred, or should it be required only to pay to reduce current emission levels? In addition, PPP offers no instruction regarding transfers between governments to resolve problems of transfrontier pollution.

As a result of an OECD conference on transfrontier pollution, it was suggested that the OECD adopt the so-called "mutual compensation principle." This proposal requires the polluting country to provide an estimate of the costs of pollution abatement for various levels of pollution, while the polluted country similarly provides an estimate of the costs of treating the damages. An independent agency determines the optimal level of pollution with these two cost functions. Given the level of pollution set by the agency and the cost functions provided by the two countries, the polluting (polluted) country pays a pollution (treatment) tax based on the cost of clean-up (control) estimated by the other country and is also required to pay for the cost of pollution abatement (clean-up) in their own country. The advantage of this approach is that it induces countries to reveal their "true" value of the environment.[24] Unfortunately, because of the problems inherent in determining the optimal level of pollution as well as negotiating and implementing such a proposal, the mutual compensation principle has never been used.

There are other impediments to reaching international agreements on environmental use. For certain types of environmental degradation, there is debate about how much damage is actually being done to the environment. An obvious example of this is global warming.[25] Many environmentalists and governments are concerned that excessive emissions of carbon dioxide, nitrogen oxide and methane gas from energy use are irreversibly warming the planet. Many others, including the U.S. government, however, feel that the evidence is insufficient at this point and are unwilling to significantly alter their environmental policy. Scientific evidence on global warming is inconclusive. An August

[23]These countries are the 24 main industrialized countries.

[24]See OECD (1976) for an analytic discussion of why this is true. For more information on the mutual compensation principle, see the discussion therein.

[25]For a discussion of the effects of global warming see, for example, Winters (1992) and Schelling (1992).

31, 1991, survey on energy and the environment in *The Economist* pointed out one of the difficulties with transfrontier environmental damage such as global warming: the appropriate policy may need to be implemented before conclusive proof that the damage appears, because of the cumulative effects of some types of environmental damage over time.

Nevertheless, some international agreements have been reached (see table 1) and, if the significant increase in articles, studies and conferences on transfrontier pollution are any indication, there will be additional pressures to find new ways to deal with the increasing problem of transfrontier pollution.

NORTH-SOUTH ISSUES

One of the main reasons environmental policy affects trade is because countries are at different levels of industrialization and thus have different income levels, which can cause their optimal levels of pollution to differ. Because the interests between high- and low-income countries may differ, it is important to look more closely at these so-called North-South issues.[26]

Currently the industrialized countries, in general, are greater polluters than less industrialized countries and thus tend to put a relatively greater demand on worldwide assimilative capacity. One concern heard in developing countries is that industrial economies, rather than reducing their own demand for assimilative services, could impose their environmental standards on developing countries without any assistance in paying for them, thereby reducing the opportunity for less-industrialized countries to grow. As one news commentator suggests:

> Developing nations are suspicious that born-again environmentalists in the North will saddle them with commitments to regulate pollution, slow down deforestation, and control population growth, all in the name of sustainable development, yet won't follow through with economic aid to improve their own productivity and employment. Meanwhile, developed nations are reluctant to undertake radical domestic [environmental] policy changes that threaten their own economic growth.[27]

Other types of environmental issues have a particular North-South nature. For example, many of the world's nature preserves are in developing countries in Africa. Currently, trade in elephant hides and ivory, along with other endangered species, are prohibited under the Convention on International Trade in Endangered Species (CITES). At a recent conference on CITES in Kyoto, Japan, several African countries argued that their elephant herds are large enough to be culled without endangering the species. In addition, they argued, revenue generated by the sale of ivory and other elephant products is needed to fund future preservation.

Here, the interest of the industrialized countries, who do not have a native elephant population, is to protect an endangered species. The African countries, however, face a tradeoff between the benefits of protecting the species and the loss of revenue associated with the prohibition of trade in elephant products.[28] As a result, less-industrialized countries are putting increased pressure on industrialized countries to help pay for the services they are providing (such as species diversity).

In March 1992, the General Agreement on Tariffs and Trade (GATT), the main body regulating international trade, released a report entitled "Trade and the Environment" that takes a non-traditional approach to North-South problems. One hotly debated issue concerns the protection of the rainforests, most of which are located in Latin America.[29] Industrialized countries have moved to bar wood imports from Brazil and Thailand, for example, as a way to reduce deforestation in those countries. GATT argues that, rather than barring imports of wood products (much of which is GATT-illegal), the industrialized countries should compensate rainforest countries for providing "carbon absorption services."

Although this approach is novel, its advantage is that poorer countries are assisted with financ-

[26]For a more complete discussion of North-South issues in environmental economics, see Walter (1975).

[27]Walter Truett Anderson, in Walljasper (1992), p. 159.

[28]At the close of the Kyoto conference, the calls for partially opening trade in elephants and rhinoceroses were ignored.

[29]Rainforests are valued for, among other things, their ability to reduce carbon dioxide in the air and for the biological diversity they contain.

Table 1

Examples of Multilateral Environmental Agreements with Trade Provisions

Convention Relative to the Preservation of Fauna and Flora in their Natural State, 1933[1]

Objective: to preserve the natural fauna and flora of the world, particularly of Africa, by means of national parks and reserves, and by regulation of hunting and collection of species.

Trade Provision: prohibits the import and export of trophies unless the exporter is given a certificate permitting export. Parties shall take measures to control and regulate in each of its territories the internal import and export of trophies acquired in a manner not in accord with national law (Art. IX).

Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, 1940[2]

Objective: to preserve all species and genera of native American fauna and flora from extinction, and to preserve areas of extraordinary beauty, striking geological formation or aesthetic, historic or scientific value.

Trade Provision: provides for the regulation of trade in protected species by the issuance of export permits (Art. IX).

African Convention on the Conservation of Nature and Natural Resources, 1968[3]

Objective: to conserve, utilize and develop the soil, water, floral and faunal resources of the African continent.

Trade Provision: for all species, a Party shall regulate trade in and the transport of specimens or trophies, and shall do so in such a manner as to prevent the illegal capture or killing of these. Trade in trophies and transport of specimens of protected species shall be subject to a standard authorization (i) additional to that required for the hunting, killing, capture or collection; (ii) which indicates the destination; (iii) which shall not be given unless they have been legally obtained; (iv) which shall be examined prior to exportation. Parties will make the import and transit of such specimens or trophies subject to the presentation of the authorization required under (i) and confiscate illegally exported specimens or trophies (Art. IX). NOTE: Parties are all members of the Organization of African Unity.

ing environmental protection, so that it does not come at the expense of economic development. This approach also reduces the free-rider problem that enables much of the world to benefit from the carbon absorption services provided by rainforests and the diversity of species provided by countries that are not the primary users of the environment. In addition, the approach directly protects the rainforests, rather than barring certain types of wood products in the hopes that doing so will cause the exporting countries to protect them.

Other approaches taken to improve environmental standards in lower-income, less-industrialized countries include debt-for-nature swaps. Here, foreign debt is purchased by environmental groups and sold back to the issuing governments in exchange for investment in local environmental projects, including the purchase of land that is then turned into environmental preserves.[30]

CURRENT INTERNATIONAL REGULATIONS

At present, international agreements do not allow a country to discriminate against products based on their production techniques. Under GATT, barring imports because the production methods used do not meet the standards of the importing country is illegal. This rule has come under fire recently, particularly in light of the

[30]For a discussion of debt-for-nature swaps and a partial list of some of these arrangements, see Devlin (1991).

Table 1 (continued)

Examples of Multilateral Environmental Agreements with Trade Provisions

Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973[4]

Objective: to protect endangered species against overexploitation through international trade.

Trade Provisions: trade of species threatened with extinction (listed in Appendix I), and trade in species that may become endangered unless trade is strictly regulated (listed in Appendix II), is authorized by export and import permits approved by the Scientific Authorities of the Parties concerned (Articles III and IV). Species that a Party identifies as being subject to regulation within its own jurisdiction and as requiring international cooperation to control trade (listed in Appendix III) is subject to an export permit authorized by the Scientific Authority of the Party (Article V). Article XXIII permits a party to exempt itself from the requirements of the convention with regard to a specific species listed in Appendices I, II or III. NOTE: CITES builds on a long history of controlling trade in endangered species through the issue of export permits. It adds the twist of requiring an import permit for an export permit to be issued, in order to prevent circumvention to non-Parties.

Montreal Protocol on Substances That Deplete the Ozone Layer, 1987[5]

Objective: to reduce and eliminate man-made emissions of ozone-depleting substances.

Trade Provisions: trade provisions affect non-Parties only. Parties are to ban the importation of controlled substances as of January 1, 1991, and ban the export of controlled substances as of January 1, 1993. Parties are also to ban the export of the relevant technology to non-Parties. The 1990 amendments, which are not in force, require Parties to ban the importation of CFC-containing products as of January 1, 1993.

SOURCES: GATT (1992) and U.S. Department of State (1991).

[1]The signatory countries are: Belgium, Italy, Portugal, Spain, Sweden, United Kingdom, Egypt, South Africa, United Republic of Tanzania and India. For notes regarding certain countries, please consult original source.

[2]The signatory countries are: United States, Argentina, Brazil, Chile, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay and Venezuela. For notes regarding certain countries, please consult original source.

[3]The signatory countries are: Algeria, Burkina Faso, Cameroon, Central African Republic, Congo, Djibouti, Egypt, Ghana, Ivory Coast, Kenya, Liberia, Madagascar, Malawi, Mali, Morocco, Mozambique, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sudan, Swaziland, Togo, Tunisia, Uganda, United Republic of Tanzania, Zaire and Zambia. For notes regarding certain countries, please consult original source.

[4]The signatory countries are: all OECD countries except Greece, Iceland, Ireland and Turkey; Argentina, Brazil, Costa Rica, Venezuela, Congo, Egypt, United Republic of Tanzania, Zaire, Zimbabwe, India, Indonesia, Malaysia, Union of Soviet Socialist Republics and Israel, plus 73 other developing countries. For notes regarding certain countries and for Appendices I, II and III, please consult original source.

[5]The signatory countries are: All OECD countries except Turkey; Argentina, Brazil, Mexico, Egypt, Kenya, South Africa, Zambia, Malaysia, Thailand, Union of Soviet Socialist Republics, Bulgaria, Czechoslovakia and Hungary, plus 25 other developing countries. For notes regarding certain countries, please consult original source.

controversial tuna-dolphin dispute between the United States and Mexico.[31]

The justification for prohibiting trade restrictions based on the production method is to prevent countries from using such restrictions to protect domestic industries. Unfortunately, GATT was not designed to address some of the more complicated issues of environmental protection, particularly regarding production methods that could have transborder or global

[31]In this case, the United States barred Mexican tuna because the process by which it caught tuna killed more dolphins than is permitted by the United States. According to GATT, however, the ban was illegal because the fishing waters in question were not under U.S. jurisdiction. For a discussion of the tuna-dolphin case, see GATT (1992) or the original panel report.

GATT and the Environment

GATT is a multilateral trade agreement that sets the rules for international trade, provides a mechanism by which to settle trade disputes among countries, and conducts multilateral trade negotiations (called Rounds) to reduce trade barriers. The agreement, however, is silent concerning the complications stemming from environmental policies that have trade effects. The only article that remotely deals with the environment is Article XX, which lists general exceptions to GATT rules. Under Article XX:

> Subject to the requirement that such measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade, nothing in this Agreement shall be construed to prevent the adoption or enforcement by any contracting parties of measures. . .necessary to protect human, animal or plant life or health.[1]

Under GATT, countries can regulate polluting firms in their own country as long as no distinction is made between domestic and foreign-owned firms. In fact, nothing in GATT restricts a government's autonomy in such things as taxation, regulation and subsidies as long as foreign and domestic firms are treated equally.

In regard to polluting consumption goods (e.g., cars that produce air pollution), it is also GATT-legal to place controls on these products, or require pollution control devices (such as catalytic converters), as long as these regulations are applied equally to domestically produced and imported products. These regulations tend to be applied equally, causing fewer trade-related problems with consumption pollution.

According to the recent GATT report on the environment, "In principle, it is not possible under GATT's rules to make access to one's own market dependent on the domestic environmental policies or practices of the exporting country."[2] As a result, two primary sources of conflict have arisen between environmental policy and GATT. The first is the violation of the national treatment provision, which states that foreign firms producing or selling a product in a country must be treated the same as a domestic firm (i.e., a foreign firm located in another country cannot be subject to more stringent environmental standards than a domestic firm). The second is violations of the non-discriminatory status, which states that any trade concession made to one GATT member must be made to all.[3] For example, the trade provisions of the Montreal Protocol stipulate different trade measures for signatories and non-signatories [otherwise known as most-favored nation (MFN) status], which is a violation of non-discrimination.

There are several ways that environmental issues could be explicitly addressed in GATT. The rules could be amended, for example, to set up a penalty system for countries that are below some agreed-upon level of environmental standards. This requires acceptance by two-thirds of the contracting parties (in which countries it thereby becomes effective) and is effective in the other countries as they accept the amendment. The difficulty with this approach is that a sufficient number of member countries must agree to the "acceptable" standards. Even if there are different provisions for developing and industrialized countries, agreement is still likely to be difficult.

Another possibility is that specific waivers may be granted to all or some of the signatory countries. This waiver requires a two-thirds majority of those voting, as long as the

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[1]GATT (1986), p. 37.

[2]GATT (1992), p. 10.

[3]There are, however, GATT-sanctioned exceptions to nondiscrimination, such as the Generalized System of Preferences for developing countries.

majority comprises at least half of the contracting parties. Waivers, however, are not assumed to be long-term solutions, but exceptions for a limited time.

GATT could also clarify whether MFN and national treatment, which requires equal treatment for "like products," consider products that are produced with significantly different environmental standards as "like products." If not, they can be subject to different regulations. The advantage of all of these approaches is that they address environmental issues in a transparent, multilateral way and are not used to mask protectionist policies.

The concern that motivated the recent GATT study is that trade policies justified by a trading partner's environmental policies are often simply another way to protect a domestic industry at the expense of its foreign competitors. The next set of GATT talks will likely attempt to make explicit rules about environmental policy to prevent differences in these policies from being used as a new type of non-tariff barrier.

effects.[32] For a discussion of GATT regulations and environmental protection, see the shaded insert at left.

GATT's recently released report on the environment attempts to address some of these issues. Some have suggested, in addition, that GATT focus the next round of talks on environmental issues (assuming the current "Uruguay Round" of talks is successfully completed).[33] The United Nations-sponsored "Earth Summit" in Rio De Janeiro scheduled for this spring is also an attempt to increase international cooperation on protecting the environment, particularly in regard to North-South issues.

CONCLUSION

This article examines the role of environmental policy on international trade. Environmental policy is justified because of the nature of externalities associated with using the environment. When the divergence between the social and private costs of using the environment is ignored, polluting activities receive an implicit subsidy. Environmental regulations may change international trade, but enhance social welfare by removing this subsidy. The optimal amount of environmental protection, however, can differ significantly across countries because of differences in preferences, income and assimilative capacities.

One important concern is that countries will use environmental policies as an excuse to establish protectionist policies. As environmental protection and environmental use take on a more transnational nature and the assimilative capacity is reduced worldwide, new agreements will have to be designed to both protect scarce resources and protect countries from being discriminated against because of how they choose to use their environmental endowments domestically. As the recent GATT report suggested, however, it is possible to protect the environment without distorting trade flows. Thus, free trade and environmental policy are not mutually exclusive but can work together to encourage both economic growth and environmental quality worldwide.

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[32]For a comprehensive discussion of the application of environmental exceptions under GATT, see Charnovitz (1991), and Sorsa (1992).

[33]For an additional discussion of why GATT should look more closely at environmental regulation, see Petersmann (1991).

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Foreign-Owned Companies in the United States: Malign or Benign?

FOREIGN DIRECT INVESTMENT in the United States increased more than eleven-fold between 1977 and 1990. The rapid increase in U.S. businesses acquired or established by foreign firms has generated much controversy.[1] Some observers worry that foreign-owned firms are more likely than U.S. firms to take actions that would reduce employment, worsen the U.S. trade deficit, inhibit technological progress or threaten national security. Defenders of foreign direct investment stress the increased economic activity stemming from new jobs and the transfer to the United States of improved management, marketing and production techniques.

This paper examines three aspects of foreign direct investment in the United States (FDIUS) to assess whether foreign-owned companies are more likely to have malign or benign effects on the U.S. economy. First, the paper highlights the basic facts about FDIUS—its amount, the home countries of the foreign-owned companies, its distribution across industries and the relative share of the U.S. economy controlled by foreign companies. Second, it summarizes research on what causes FDIUS. Third, it scrutinizes the economic effects of this investment.

THE WHO, WHERE, HOW AND HOW MUCH OF FDIUS

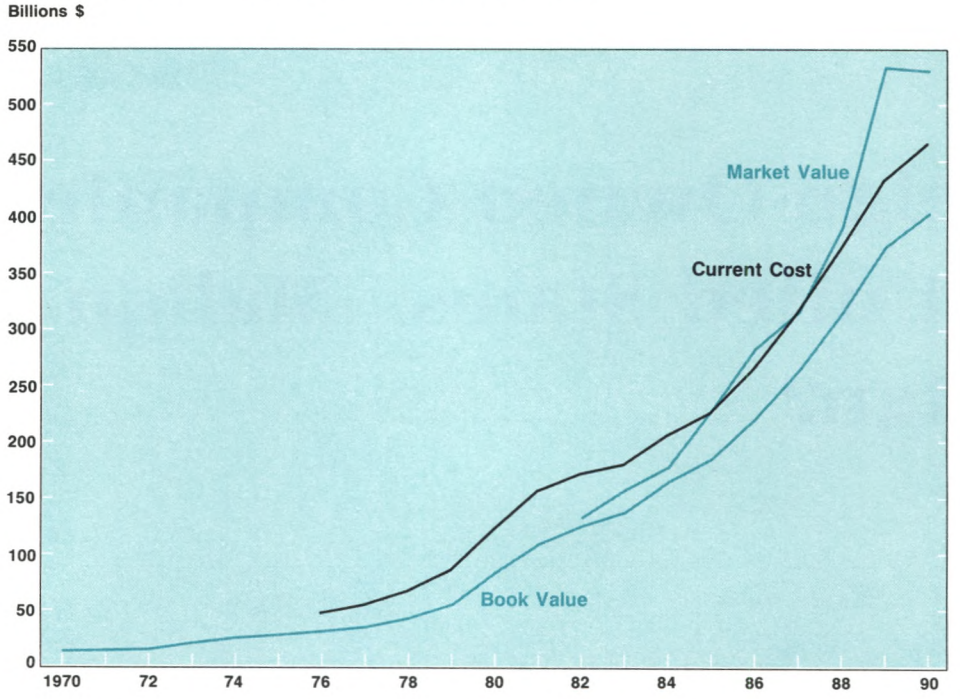
Foreign direct investment (FDI) is the purchase of ownership in, or the flow of lending to, an enterprise located in a foreign country that is largely owned by residents of the investing country. FDIUS results in a foreign enterprise operating in the United States under the control of a firm (or individuals) of a country other than the United States. Thus, FDI is ownership with actual control of the enterprise, which is what distinguishes FDI from portfolio investment.[2]

The official definition of FDIUS used by the Bureau of Economic Analysis requires the investing firm to have a minimum of 10 percent ownership of the enterprise in the United

[1]In fact, the increase in foreign ownership of *all* types of assets in the United States has generated much controversy. See Ott (1989) for a discussion of this broader topic.

[2]Foreign portfolio investment in the United States, such as a Japanese resident owning U.S. Treasury bonds, affords no managerial control; rather, it establishes a claim on an asset for the purpose of realizing some return. As noted in the text, when a foreign firm or resident owns stock in a firm located in the United States, the distinction between foreign portfolio investment and FDI is less clear.

Figure 1
Foreign Direct Investment in the U.S.



States. The use of 10 percent as the dividing line is arbitrary, but unlikely to cause an inaccurate measurement of FDIUS because most U.S. affiliates of foreign firms are majority-owned (that is, the ownership share held by the foreign investor exceeds 50 percent).[3] For example, in 1988 the foreign parent, on average, owned 80.7 percent of the equity of its U.S. affiliate. An ownership share exceeding 50 percent is strong evidence of control, so any misstatement of FDIUS is likely to be small. In fact, preliminary calculations by the Bureau of Economic Analysis reveal that raising the minimum ownership percentage to 20 percent, or even 50 percent, affects only slightly the measure of FDIUS.

How Much FDIUS

The most common measure of FDIUS uses the cumulative stock of prior FDI. This measure is the sum of foreign owners' equity (including retained earnings) for all foreign affiliates, plus net lending to these affiliates from their parents. This investment is measured at its historical cost, that is, the value of the investment when it actually occurred. As figure 1 shows, the book value of FDIUS rose from $13.3 billion in 1970 to $403.7 billion in 1990, an annual growth rate of 18.6 percent.[4] This rapid growth has made the United States the leading host country in the world for FDI.

[3]Graham and Krugman (1991) provide examples to show that the 10 percent ownership requirement can either understate or overstate FDIUS. To illustrate an understatement, assume that 15 Japanese residents together own 80 percent of a firm in the United States, but that no one resident owns 10 percent or more. Even if these foreign owners were not an organized group, foreign interests would largely control such a firm. On the other hand, the treatment of Du Pont illustrates a case in which the official definition of FDIUS overstates the extent of foreign control. Du Pont, 22.9 percent owned by the Bronfman family of Canada, is classified as a Canadian firm, but foreign interests do not have managerial control of the firm.

[4]The rapid growth of FDIUS partially reflects the rapid increase in FDI worldwide. For example, according to Rutter (1990), the world stock of FDI increased from $208 billion in 1973 to $1,403 billion in 1989. Since FDIUS increased faster than FDI worldwide, the U.S. share increased from 10.1 percent to 28.6 percent over this period.

Unfortunately, the use of historical cost ignores the effects of both real and nominal changes in the value of the investment. For example, changes in the earnings prospects of a foreign-owned firm in the United States can change the value of a specific investment, and changes in the overall price level can affect the value of FDI generally. These drawbacks prompted the development of two other measures of FDI. The first, called current cost, re-values investment using estimates of the current value of the net stock of direct investment capital, land and inventories. A second, more general measure is the market value of a firm's net worth. This measure implicitly values both tangible and intangible assets, such as patents and trademarks, because a firm's net worth is the difference between its assets and liabilities.

The current cost and market value measures, also shown in figure 1, reveal two facts. First, like the book value measure, both have grown rapidly in recent years and, second, both differ from the book value of FDIUS. Between 1982 and 1990, the current cost value of FDIUS increased from $173.2 billion to $465.9 billion, an annual growth rate of 13.2 percent, while the market value measure increased from $133.0 billion to $530.4 billion, an annual growth rate of 18.9 percent. These different growth rates have resulted in a book value of FDIUS for 1990 that is 87 percent of the current cost value and 76 percent of the market value.

By themselves, these levels of FDIUS are not especially revealing. One way to provide perspective is to examine the counterpart of FDIUS, the levels of FDI held by U.S. firms. Not only is the United States the leading host country in the world for FDI, it is also the leading source country. Despite the rapid growth of FDIUS, FDI held by U.S. firms as of 1990 exceeds FDIUS, irrespective of the method of measurement. For example, FDI held by U.S. firms in 1990 was $421.5 billion using the book value, $598.1 billion using current cost value and $714.1 billion using the market value. Thus, FDI held by U.S. firms exceeded FDIUS by $17.8 billion, $132.2 billion or $183.7 billion, respectively.

A second way to provide perspective is to calculate the ratio of FDIUS to the total net worth of U.S non-financial corporations (using the book value of each). Between 1977 and 1990, according to Graham and Krugman (1991), this ratio increased from 2.1 percent to 10.5 percent. This suggests "foreign control" of about 10 percent of the U.S. economy.[5]

Another way to assess the extent of foreign control is to examine the share of U.S. workers employed by foreign-owned firms. Between 1977 and 1988, employment at non-bank foreign-affiliated firms rose from 1.7 percent to 4.3 percent of all U.S. non-bank employment.[6] When one focuses only on the manufacturing sector, the share rises from 3.5 percent to 8.9 percent.

No matter which measure is used, foreign ownership and control have increased substantially in recent years.[7] The level of foreign control, however, is not as high as it is in most other developed countries. For example, according to Julius and Thomsen (1988), the share of foreign-owned firms' manufacturing employment in 1986 was 7 percent in the United States, 21 percent in France, 13 percent in Germany, 14 percent in the United Kingdom and 1 percent in Japan. Except for Japan, the rapid increase in FDIUS has made the level of foreign control in the United States closer to that of other developed countries.

The How of FDIUS

FDIUS occurs in either of two ways. One way, termed "greenfield" investment, involves the construction of new production facilities in the United States—either brand new subsidiaries or expansions of existing subsidiaries. The other method of FDIUS is the acquisition of existing U.S. firms. Despite some greenfield investments

[5]There are problems with such an assessment. First, both the numerator and the denominator are measured according to book value. A better measure would use market values. Since the market value of FDIUS exceeds the book value, the numerator would clearly increase. To determine how the ratio would change, the market value of U.S. non-financial corporations is required. This might produce a reduction in the ratio. Another problem is that this ratio does not measure the extent to which these claims are leveraged through less than 100 percent ownership and borrowing from unrelated parties into control over a larger amount of assets. For example, a foreign investor with 80 percent ownership of a company with $100 million in assets controls $100 million in assets, but the measure of FDIUS indicates control of only $80 million (80 percent of $100 million).

[6]For 1977, see Graham and Krugman (1991), page 12 and, for 1988, see *Survey of Current Business*, July 1991, page 77.

[7]Figures for 1990 and 1991 reveal a slowdown of FDIUS. It is premature to say whether the smaller flows are temporary or more long-lasting.

Table 1

Sources of Growth in Foreign Control of U.S. Firms (billions of dollars)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990[1]
Investment in:											
Acquisitions	$9.0	$18.2	$6.6	$4.8	$11.8	$20.1	$31.5	$33.9	$64.9	$59.7	$56.8
Establishments	3.2	5.1	4.3	3.2	3.4	3.0	7.7	6.4	7.8	11.5	7.7

[1]Figures are preliminary.

SOURCE: BEA, "U.S. Businesses Acquired or Established by Foreign Direct Investors in 1990," *Survey of Current Business*, May 1990, supplementary tables 5 and 11; see various issues of the *Survey of Current Business* for prior years.

that have generated much publicity, such as the opening of Japanese-owned automobile plants, FDIUS has occurred primarily by way of acquisitions. Table 1 shows the relative dominance of acquisitions from 1980 to 1990. For example, the $56.8 billion outlay in 1990 by foreign firms to acquire existing firms was more than seven times larger than the $7.7 billion outlay to establish new subsidiaries.

The Who and Where of FDIUS

FDIUS occurs in various industries and involves numerous, primarily developed, foreign countries. As figure 2 shows, the United Kingdom, whose share of FDIUS was 26.8 percent in 1990, is the leading source country. The other leading investors and their shares in 1990 are: Japan—20.7 percent; the Netherlands—15.9 percent; Germany—6.9 percent; and Canada—6.9 percent. Despite having a smaller share than the British, Japanese FDIUS has generated much more publicity than British FDIUS. Part of the reason for this attention is due to the industries in which the Japanese are involved, of which more is said later, and part is due to the rapid rise of Japanese FDIUS in the 1980s. Between 1980 and 1990, Japanese FDIUS increased at an annual rate of 33.3 percent, boosting the Japanese share from 5.7 percent to 20.7 percent.

Table 2 shows that the largest share of FDIUS remains in manufacturing. Between 1980 and 1990, investment in this sector increased nearly fivefold. Since total FDIUS increased similarly, the manufacturing share of FDIUS was slightly less than 40 percent in both 1980 and 1990. The United Kingdom is the leading foreign investor in manufacturing by a wide margin. In 1990, its share was 33.1 percent, more than double the Netherlands' 15.3 percent. The other leading investors are: Germany—9.5 percent; Japan—9.5 percent; and Canada—5.8 percent. The largest portion (26 percent) of manufacturing FDIUS in 1990 was in chemicals, followed by machinery (18.5 percent), food processing (14.3 percent) and primary and fabricated metals (11 percent).

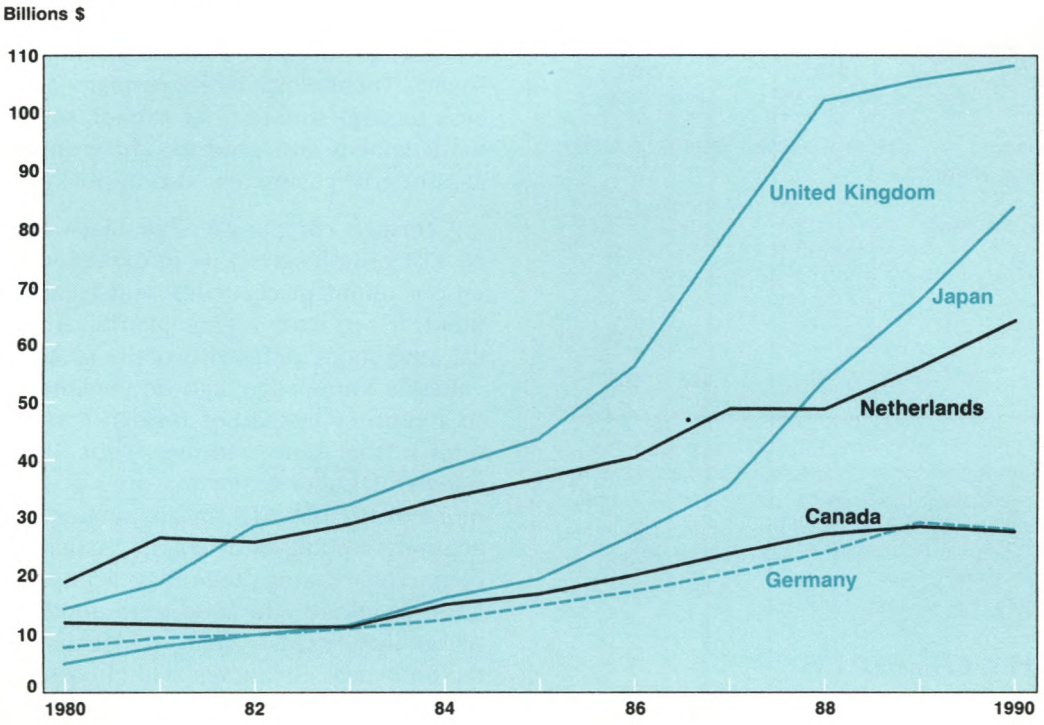
The wholesale and retail trade sector has the second-largest share of FDIUS. Its share was 15.4 percent in 1990, down from 18.3 percent in 1980. These shares, however, are likely overstated because of the method used to allocate industry statistics: wholesale trade in automobiles includes some manufacturing of automobiles. As automobile production by Japanese-owned affiliates increases, sales of automobiles manufactured in the United States will rise relative to the sales of automobiles imported from Japan for resale. As this occurs, more affiliates will be reclassified from wholesale trade into manufacturing, causing reported FDIUS in transportation equipment manufacturing to rise and FDIUS in wholesale trade to fall.

Finance and insurance accounted for 9.7 percent of FDIUS in 1990, up from 8.9 percent in 1980. Countries with major financial markets—Japan, the Netherlands, Switzerland, Canada and the United Kingdom—account for the majority of this investment.

The share of FDIUS in petroleum, the fourth-leading industry, declined from 14.7 percent in 1980 to 9.4 percent in 1990. According to Rutter (1991), there were fewer acquisitions in petroleum than in most other industries during the decade. In fact, both foreign and domestic investment in the petroleum industry grew relatively slowly during the 1980s.

The remaining industries, real estate and banking, are probably the most controversial.

Figure 2
Foreign Direct Investment in the U.S. by Major Source Country



The share of FDIUS in real estate increased from 7.3 percent in 1980 to 8.6 percent in 1990. The $34.6 billion of real estate FDIUS reflects the investment of foreign parents in U.S. affiliates whose major activity is real estate. Large amounts of U.S. real estate are also held by affiliates classified in other industries. Thus, the actual level of real estate FDIUS exceeds $34.6 billion. In addition, the value of assets actually controlled by foreign owners is likely much greater because of the high debt leverage in this industry (foreign investors are able to control real estate valued far greater than their own equity by borrowing from unrelated parties).

Some of the controversy surrounding this investment is because foreign ownership of real estate tends to be concentrated in a few locations, such as Hawaii, downtown Los Angeles and Houston and a few other urban areas. Some foreign ownership may also go unreported; however, Graham and Krugman (1991) conclude its importance is likely to be small. A final cause of controversy is the large share of Japanese ownership.[8]

The Japanese also play a prominent role in the FDIUS that has occurred in banking. Between 1980 and 1990, the share of FDIUS in banking declined from 5.5 percent to 4.7 percent; however, foreign ownership in the U.S. banking industry is large and has been increasing. In 1980, 11.9 percent of the total assets of all U.S. banks were held by financial affiliates of foreign banks and holding companies. By 1990, this figure had risen to 21.2 percent, more than half of which is held by Japanese-owned banks.[9]

[8]The U.S.-Japanese controversy encompasses much more than Japanese ownership of real estate in the United States. For an examination of one of the key sources of controversy, the U.S. bilateral trade deficit with Japan, see Butler (1991).

[9]For a more complete discussion of FDIUS in banking, see Lund (1991).

Table 2

Foreign Direct Investment in the United States by Industry (dollar amounts in billions)

Industry	1980 Level	1980 Share	1990 Level	1990 Share
Manufacturing	$33.0	39.8%	$160.0	39.6%
Wholesale and Retail Trade	15.2	18.3	62.0	15.4
Finance and Insurance	7.4	8.9	39.3	9.7
Petroleum	12.2	14.7	38.0	9.4
Real Estate	6.1	7.3	34.6	8.6
Banking	4.6	5.5	19.1	4.7
Other Industries	4.5	5.4	50.7	12.6
Total	$83.0	100.0	$403.7	100.0

SOURCES: Data for 1980 from BEA, "Foreign Direct Investment in the United States in 1983," *Survey of Current Business* 64, no. 10 (October) 1984, table 12; data for 1990 from BEA, "The International Investment Position of the United States in 1990," *Survey of Current Business* 71, no. 6 (June) 1991, table 7.

THE WHY OF FDIUS

Much research has been devoted to developing theoretical explanations of FDI. The importance of specific factors that might explain FDIUS has also been examined thoroughly. Rather than provide an in-depth review of this voluminous literature, let's examine the primary explanation of FDI, which is based on the "industrial-organization" approach, and the commonly identified determinants of FDI. It is important to stress that this explanation is most useful in discussing FDI in manufacturing.

FDI Theory: The Industrial-Organization Approach

Standard FDI theories rely on "firm-specific advantages" to explain why it occurs.[10] The foreign investor must have some advantage over local firms to compensate for the fact that the multinational corporation (MNC) incurs additional costs because of 1) cultural, legal, institutional and linguistic differences; 2) a lack of knowledge about local market conditions; and 3) lengthier lines of communication and, therefore, an increase in communication failures.

A foreign investor's advantages can take many forms. Technology is the primary advantage; access to large amounts of capital, superior management and products differentiated by successful advertising are also important.

A foreign company's advantages are exploited by FDI only if, given its information and expectations about prices, costs and legal environment, it can earn higher profits. Any technological advantage, defined broadly as economically valuable knowledge, can be exploited by exports to a country instead of foreign production and sales in that same country. Thus, the firm selects FDI over exporting only if the former is more profitable. FDI and exporting, however, are not the only alternatives. A firm with a technological advantage may license a firm in another country to produce a good using its technology.[11] Once again, the firm with the technological advantage will choose the route with the highest anticipated profits.

Firm-specific advantages have led scholars to develop theories of FDI in which the MNC has some unique market power.[12] Two variants of the so-called industrial-organization approach, one most closely associated with Hymer (1976) and the other with Magee (1977), demonstrate this approach.

In Hymer's view, because a foreign direct investor is one of a small number of producers of a specific good, the firm can affect the price of the good by altering its production. By decreasing its production, the firm can force the market price higher and vice versa. The MNC, according to Hymer, uses FDI strategically to limit competition and protect its market power. Thus, the MNC engages in FDI to beat its competitors into a particular foreign market.

[10]An alternative theory explains FDI by requiring that foreign firms have access to capital at a lower cost than domestic firms. As Graham and Krugman (1991) point out, this approach is subject to serious criticisms. First, foreign investors with relatively lower capital costs can achieve higher returns by portfolio investments as well as by FDI. Therefore, this approach does not differentiate among various types of investment. In addition, the facts that, first, FDI is frequently financed by funds provided by the host country and, second, FDI among developed countries, which is the majority of worldwide FDI, often occurs in both directions, raise doubts about the cost of capital explanation.

[11]For an elementary discussion of the choice among FDI, exporting and licensing by firms in the beer brewing industry, see Karrenbrock (1990).

[12]See Cantwell (1991) and Graham and Krugman (1991), appendix B, for summaries of industrial-organization explanations of FDI.

Some concerns have been raised about FDI in this context because of fears that the foreign investor, as part of the firm's commitment to investment, will extract promises from the host government to limit imports from other competitors or prevent FDI by other competitors. If this were to happen, there would be little competition in the host country for the foreign investor. Consumers would ultimately pay higher prices than they would in the absence of trade or investment restrictions.

In Magee's view, which is known as the appropriability theory, the firm-specific advantages that stimulate FDI do not reduce competition in product markets. Even though firm-specific advantages allow the MNC to generate profits, they do not imply that the firm will necessarily have market power in product markets. Rather, FDI allows the benefits of technology to spread.

FDI is necessary for the firm to "appropriate" the potential gains from its technology. Generally speaking, the reasons to favor FDI over the explicit sale of the advantage to outsiders revolve around the difficulties involved in market transactions. In some cases, the technology involved in an activity, such as running a factory, is spread among members of a group. Since the knowledge is not easily summarized or communicated, it is hard to package and sell. Such a market transfer is complicated further because it is difficult for a potential buyer to decide how much the knowledge is worth. If the buyer had sufficient information to value the knowledge, he would likely know as much as the seller and, thus, have no reason to buy the "technology."

The appropriability theory, therefore, stresses the importance of the transfer of technology from one country to another within an MNC. Restrictions on FDI limit the transfer of the firm-specific advantages of MNCs. Since these advantages contribute to rising productivity and incomes, restrictions on FDI flows into a country can harm that country's economic performance.

Empirical Evidence on FDIUS

The rapid rise of FDIUS since the late 1970s has prompted much research that attempts to isolate specific factors that explain it. Since FDI theory stresses the importance of technological differences, the role of technology in the rapid growth of FDIUS is examined first. The effects of exchange rate changes, taxation, protectionist pressures and the business cycle on FDIUS are then explored.

Table 3

Royalties and License Fees (millions of dollars)

	Receipts of U.S. affiliates from foreign parents	Payments by U.S. affiliates to foreign parents
1982	$ 69	$ 398
1983	60	465
1984	68	665
1985	102	568
1986	171	773
1987	240	1083
1988	238	1205
1989	343	1662
1990	333	1954
Compounded annual growth rate	21.7%	22.0%

SOURCE: BEA, "Foreign Direct Investment in the United States: Detail for Position and Balance of Payments Flows," *Survey of Current Business*, various issues.

Technology and FDIUS

The preceding views of FDI stress the importance of the transfer of technology from a parent to its foreign affiliate. MNCs, however, can also transfer technology from the affiliate to the parent. Rapid increases in foreign direct investment in the United States during the 1980s have worried some observers that foreign firms are investing primarily to acquire U.S. technology, which could harm the competitive position of U.S. firms.

One way to assess international transfers of technology involving U.S. affiliates of foreign-based MNCs is to compare receipts of royalties and license fees *from* their foreign parents with payments of such fees *to* their foreign parents. Receipts measure the value of technology transferred from foreign-owned companies in the United States to their parents, while payments measure purchases of technology from their parents. According to table 3, both measures have increased at annual rates of more than 20 percent since 1982. Payments by U.S. affiliates, however, far exceed receipts in each year and were nearly six times the value of receipts in

1990. Thus, technology transfers are occurring to a far greater extent from foreign-based MNCs to their American affiliates than the reverse.

While the preceding evidence is consistent with FDI theory, it still does not explain why FDIUS has risen faster than FDI by U.S. firms. Once again, the role of technology in FDI theory provides insights. One explanation revolves around the shrinking and, in some cases, reversal of U.S. technological superiority. Generally speaking, from the end of World War II until 1970, U.S.-based firms had substantial advantages over foreign-based firms in technology and management skills. These advantages caused FDI abroad by U.S.-based firms to exceed FDIUS. Over the last 20 years, however, foreign-based firms have developed such advantages of their own to a far greater extent than they had previously; these advantages have provided a stimulus to FDIUS.[13] Thus, the increasing role of foreign firms in U.S. production can be related to changing patterns of the development of new technology and management innovations throughout the world.[14]

Exchange Rate Changes and FDIUS

While a pre-eminent role in explaining FDIUS can be ascribed to technology, other factors can affect FDIUS. One common argument is that a "weak" foreign exchange value of the dollar encourages FDIUS. In many discussions, a weak dollar is not defined formally, but is used informally as a value lower than its value at some previous point. The lower value of the dollar has two effects that could stimulate FDIUS. First, it deters exports to the United States as U.S. consumers are faced with higher prices. Therefore, foreign firms might find it more attractive to locate production in the United States rather than export a smaller quantity. Second, the lower value of the dollar makes U.S. productive assets cheaper for foreign firms than they were previously.

While a weak dollar makes production in the United States more attractive, all other things the same, it is crucial to emphasize that FDIUS depends on whether the U.S. productive assets are worth more to a foreign-based firm than to a U.S.-based firm. A declining dollar raises the expected returns to both a U.S. owner and a foreign owner. How might the expected returns rise more for the latter than the former?

One argument focuses on the changing composition of production in the United States. As the dollar declines, U.S. competitiveness shifts from non-traded sectors, such as services and retail trade, to traded sectors, such as manufacturing. Since FDI is more substantial in traded than non-traded sectors, production in the United States shifts from areas in which foreign-owned companies have little involvement to areas in which they have much more involvement.[15]

It is unclear exactly what impact changes in the foreign exchange value of the dollar have on FDIUS.[16] What is clear is that the long-run upward trend in FDIUS beginning in the late 1970s took place during a strengthening as well as a weakening of the dollar. Thus, the evidence suggests that changes in the value of the dollar are, at most, a factor that has had slight effects.

Tax Rate Changes and FDIUS

Changes in tax policy have also been viewed as a potential determinant of FDIUS. Two major changes in U.S. tax policy in 1981 and 1986 may have contributed to the timing of changes in the rate of FDIUS. To assess the impact U.S. tax changes on FDIUS, such changes must be viewed in conjunction with the tax systems of the source countries.

Generally speaking, two types of tax systems can be identified in the leading source countries for FDIUS. Countries with "territorial" corporate taxation, like the Netherlands and Canada, do

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[13]Kudrle (1991) notes that four recent books on FDIUS agree that the share of advantages held by firms based outside the United States has grown substantially relative to U.S.-based firms in recent years. See Chandler (1986) for a history of MNCs and global competition.

[14]Ray (1991) provides evidence that superior management underlies many acquisitions, while technological advantages of new physical capital and of relatively large operating plants have stimulated greenfield investments.

[15]A related argument by Froot and Stein (1989) highlights the role of relative wealth effects. A declining dollar raises the value of foreign firms compared with U.S. firms. If firms are limited in their borrowing capacity by their debt-equity ratios, the declining dollar raises the purchasing power of foreign firms. This may allow a foreign firm to outbid a U.S. firm in an attempt to acquire assets in the United States.

[16]Identifying the impact of exchange rate changes is complicated by the necessity of distinguishing between temporary and permanent changes. If an exchange rate change is viewed as temporary, a firm's choice between exporting and FDI is unlikely to be affected.

not attempt to tax the income earned by the subsidiaries of firms based in their countries. Countries with "worldwide" systems, like the United Kingdom and Japan, tax the earnings of subsidiaries while granting a tax credit for taxes paid to host-country governments. For example, under a worldwide system, subsidiaries of foreign firms pay corporate profit taxes similar to those paid by domestic firms. When they repatriate income to their parent, the income is subject to taxation at the home-country rate, with a credit for taxes paid to the U.S. government.

The differing tax systems provide different investment incentives for given U.S. tax changes. In the early 1980s, U.S. corporate taxes were reduced by accelerated depreciation allowances.[17] By allowing firms to reduce their taxable incomes, these cuts were valuable to U.S.-owned corporations. The cuts should also have been valuable to foreign firms, though they were more valuable to those subject to territorial rather than worldwide taxation. Firms subject to worldwide taxation faced the offsetting effects of reduced tax credits.

Overall, the tax cuts provided relatively more benefits to U.S.-owned firms than foreign-owned firms and, thus, were biased against FDIUS. In addition, the bias against firms from the United Kingdom and Japan, countries with worldwide systems, was greater than against firms from the Netherlands and Canada, countries with territorial systems. These incentives were reduced in 1986 when tax legislation eliminated the special investment incentives.

Generally speaking, little empirical evidence suggests that tax rate changes have played a major role in FDIUS. The share of FDIUS from the Netherlands and Canada relative to Japan and the United Kingdom did not rise from 1981 to 1986 and fall thereafter. Slemrod (1990) also fails to find that tax changes affect FDIUS.

There is, however, some empirical evidence that changes in taxes matter. The preceding argument suggested that U.S. tax cuts deterred FDIUS, while tax increases encouraged FDIUS. Extending this argument across industries, FDIUS should be higher in industries subject to higher tax rates on capital. In fact, Swensen (1990) has found such a positive association; Klein and Rosengren (1991), on the other hand, found no such association. In addition, Auerbach and Hassett (1991) found no evidence that the 1986 tax changes have influenced FDIUS. Overall, the empirical evidence points, at most, to a very small role for tax policy in affecting FDIUS.

Trade Barriers and FDIUS

Another factor identified as a potential determinant of FDIUS is actual or potential protectionist measures. The basic idea is that a trade barrier, or the threat of imposing one, will induce FDIUS because the profitability of production in the United States by the foreign-owned firm would rise relative to exporting to the United States. Underlying such behavior, of course, is some advantage possessed by the foreign-owned firm.

The fact that trade barriers are frequently thought of as protecting U.S.-owned firms is ironic. In fact, such protection tends to increase foreign control in the U.S. economy. A domestic industry demanding protection is likely to be one in which foreign firms have special advantages. Trade barriers erected in that industry simply attract FDIUS, stimulating additional foreign-owned production.

Protectionism has played a role in FDIUS.[18] The production of automobiles and color television sets are two examples.[19] Nonetheless, protectionism is not likely to have become so large a factor that it can explain the rapid increase in FDIUS.

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[17]A depreciation allowance reflects the reduction in the value of assets arising from their use in producing goods and services. For tax purposes, these allowances reduce net profit and, therefore, taxes. An acceleration of these allowances means that larger reductions in the values of assets are recognized earlier in their productive lives.

[18]See Ray (1991) for empirical evidence that the desire to circumvent trade restrictions has motivated FDIUS.

[19]See Graham and Krugman (1991) for brief case studies of production in the United States of both automobiles and color television sets. The authors state that by the mid-1970s Japanese producers of color television sets had developed better designs and production systems than U.S. producers. As a result, Japanese producers were able to produce higher quality sets at lower prices than U.S. producers. U.S. producers sought and received protection from their foreign competitors in the form of a ceiling on the quantity of color television sets exported to the United States. To evade the export limitation, Japanese firms simply established production facilities in the United States and used their advantages to outperform their U.S. competitors. Thus, in this industry, the voluntary export restraint stimulated FDIUS.

The Business Cycle and FDIUS

A final factor affecting FDIUS is the business cycle. The business cycle characterizes the extent to which the level of economic activity in the United States and abroad changes over time. Julius (1991), in a study of inflows into France, Germany, Japan, the United Kingdom and the United States found that FDI rose faster than output during economic recoveries and fell faster during recessions.[20] Changes in economic activity, however, are not likely to affect the relative shares of foreign- vs. U.S.-controlled production substantially because the business cycle affects the profit expectations of foreign and domestic investors similarly.

THE EFFECTS OF FDIUS

The major controversies about the effects of FDIUS encompass economic as well as political issues.[21] In addition, there are national security issues that involve economic and political considerations. This paper, however, examines the issues that are primarily economic.[22]

Technology Transfer and Research and Development Effects

FDI facilitates the movement across national borders of goods, services and, most important, technology by reducing some transaction costs that inhibit trade. For example, reaching an agreement to transfer technology within a MNC is much easier (that is, less costly) than it is with two separate companies.

The benefits of the trade stimulated by the expansion of MNCs come from three sources. The first source is known as comparative advantage. Countries have different combinations of productive resources, and goods are produced with different combinations of these resources. Trade allows countries to benefit by producing goods that, relative to other countries, they can produce and sell cheaply and exchanging them for goods that can be produced and sold more cheaply abroad. The second source of gains from trade requires increasing returns to scale. With trade, countries can produce a narrower range and larger quantities of goods than they could otherwise. Longer production runs may allow firms to achieve lower per unit production costs. Finally, trade reduces the power of firms to set prices (that is, increases competition) and allows consumers to enjoy larger quantities and lower prices.

Looking specifically at trade in technology, FDI allows a firm to appropriate (or capture) the benefits of its own research and development. When the foreign investor produces goods and services using its own technology, it is as if there were trade in the results of research and development. From the firm's point of view, its appropriation of benefits provides the incentive to engage in research and development in the first place. The data in table 3 illustrates the importance of trade in technology. Recall that, for 1990, the value of technology transferred from foreign parents to U.S. affiliates was nearly six times that transferred from U.S. affiliates to their foreign parents.

Proponents of FDI frequently stress the generation of what are termed "external benefits." Foreign firms may not be able to appropriate all of the gains from the technology they transfer. Instead, domestic firms can learn and imitate the transferred technology and management methods, and workers may take their acquired skills and use them in other jobs. Unfortunately, these external benefits are difficult to measure.

On the other hand, critics argue that FDIUS tends to reduce the spillover of external benefits, particularly those associated with engaging in research and development. Research and development involves many complex intellectual activities undertaken by highly skilled employees. Critics suggest that these activities tend to be located near the headquarters of the parent firm. Since the headquarters of foreign-owned firms are located outside the United States, some are concerned that research and development activities might be shifted out of the United States. For example, as more of the

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[20]Similarly, Ray (1991) found that FDIUS is associated with large and growing product markets in an expanding economy.

[21]Analyses of the impact of FDIUS on the U.S. economy have been hampered because of data problems. The Foreign Direct Investment and International Financial Data Improvements Act of 1990 authorizes different agencies of the U.S. government to exchange confidential information to improve the quality of data, some of which is to be published during summer 1992. See Moczar (1991) for details.

[22]See Graham and Krugman (1991) for an overview of both the political and national security issues associated with FDIUS. One concern is that foreign-owned firms might bias U.S. political decisions toward their interests. Choate (1990) argues that Japanese firms have an undue influence on U.S. public policy.

Table 4

Research and Development by U.S. Affiliates of Foreign Firms, 1988

	Affiliates	U.S. Firms	
		Total[1]	Company-funded
All industries			
R&D (millions of dollars)	$7,834	$97,889	$65,583
R&D per worker (thousands of dollars)	2.04	1.07	0.72
Manufacturing			
R&D (millions of dollars)	6,903	89,776	60,223
R&D per worker (thousands of dollars)	3.78	4.64	3.11

[1]Includes federally funded as well as company-funded expenditures.

SOURCES: Data for affiliates from BEA, "Foreign Direct Investment in the United States: Operations of U.S. Affiliates of Foreign Companies," revised 1988 estimates, tables H-1 and F-1; data for U.S. firms from National Science Foundation, *Science Indicators* (Washington: National Science Foundation, 1989).

U.S. chemical industry is controlled by foreign-owned firms, critics charge that larger shares of research and development in this industry will be shifted abroad.

One way to assess the importance of this "headquarters" effect is to compare research and development expenditures in the United States by all U.S. firms with those by U.S. affiliates of foreign firms. Table 4 contains summary information about research and development that runs counter to the headquarters effect argument. As the table shows, research and development expenditures per worker for all industries were nearly twice as large for affiliates of foreign firms ($2,040) than for all U.S. firms ($1,070). If one limits research and development expenditures to those that are company-funded, the difference becomes even larger.

These differences partially reflect the industrial composition of FDIUS, because most research and development occurs in manufacturing. U.S. manufacturing firms spend larger amounts per employee on research and development ($4,640) than U.S. affiliates of foreign firms ($3,780), a pattern that is reversed when only company-funded expenditures ($3,110) are counted. All in all, there is little evidence that a headquarters effect exists.

Employment and Wage Effects

Without question, the most controversy about FDIUS concerns employment. Advocates of FDIUS suggest that the rising number of U.S. employees in foreign-owned firms represents the creation of new jobs. Critics stress that FDIUS is a dynamic process, which may or may not create jobs. While critics concede that new plants and expansions of existing plants lead to the creation of new jobs, they reject the general presumption that acquisitions create new jobs. For acquisitions to create jobs, one would have to argue that, without the foreign purchase, the jobs in the acquired firm would have been eliminated and no other U.S. firm would have expanded following the closing of an acquired firm. Such an argument strains credibility. A more realistic view is that acquisitions have little effect on jobs and primarily reflect the transfer of jobs from U.S. to foreign owners.[23]

Graham and Krugman (1991) argue that the focus on job creation reflects a fundamental misunderstanding of how the U.S. macroeconomy functions. The supply of labor is the key de-

[23]Glickman and Woodward (1989) stress that the job creation effects of FDIUS have been "much less than meets the eye."

Table 5

Compensation per Worker in U.S. Firms and U.S. Affiliates of Foreign Firms, 1987 (thousands of dollars)

Industry	U.S. affiliates	All U.S. firms
All industries	$29.8	$24.2
Mining	43.8	39.7
Petroleum	41.8	56.7
Manufacturing	32.9	31.3
Food and kindred products	27.3	27.4
Chemicals and allied products	38.2	41.1
Primary and fabricated metals	36.1	33.1
Machinery	32.3	35.0
Other manufacturing	29.8	26.4
Wholesale trade	33.9	30.0
Retail trade	12.9	13.6
Finance, insurance and real estate[1]	51.2	31.5
Banking	n.a.	27.2
All other industries	29.3	23.9

n.a. = not available.

[1]Excluding banking.

SOURCES: Data on U.S. affiliates from BEA, "Foreign Direct Investment in the United States: Operations of U.S. Affiliates of Foreign Companies," revised 1987 estimates, table F-1; data on all U.S. firms from "National Income and Product Accounts," *Survey of Current Business* 70, no. 7 (July) 1990, tables 6.4B and 6.6B.

terminant of employment in the long run. Aggregate demand for goods and services and, thus, the demand for labor, can vary in the short run, causing employment to change; however, in the long run, the economy will move toward its so-called natural rate of unemployment. This rate is unaffected by the degree of foreign ownership of firms in the United States. Thus, the net impact of FDIUS on U.S. employment is negligible.

More important than the number of jobs associated with FDIUS is the types of jobs.[24] This issue is frequently described as "good" jobs are being replaced by "bad" jobs. One argument is that foreign-based firms prefer to engage in high-wage activities at home, while engaging in low-wage activities in the United States. Some contrary evidence has already been presented. For example, there is no evidence that foreign-based firms perform research and development in the United States, a high-wage activity, to a lesser degree than U.S. firms do.

Another way to examine job quality is to compare the wages of workers employed by foreign owners with those of U.S. owners. Table 5 indicates that compensation per worker in U.S. affiliates of foreign firms is comparable to that in U.S. firms. For all industries, pay by U.S. affiliates of foreign firms was $29,800 in 1987, substantially more than the $24,200 paid by U.S. firms. This difference, however, is primarily because the distribution of FDIUS tends to be more pronounced in higher-paying industries than U.S. investment generally.

Looking at specific industries, there is little difference in compensation per worker between the two sets of firms, except in petroleum and finance, insurance and real estate. For example, workers employed by U.S. affiliates of foreign firms in the primary and fabricated metals

[24]Reich (1991) argues that a nation's standard of living is increasingly dependent on the value of the skills and insights that its workers contribute to the world economy. Since workers learn by doing, a foreign-owned firm that hires Americans to either solve or identify complex problems helps the U.S. standard of living to a greater degree than a U.S.-owned firm that contracts with foreign workers to do the same. In such an environment, the key to well-being is to increase the skill levels of workers.

Table 6

Employment and Foreign Trade of U.S. Multinational Corporations and U.S. Affiliates of Foreign Firms, 1988

	U.S. multinationals		Affiliates of foreign firms	
	All industries	Manufacturing	All industries	Manufacturing
Employment (thousands of workers)	17,935.2	9,815.0	3,844.2	1,828.6
Exports (millions of dollars)	$215,392	$147,882	$69,541	$25,192
Imports (millions of dollars)	179,543	69,340	155,533	32,762
Exports per worker (thousands of dollars)	12.01	15.07	18.09	13.78
Imports per worker (thousands of dollars)	10.01	7.06	40.46	17.92

SOURCE: Graham and Krugman (1991), p. 68.

manufacturing sector averaged $3,000 more in compensation than all U.S. workers in this sector. Meanwhile, in the chemicals and allied products manufacturing sector, the former averaged $2,900 less than the latter. Thus, there is no evidence that FDIUS is causing good (high-paying) jobs to be replaced by bad (low-paying) jobs.

Trade Balance Effects

Another source of controversy concerns the export and import activity of foreign-owned firms in the United States. Critics charge that foreign-owned firms are major contributors to U.S. trade deficits. Table 6 provides data on which such charges are based.

Comparing parent companies of U.S.-based MNCs in manufacturing with U.S. affiliates of foreign firms in manufacturing, one finds that U.S. affiliates of foreign firms export less per worker ($13,780 vs. $15,070) and import more per worker ($17,920 vs. $7,060) than parent companies of U.S.-based MNCs.[25] Caution is required in interpreting these numbers, however.[26] First, to infer that, on average, when a foreign firm acquires a firm in the United States, imports per worker will more than double, is inappropriate. There is no reason to expect the newly acquired firm to change its trading pattern substantially simply because of a change in owners.

Second, especially with greenfield investments, FDI in manufacturing frequently begins with assembly operations that require many imported inputs; however, over time, local sourcing grows. Japanese auto manufacturing in the United States provides an example of how local content has increased over time. For example, the General Accounting Office (1990) reported that the U.S. content of output by Japanese-owned U.S. automobile affiliates increased from 38 percent in 1988 to 50 percent in 1989.

Closely related is the fact that FDIUS might be displacing imports. In other words, the produc-

[25]Graham and Krugman (1991) argue that using all industries rather than manufacturing only overstates the differences between U.S.-based MNCs and U.S. affiliates of foreign companies. These numbers, which show that U.S. affiliates of foreign firms both export and import more per worker ($18,090 vs. $12,010 and $40,460 vs. $10,010, respectively), are misleading because some foreign-owned firms are primarily trading branches. For example, the trading operations of Japanese automobile firms are foreign-owned and, as a result, have a large effect on the import numbers.

[26]The accuracy of imports per worker by U.S. affiliates of foreign firms is important for assessing the profitability of FDIUS. Lawrence (1990) and others have noted that FDIUS has not been especially profitable. For example, the ratio of income to equity for FDIUS in manufacturing in 1987 was 5.9 percent, less than half the 12.8 percent return in U.S. manufacturing. One explanation is that foreign-owned companies under-report their U.S. earnings by overstating the cost of imports purchased from their parents. If undertaken, this practice, termed transfer pricing, shifts profits and tax revenue from the United States to foreign countries. An alternative explanation, supported empirically in a study released by the Organization for International Investment (1992), stresses the rapid growth of FDIUS relative to investment by other corporations. The rapid growth of FDIUS has caused foreign-owned companies to incur substantial start-up costs and large expenses for interest and depreciation, causing their net income and pre-tax rates of return to fall below that of corporations in general.

tion associated with FDIUS could reduce imports. For example, prior to Japanese automobile production in the United States, purchases of Japanese automobiles were entirely imports. Now, even though the typical Japanese automobile produced in the United States might have less U.S. content than the typical U.S. automobile produced in the United States, the fact that some portion of the Japanese automobile is produced in the United States means less imports than previously.

Finally, it is important to note that the trading behavior of foreign-owned firms, like trading behavior in general, is beneficial. The technology being transferred from foreign firms to their U.S. affiliates, which the affiliate is importing, makes the affiliate more productive and, thus, more competitive. Similar statements can be made about other imported inputs. To the extent that trade allows the U.S. affiliate to make better use of its resources, the U.S. economy gains.

CONCLUSION

No matter how it is measured, foreign direct investment in the United States has increased substantially since the late 1970s, primarily via acquisitions. The current level of foreign ownership, however, is not high relative to that in most other developed countries. In addition, the foreign direct investment of U.S. firms still exceeds FDIUS.

Overall, the rise in FDIUS can be viewed as the result of technological developments abroad that are being transferred to the United States. Other factors have also affected FDIUS. There is general agreement, for example, that the business cycle affects FDIUS and that, in some industries, the threat of protectionism or protectionism itself has influenced the investment decisions of foreign firms. Foreign exchange and tax rate changes have had, at most, slight effects.

The transfers of technology are a positive development in that they reflect the expectation that production in the United States will be profitable. For the United States as a whole, this transfer of technology allows resources to be more productive, not only in the industry directly affected by the FDI, but also possibly in other industries because of external benefits.

Critics have raised numerous concerns about whether foreign-owned firms in the United States behave differently than U.S. firms and whether this behavior might be detrimental to U.S. interests. These concerns do not stand up to empirical scrutiny. For instance, more technology is being transferred into the United States than out of the United States. The research and development activity of foreign-owned firms is similar to that of U.S. firms. Compensation in foreign-owned firms is similar to U.S. firms, suggesting that foreign ownership is not replacing good jobs with bad ones. Finally, while foreign-owned firms tend to import more than they export, it is far from certain that this is detrimental to U.S. interests.

Overall, foreign-owned companies are a positive factor in making the U.S. economy more competitive and productive. Advocates of public policies to deter foreign ownership should be viewed with skepticism.

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Foreign Exchange Intervention by the United States: A Review and Assessment of 1985-89

THE FEDERAL RESERVE Bank of New York, acting as an agent of the U.S. Treasury, occasionally intervenes in foreign exchange markets. These actions, which involve the purchase or sale of assets denominated in foreign currencies in exchange for dollars, are intended to affect the exchange rate by altering the asset supplies denominated in one currency relative to that of another. Intervention can be directed to a variety of objectives including a change in the level of the dollar exchange rate, a reduction in the volatility of the dollar's value around some level, or an adjustment of the Federal Reserve's holdings of assets denominated in foreign currencies relative to its holdings of dollar-denominated assets.

This article explains the mechanics of foreign exchange intervention for people who are not specialists in this area of study and identifies avenues through which sterilized intervention conceivably could affect the exchange rate. It then describes and analyzes daily data recently released by the Federal Reserve Board on its intervention activities in the Deutsche mark (DM) and Japanese yen for the period 1985-89. Because these data had been confidential and similar data from the Bundesbank and Bank of Japan still are not publicly available, investigating the effects of intervention on the exchange rate has been difficult for at least two reasons. First, without hard data on the activities of all central banks involved, statistical tests and inferences require assumptions about the unknown actions of some participants. Second, even with complete data, stating an hypothesis about the effectiveness of intervention is subject to further assumptions about the unknown objectives of the central banks involved.

Recognizing these limitations, the last section of this paper nonetheless attempts to test several hypotheses about the effectiveness of intervention.[1] While offering no firm conclusions on its effectiveness during the period examined, the

[1]See Almekinders and Eijffinger (1991) or Weber (1986) for a survey of issues and evidence on the effectiveness of intervention.

newly-released Fed data and some qualitative data on the timing of foreign central bank interventions give a flavor of the frequency and scale of these activities. And, under certain assumptions, these data also identify some circumstances under which intervention had statistically significant effects on the DM/dollar and yen/dollar exchange rates.

THE EXCHANGE RATE AND INTERVENTION

An exchange rate is simply the relative price of two currencies. So, for example, if two Deutsche marks can be exchanged for $1, the dollar price of 1DM is $.50; conversely, the DM price of $1 is 2DM. Just like any relative price in the marketplace, the value of the exchange rate is determined by the interaction of the supply and demand for the two currencies.

One reason for intervention is to avoid exchange rates that are higher (or lower) than some perceived "correct" level, which can have deleterious short-run effects on a country's international trade.[2] To see how foreign exchange intervention might be used to affect the level of the exchange rate, refer to figure 1. Panel A shows the markets for the dollar and DM, using an exchange rate of 2DM per $1 (1DM = $.50) as an initial market equilibrium. This equilibrium is shown by points A and A′ at the intersections of the respective supply and demand curves in the two markets.

Without developing a theoretical model of the variables that may cause a change in either the supply or demand for either currency—and, hence, cause a change in the exchange rate—assume that the demand for dollars by German citizens rises, shifting $D^0_\$$ rightward to $D^1_\$$ and creating a new equilibrium in the market for dollars at point B.[3] Here, the new DM price of $1 has risen to 2.5, which implies that, for an equilibrium to exist in the market for DM, the dollar price of one DM must have fallen to $.40 (1/2.5). A change in the equilibrium price of dollars will cause a corresponding change in the equilibrium price for DM because changes in supply (demand) of one currency necessarily will cause corresponding changes in the demand (supply) of the other currency to reach the new equilibrium price in that market. In other words, if the increased German demand for dollars raises its price to 2.5 DM, then German citizens have increased the supply of DM they are willing to offer for sale in the market for any given value of the exchange rate. Indeed, the DM supply curve (S^0_{DM}) must shift outward until, at its new position (S^1_{DM}), the dollar price of DM has fallen to the new equilibrium value of $.40.

If this change in the exchange rate were deemed undesirable by policymakers, then the two central banks that control the supplies of dollars and DM could alter these supplies to restore the original exchange rate of 2DM per dollar. Though central banks often attempt to act jointly, each reinforcing the action of the other, assume for present purposes that the Federal Reserve embarks on intervention alone.[4] If the Fed's intention is to restore the initial equilibrium, the figure shows that it must increase the supply of dollars to a position at $S^1_\$$ so that the intersection with $D^1_\$$ occurs at the original equilibrium exchange rate of 2DM per dollar (point C). The Fed would try to accomplish this by purchasing DM in the open market in exchange for dollars which, by withdrawing DM from circulation, would move the DM supply

[2]Purchasing a foreign good requires the exchange of the home currency for an amount of foreign currency equal to the foreign price of the good, so that changes in the exchange rate can affect the amount of goods one country exports and another imports. Indeed, many observers who perceive the persistent U.S. deficits in merchandise trade as a problem have recommended policies to reduce the dollar's value. Although a reduction in the dollar's *nominal* value is potentially a short-run stimulant to exports, only changes in its *real* value (nominal value adjusted for price level differences across countries) will have a permanent effect on exports. See Batten and Belongia (1984) for further discussion of the distinction between real and nominal exchange rates and the consequences of this distinction in debates about exchange rates and trade flows.

[3]Throughout, we will focus on the effects of changes in relative money supplies alone as the main determinants of exchange rate changes. This is not in itself controversial in theoretical discussions of exchange rate determination, although economists have been unable to agree on other elements of a theoretical model to represent exchange rate behavior. Other factors typically incorporated in such models are differentials between domestic and foreign real growth and between domestic and foreign interest rates. This potential role for interest rate differentials is discussed briefly in the appendix. For discussions of models of exchange rate determination see Krueger (1983). For a survey of some empirical issues, see Mussa (1979).

[4]This assumption is made for ease of exposition. Balbach (1978) presents an extensive list of ways that intervention may be conducted by involving the U.S. Treasury's Exchange Stabilization Fund, the Federal Reserve and foreign central banks. For a specific example of how the Bundesbank might act to support the value of the DM, see Batten and Ott (1984).

Figure 1
Panel A
Changing the Level of the Dollar's Value

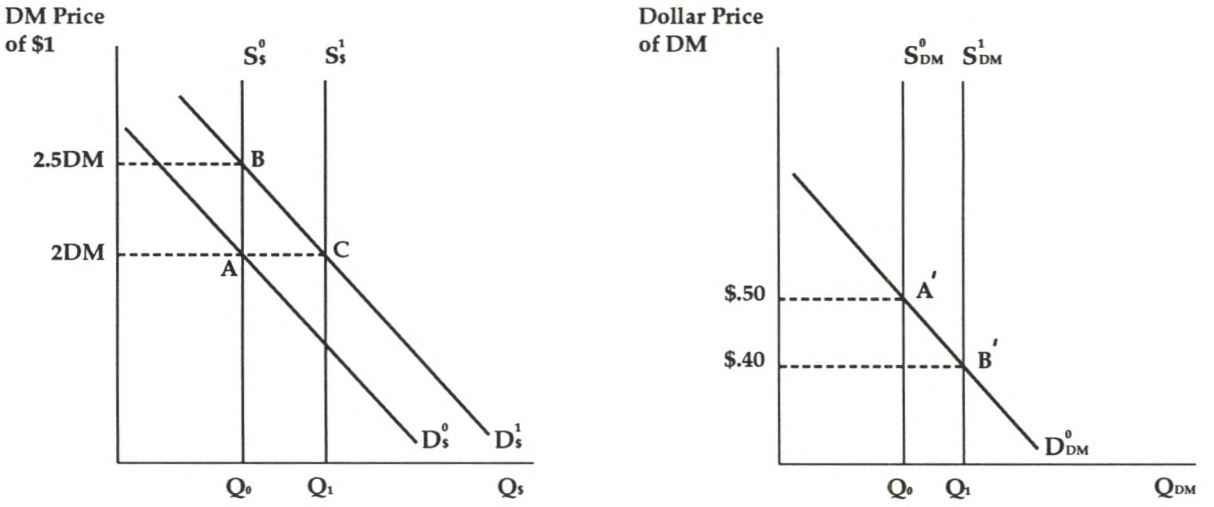
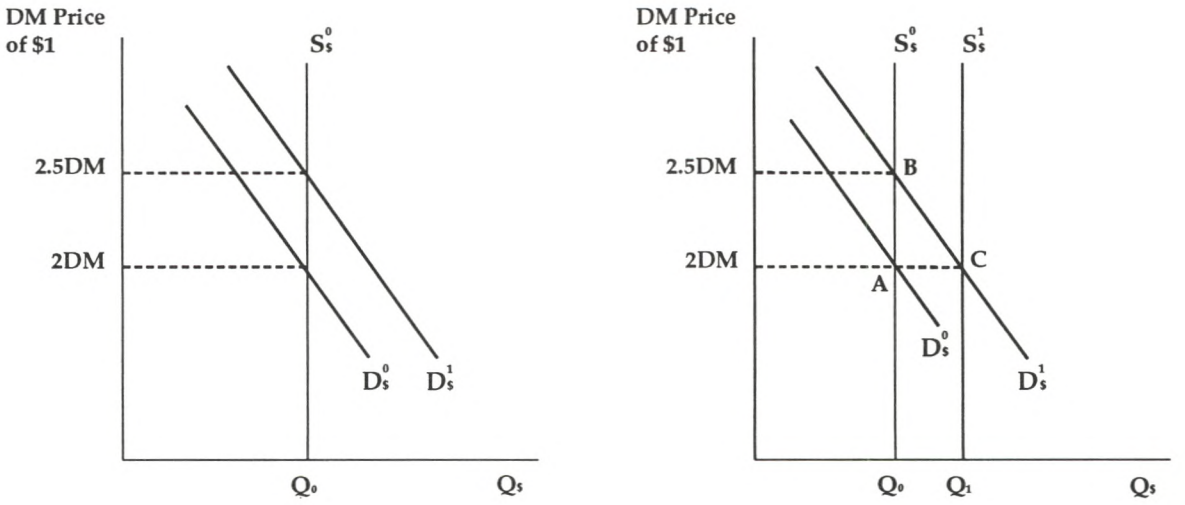


Figure 1
Panel B
Stabilizing the Dollar's Value Around a Target Level



curve back to its original position at S^0_{DM}. Increasing the quantity of dollars in circulation relative to DM will reduce the dollar's value in terms of DM. All other factors the same, this simple example shows how, by altering the relative quantities of any two currencies in circulation, central banks might be able to change the prevailing level of the exchange rate. Precisely how the Fed would conduct this operation is discussed in a later section.

Another point, which will be developed more fully, needs to be mentioned here. As the example shows, the exchange rate changes because the supply of dollars has changed relative to the supply of DM. Direct intervention is not necessary, however, to achieve this result. Instead, a central bank can affect the exchange rate (by design or as a side effect of actions directed to other goals) by changing its money supply during normal domestic open market operations and without any sales or purchases of foreign-denominated assets. Conversely, some central banks, such as the Bundesbank and Swiss National Bank, conduct their *domestic* monetary policy through transactions in the foreign exchange market rather than through transactions in a domestic credit market in the manner of the Fed's purchases and sales of U.S. Treasury securities.[5] Therefore, if intervention is to be viewed as an independent tool of monetary policy, it must be able to alter the exchange rate without affecting the operations of domestic monetary policy.

Intervention and Exchange Rate Volatility

In addition to altering the level of the exchange rate, another reason for intervention is to dampen the volatility of exchange rate movements. Though the level of the exchange rate might not change much over time, some people believe that erratic short-run fluctuations in the exchange rate can be destabilizing. For example, people in two countries may have contracts to buy or sell a good or service on an agreed date at an agreed price. A random fluctuation in the exchange rate just before the contract date will inflict unexpected losses on the buyer whose currency has depreciated (because he must give up more units of his domestic currency to get the same number of units of the foreign currency to pay the seller of the good). Conversely, the buyer whose currency has appreciated will realize windfall gains. To the extent these effects occur and are thought to be unpredictable, the exchange rate fluctuations behind them may impede international trade as exporters and importers perceive such transactions to be risky.[6] Indeed, the perception that exchange rate volatility impedes trade flows is the rationale for the current European Monetary System (EMS) and for the planned move to a single currency in the European Community (EC) by 1999.[7]

To see how intervention can reduce or eliminate volatility, consider panel B of figure 1. For simplicity, both panels refer only to the market for dollars. Referring to the left panel, assume there are random movements in the demand for dollars between positions at $D^0_\$$ and $D^1_\$$. For a given supply of dollars, the DM/$ exchange rate will fluctuate between 2.0 and 2.5. To offset these fluctuations, as shown in the right panel, the Federal Reserve could intervene to increase the supply of dollars to $S^1_\$$ when the demand for dollars rises to $D^1_\$$, and intervene to reduce the supply of dollars to $S^0_\$$ when the demand for dollars falls to $D^0_\$$. Abstracting from real-world problems such as adjustment lags, lack of information, changes in the supply or demand of DM, and other factors that may inhibit exchange rate smoothing, such a strategy conceivably could keep the DM/$ exchange rate at a value of 2.0 as it moved between the supply and demand equilibria represented by points A and C. The equilibrium at point B, where the exchange rate rises to 2.5, would be eliminated by successful intervention. Presumably, trade would increase if exporters and importers became convinced that intervention eliminated the risk of an exchange rate change.

[5]The foreign exchange market is used in these cases because the government securities market does not have the depth necessary for central bank open market operations.

[6]Buyers and sellers can protect themselves from these losses by hedging their transactions; see Williams (1986) for more detail on how hedging of foreign exchange risk can be accomplished. Rolnick and Weber (1989) report that the costs of hedging against this sort of exchange rate volatility range from 0.5 percent to 3 percent of total foreign sales. For the U.S. in 1989, this would have put the costs of hedging exchange rate risk between $6.5 billion and $39 billion.

[7]The EMS was founded in 1979 to keep bilateral exchange rates among EC currencies within relatively narrow bands—(+) or (−) 2 1/4 percent of an agreed level was typical for most currencies. For an overview of the mechanics of this system, see Ungerer, et al. (1986); for a critique, see Belongia (1988) or Meltzer (1990).

STERILIZED VS. UNSTERILIZED INTERVENTION

In the two examples of intervention just discussed, the value of the exchange rate was altered only if there was a change in one money supply relative to the other. Moreover, these examples assumed that only the Federal Reserve was intervening. Complications would arise if, on the one hand, one or more other central banks reinforced the Fed's activities by selling dollars and purchasing DM while the Fed was trying to reduce the dollar's value against DM. On the other hand, other central banks could have subverted the Fed's intervention goals had they made equal and offsetting purchases of dollars and sales of DM. Generally speaking, in the presence of large and highly developed world markets for the major currencies, the exchange rate between any two ultimately depends on the *world* supplies and demands for them rather than on the limited actions of just one central bank.

Although the case of two central banks working at cross-purposes may seem unlikely, individual central banks often take two, largely offsetting, actions when they intervene in exchange markets. This "sterilized" intervention occurs when a central bank undertakes an open market operation in its domestic market that exactly offsets the effects of its actions in the foreign currency market on the domestic money supply. Such intervention is called sterilized because the two actions, on net, produce no change in the domestic money supply. The problem, of course, is that, without affecting the money supply, there is presumably no avenue for sterilized intervention to affect the exchange rate.[8] Understanding these procedures will be important to the statistical tests that follow because Federal Reserve interventions are routinely sterilized.[9]

To understand sterilized intervention and the mechanics behind the shifts in the supply of dollars shown in figures 1A and 1B, consider the simplified Federal Reserve balance sheet shown in figure 2. Before any intervention occurs, the Fed's assets are U.S. Treasury securities and its liabilities are the reserves of the U.S. banking system; these two items are the sources and uses of the monetary base which, in turn, is the basis of the U.S. money supply. If the Fed wanted to increase the U.S. money supply, it would make an open market purchase of Treasury securities from U.S. banks and pay for them by crediting the reserve balances of these banks at the Fed. Thus, both the assets and liabilities sides of the Fed's balance sheet would increase. A simplified Federal Reserve balance sheet showing the effects of injecting reserves into the U.S. banking system is depicted in the top panel of figure 2.

Now consider what happens when the Fed decides to engage in foreign exchange intervention. Say that at 4:30 a.m. New York time (10:30 a.m. in Frankfurt, Germany), the Fed and the Bundesbank agree that they should try to reduce the value of the dollar by some amount. To do so, the U.S. money supply must be increased relative to the German money supply. As a matter of practice, the Fed could purchase DM-denominated deposits that large U.S. banks hold with German banks and pay for them in the same way the Fed would conduct a normal open-market operation: by crediting the reserve accounts of the U.S. banks that sold their DM deposits. These transactions are shown in the two left-hand accounts in the lower panel of figure 2.

The process does not end there, however. When the drafts made against the DM accounts of U.S. banks are presented by the Fed to the Bundesbank for clearing, this transaction adds the DM deposits of the Fed to the Bundesbank's liabilities but reduces the reserves of the German banking system; this is shown in the right-hand columns in the lower panel of figure 2. This draining decline in reserves reduces the German money supply. Conversely, the U.S. money supply rises because this transaction increases both the assets and liabilities sides of the

[8]A question arises, in the context of the simple supply and demand mechanics of exchange rate determination, why a central bank would engage in sterilized intervention. Two arguments have been advanced along these lines. A recent one, with some empirical support, is that such activities provide a valuable "signal" to participants in the foreign exchange market about the future course of monetary policy and its likely effects on future values of the exchange rate; see Dominguez (1988, 1990). Another argument, for which the empirical support has been mixed, is that foreign and domestic assets are imperfect substitutes and that, by altering their relative supplies through sterilized intervention, the exchange rate can be changed by affecting the differential between domestic and foreign interest rates. For a general review of theory and evidence, see Henderson (1984).

[9]See Balbach (1978).

Figure 2
Domestic Open Market Operations and Foreign Exchange Intervention

Panel A: An Expansionary U.S Open Market Operation

Federal Reserve Banks (FRB)		U.S. Commercial Banks (cb)	
Assets	**Liabilities**	**Assets**	**Liabilities**
+ U.S. Treasury securities	+ Reserves of cb	– U.S. Treasury securities	
		+ Reserves	

Panel B. U.S. Intervention to Reduce the Dollar

Federal Reserve Banks (FRB)		U.S. Commercial Banks (cb)		Bundesbank (B)		German Commercial Banks (Gcb)	
Assets	**Liabilities**	**Assets**	**Liabilities**	**Assets**	**Liabilities**	**Assets**	**Liabilities**
+ DM deposits at B	+ Reserves of cb	+ Reserves			+ DM deposits of FRB	– Reserves	– DM deposits of cb
		– DM deposits at Gcb			– Reserves of Gcb		

Fed's balance sheet. If no further action is taken, these actions would reflect *unsterilized* intervention because they alter the relative supplies of dollars and DM.

Under current practices, however, the action made at 4:30 a.m. New York time will be reversed at 11:30 a.m. when the Open Market Desk of the New York Fed conducts its domestic open market operation for the day. To achieve its domestic reserve objectives, the Open Market Desk assembles projections each day of elements of the Fed's balance sheet. Thus, the staff will note that the foreign exchange activity of several hours ago had the effect of increasing the reserves of the U.S. banking system and will be reflected as an increase in the monetary base.

Consider, for example, that the Open Market Desk of the New York Fed would have determined—absent any intervention—that the System's domestic objectives for that day would be met without an open market operation. If the intervention activity caused a $1 billion increase in the monetary base, the domestic Desk, noting this effect, would undertake a $1 billion *sale* of U.S. Treasury securities to reduce reserves. Thus, the desire to achieve its domestic monetary objective has led to actions that cancel the domestic effects on the money supply of the earlier intervention. Indeed, because offsetting domestic open market operations leave bank reserves, the monetary base, and, hence, the supply of dollars unchanged, the only effect of sterilized intervention is a change in the composition of the Fed's balance sheet. Its holdings of foreign-denominated assets increase and its holdings of U.S. Treasury securities fall, but the domestic money supply is unchanged. (See the appendix for a more detailed discussion of how other channels might operate and how sterilized intervention, in fact, may not be "sterilized" in the conventional use of the term.)

These mechanics highlight the fact that, if a central bank wishes to change the nominal value of its currency, it need not intervene in the foreign exchange market at all. Instead, because relative money supplies determine to a large extent the relative values of the two currencies in question, domestic open market operations alone can have the same effect on the exchange rate as unsterilized intervention.[10] Ac-

[10]Weber (1986) makes this point in much greater detail.

cording to the simple theory outlined in the preceding section, a central bank wishing to reduce its currency's nominal value need only engineer a rate of money growth faster than the growth rate of the money supply in the other country. In this context, the very rapid growth rate of M1 in the United States from May 1985 through December 1986 has been interpreted by some economists as an attempt by the Federal Reserve to reduce the dollar's value without engaging in any substantial intervention activity.[11] Conversely, an increase in the dollar's value can be achieved by engineering a relatively slower growth rate of the money supply.[12] This suggests that exchange market intervention may be motivated by a central bank's desire to give signals to market participants or to alter the relative shares of domestic and foreign assets on its balance sheet, rather than to alter the level of the exchange rate directly.

UNITED STATES INTERVENTION: 1985-89

Figures 3-6 provide a general reference to movements in the DM/$ and yen/$ exchange rates and the scale of U.S. intervention during the period 1985-89; neither the Fed nor the U.S. Treasury undertook any intervention in 1986. Negative values in the bottom portions of these figures indicate a sale of dollars—that is, a purchase of the foreign currency by the U.S. authorities. Although matching exchange rate and intervention data in this manner offers the temptation of making inferences about cause and effect, the discussion that follows will indicate that this strategy is not warranted.[13]

To put figures 3A and 3B, showing exchange rate and intervention data for 1985 in the proper context, note that the dollar's value peaked against both the yen and DM in February, then fell by more than 6.5 percent against both currencies by the end of August. During the weekend of September 22, 1985, the now-famous Plaza Accord was agreed upon in a meeting of Finance Ministers of the G-5 countries at the Plaza Hotel in New York. In effect, this agreement pledged support for coordinated intervention to reduce the dollar's value.[14]

In contrast to the press coverage of the time, the data show, first, that declines in the dollar's value between February and September occurred with little or no intervention by the Federal Reserve or the Treasury. Figures 3A and 3B also show that the United States limited its intervention activities to a period of 34 days immediately following the Plaza agreement. Finally, U.S. *cumulative* purchases of yen and DM during this 34-day period amounted to only $1.44 billion and $1.86 billion (equivalent), respectively. These figures can be contrasted with *daily* volume in the New York market alone that averaged $129 billion per day in April 1989.[15] Therefore, even if the comparable trading volumes of the London and Tokyo markets are ignored, (which would raise total daily volume to in excess of $400 billion) the actual scale of intervention typically was a trivial share of total volume in the foreign exchange market during this period.

The data for 1987 in figures 4A and 4B also highlight at least two interesting features of recent U.S. interventions. The first is that the dominant activity switched from purchasing foreign currencies and selling dollars—which would tend to reduce the dollar's value—to selling foreign exchange and buying dollars—actions consistent with supporting the dollar's value. The figures also show that this intervention occurred over a period of steady declines in the dollar's value. Indeed, between the time of the Plaza Accord in September 1985 and March 1987, when a new burst of intervention occurred, the dollar's value fell from 231.90 yen and 2.73 DM to 151.70 yen and 1.83 DM. Although no rationale was made public for each intervention, the data for early 1987 are consistent with the view that U.S. Treasury officials believed further declines in the value of the dollar below these levels should be resisted.

The Louvre Accord, reached on February 20, 1987, marks a second interesting period. This agreement brought together the G-7 Finance

[11]See, for example, Bernanke and Mishkin (1991).

[12]Bordo and Schwartz (1990, pp. 5-6) provide evidence on relative rates of M1 growth in the United States, Germany and Japan and corresponding movements in the DM/$ and yen/$ exchange rates since 1985.

[13]Briefly, if intervention is directed to *resisting* exchange rate changes, the coincidence of a large intervention and a change in the exchange rate would be evidence on the failure of intervention.

[14]For a critique of intervention since the Plaza Accord specifically, see Bordo and Schwartz (1990).

[15]See Federal Reserve Bank of New York (1989).

Figure 3a
DM/$ Exchange Rate Data for 1985

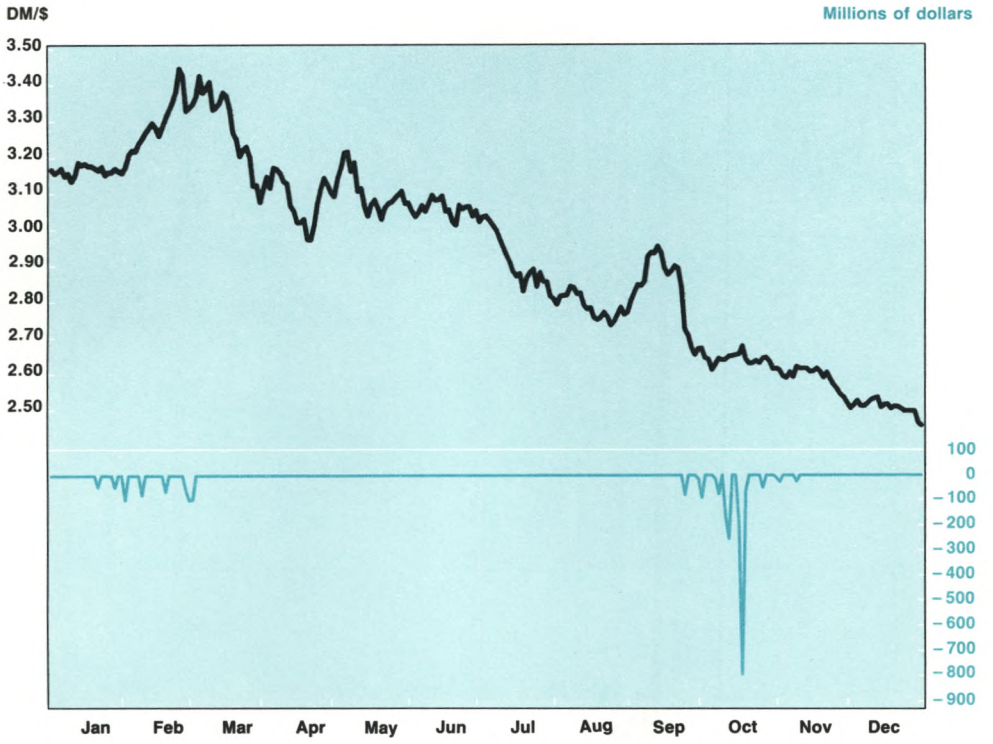


Figure 3b
Yen/$ Exchange Rate Data for 1985

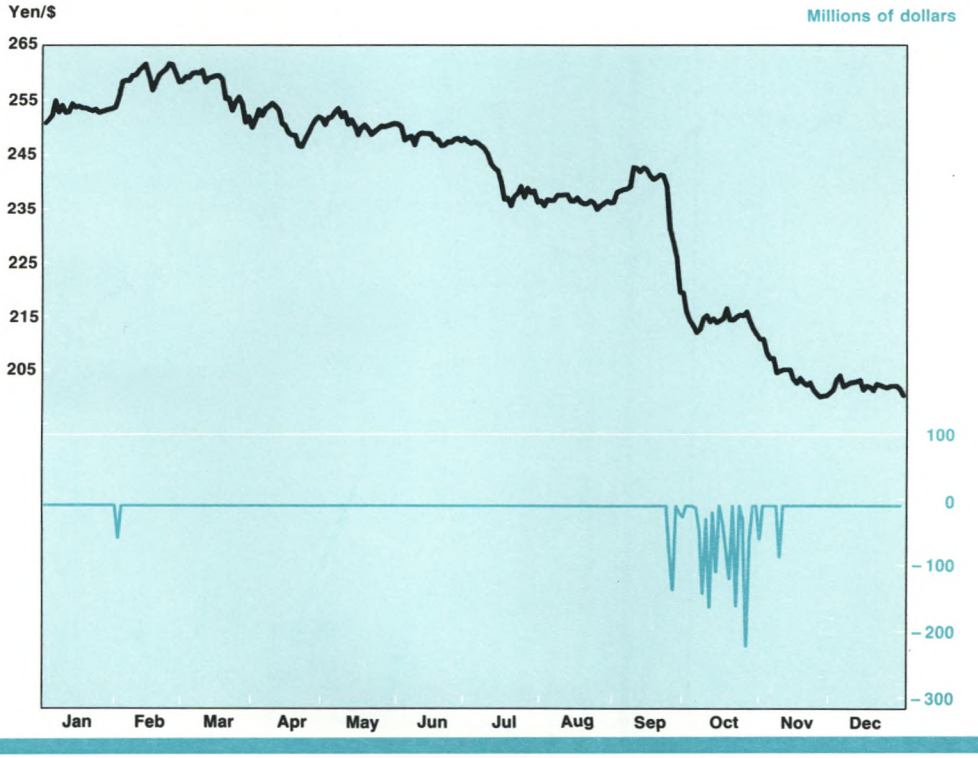


Figure 4a
DM/$ Exchange Rate Data for 1987

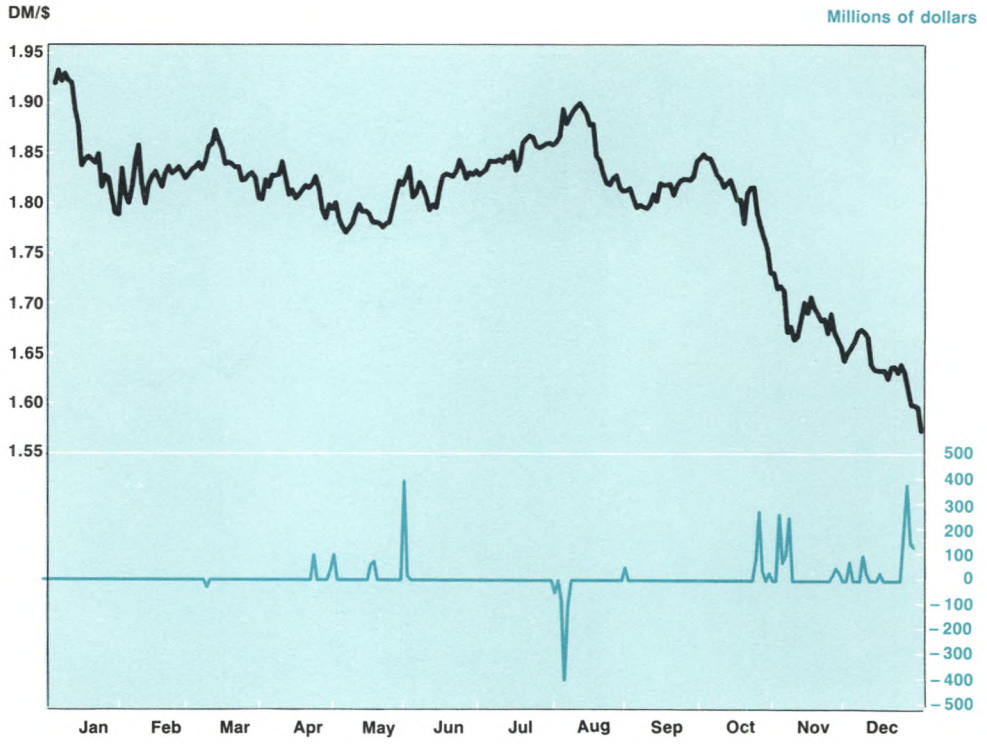


Figure 4b
Yen/$ Exchange Rate Data for 1987

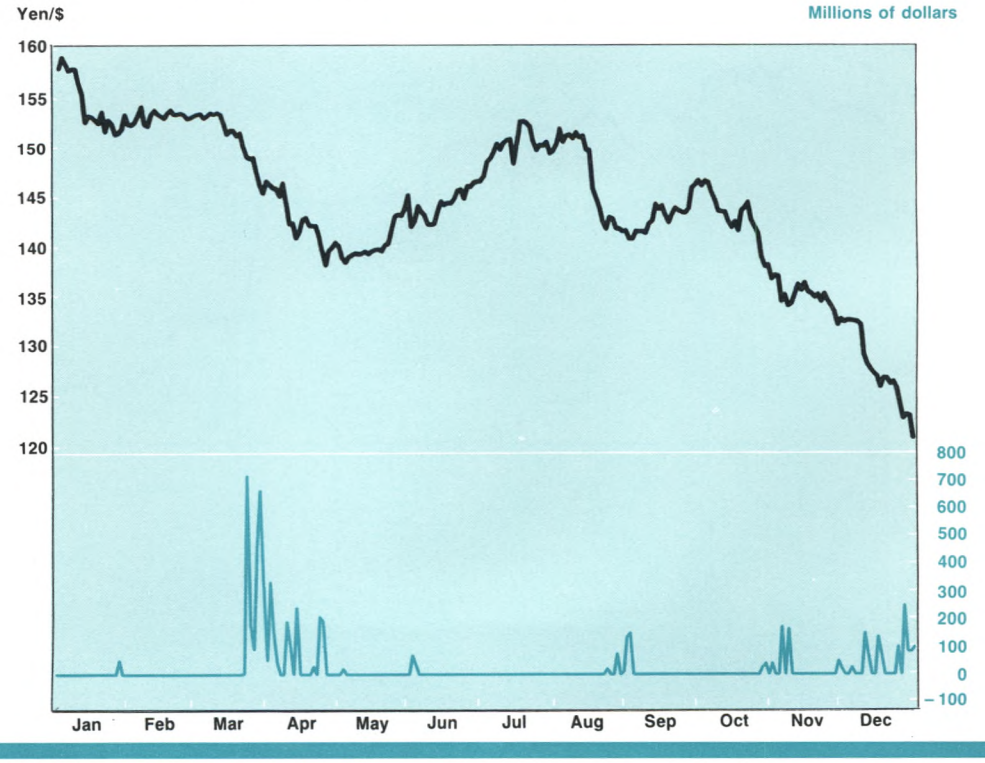


Figure 5a
DM/$ Exchange Rate Data for 1988

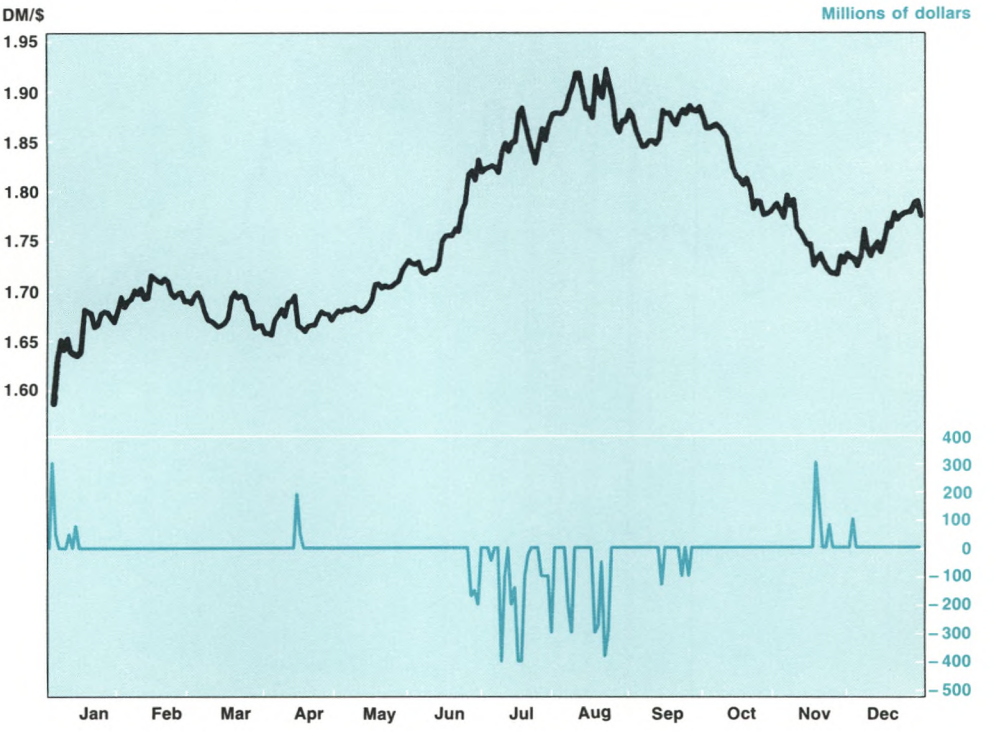


Figure 5b
Yen/$ Exchange Rate Data for 1988

Figure 6a
DM/$ Exchange Rate Data for 1989

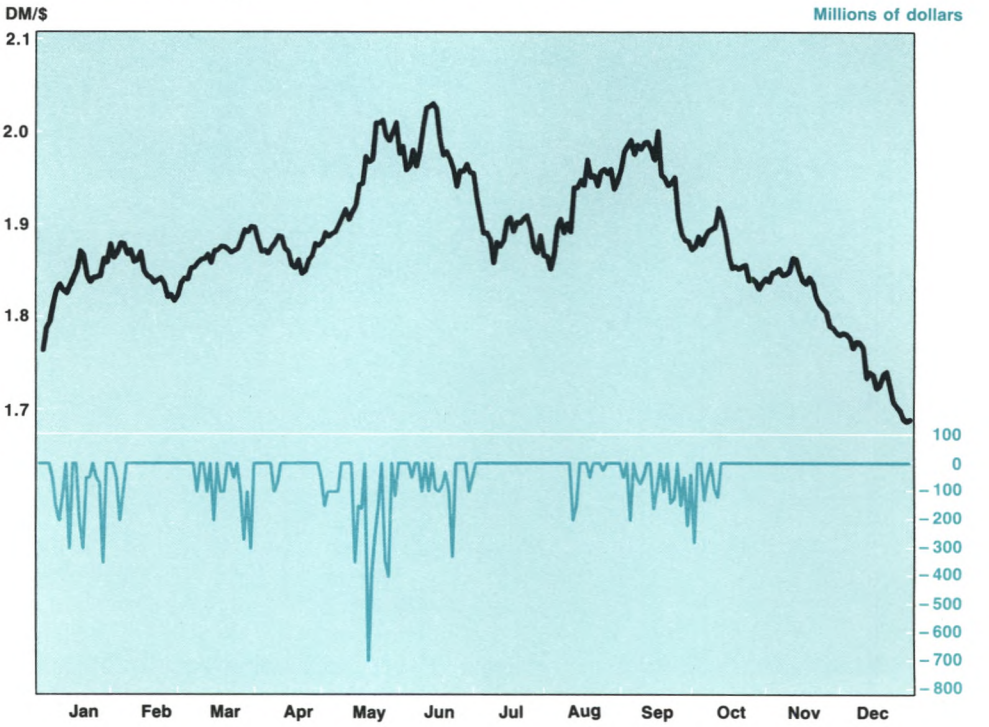
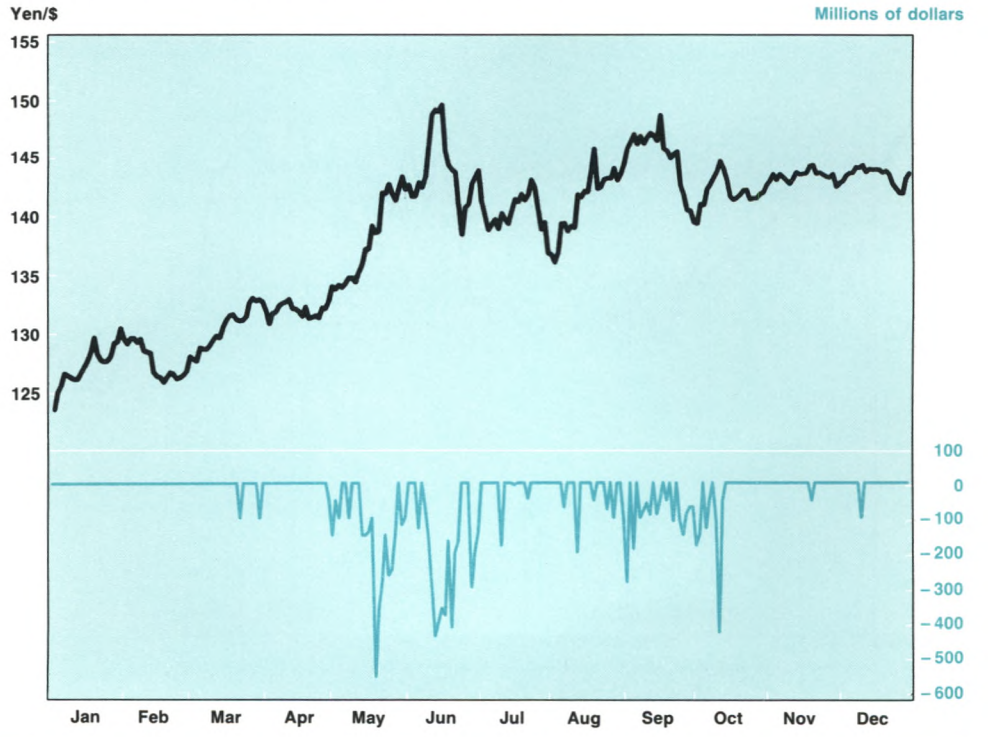


Figure 6b
Yen/$ Exchange Rate Data for 1989



Ministers to agree on intervention activities but, in contrast to Plaza, the Louvre Accord directed their attention to stabilizing exchange rates around then-current levels rather than changing the level itself.[16] As with Plaza, the United States followed this agreement with an initial burst of activity in March, the month following the agreement; during a period of 53 days, the U.S. authorities sold an equivalent of $4,088 million in yen and $782 million in DM. The United States did not intervene again in any concerted way until December when the dollar's value was approaching record lows for the postwar era. Even in this case, however, intervention by the United States had ceased by January 1988. One is left to speculate, then, whether the exchange rate levels at this point were consistent with the target zones established at the Louvre meeting in February or whether the United States had decided for some other reason to limit its intervention activities.[17] The remaining data for 1988, shown in figures 5A and 5B, reveal several episodes of intervention on both sides of the market: selling foreign exchange for dollars in the spring and fall and buying DM against dollars in the summer.

The data for 1989 (figures 6A and 6B), in contrast to the previous figures, show relatively persistent and consistent intervention against both the yen and DM. For the year as a whole, the United States bought, cumulatively, $10,925.60 million and $11,130.50 million (equivalent) of yen and DM, respectively; indeed, the United States purchased more DM and yen in 1989 than it did in the years 1985-88 combined. At the same time, the dollar's value moved in different directions against the two currencies, rising from 123.60 to 143.80 against the yen (+16 percent) and falling from 1.76 to 1.69 against DM (−4 percent). Although it is impossible to prove the counterfactual argument that the dollar's value would have changed even more without this intervention, its efficacy may be questioned if intervening in the same manner against two different currencies is associated with appreciations against one and depreciations against the other. Certainly this diverging pattern suggests the influence of some other factor on the exchange rate beyond intervention.

WHAT HAS INTERVENTION ACCOMPLISHED?

As noted in the introduction, the story of intervention is incomplete without looking at comparable data on the activities of the Bundesbank and Bank of Japan. Although data on the value of foreign central bank actions are not available, it is possible to identify days on which foreign central banks intervened. In making partitions of the data set, it is assumed that, at a minimum, these central banks were not working against Federal Reserve actions. In other words, we assume that on the days the Fed intervened, the Bundesbank and Bank of Japan either did nothing or they conducted a complementary intervention that would reinforce the effect of the Fed's actions.

It also should be noted that it is impossible, or at least very difficult, to refute the counterfactual argument—that the exchange rate would have changed without intervention. Indeed, without knowing the reasons for central bank actions, intervention may be motivated primarily by a desire to *resist*—rather than cause—changes in the exchange rate. Because this possibility is a hypothesis that cannot be tested, we will assume that, in the absence of intervention, the exchange rate would not have changed. We also will assume that the purpose of intervention was to make the exchange rate move in a certain direction even though a large change on the day of intervention might indicate the failure of an action that was intended to *prevent* a change in the exchange rate.

In view of the earlier discussion and these two assumptions, several hypotheses merit testing. The first is that the average absolute change in the exchange rate on days when the Fed intervenes alone should not be different from the changes in the exchange rate when no intervention occurs. This test is based on the earlier discussion of sterilized intervention, which predicted that its failure to change relative money supplies also should leave the exchange rate unaffected. A second test is motivated by the practice of the Bundesbank not to sterilize (at least not completely) *its* intervention; thus, on

[16]Funabashi, (1988).

[17]Target zones establish upper and lower bounds for the exchange rate. Typically, the exchange rate is free to vary within the established range but central banks pledge to engage in coordinated intervention if the exchange rate begins to move outside of the range.

Table 1

Mean Changes in the Absolute Value of the DM/$ Exchange Rate (*100)

Year	$\bar{X}_1$ (n)	$\bar{X}_2$ (n)	$\bar{X}_3$ (n)	$\bar{X}_4$ (n)
1985	1.00 (7)	1.36 (32)	3.05 (12)	2.05 (188)
1986	- - - -	1.24 (15)	- - - -	1.25 (226)
1987	1.21 (10)	1.01 (19)	1.27 (20)	0.77 (194)
1988	0.90 (4)	0.87 (42)	1.43 (30)	0.67 (165)
1989	0.76 (20)	0.84 (11)	0.99 (33)	0.91 (61)
All years	0.92 (41)	1.07 (119)	1.45 (95)	1.18 (834)

Test Statistics for Equality of Mean Changes (Absolute Values)

Year	$\bar{X}_1 = \bar{X}_4$	$\bar{X}_2 = \bar{X}_4$	$\bar{X}_3 = \bar{X}_4$	$\bar{X}_1 = \bar{X}_2$	$\bar{X}_1 = \bar{X}_3$	$\bar{X}_2 = \bar{X}_3$
1985	1.59	2.19*	1.75	0.86	1.41	2.39*
1986	- - - -	0.04	- - - -	- - - -	- - - -	- - - -
1987	1.75	1.26	2.64*	0.67	0.16	0.87
1988	0.69	1.76	5.32*	0.07	0.91	2.62*
1989	0.75	0.28	0.49	0.28	0.97	0.52
All years	1.28	0.95	1.89	0.92	1.88	2.14*

Subscripts to $\bar{X}$s and null hypotheses indicate the following:

$\bar{X}_1$ = intervention only by Federal Reserve

$\bar{X}_2$ = intervention only by Bundesbank

$\bar{X}_3$ = intervention by both the Federal Reserve and Bundesbank

$\bar{X}_4$ = no intervention by either central bank

* = statistically significant at the 5 percent level

days when a foreign central bank intervenes alone, the average absolute change in the exchange rate should be significantly larger than on days when no intervention occurs.[18] The reason, of course, is that unsterilized intervention will affect relative money supplies and, therefore, should affect the exchange rate as well.

Making clear predictions about the effects of intervention on the volatility of daily exchange rate changes, however, is more difficult. Using the variance of daily absolute changes in the exchange rate as our measure of volatility, it is possible to argue that intervention, conceivably, could raise or lower the variance of exchange rate changes.[19] On one hand, if intervention is associated with larger average daily changes, the variance of these changes might rise as well. On the other hand, if the purpose of intervention is to reduce daily volatility in the exchange rate and it is successful, the variance could be smaller with intervention. With this uncertainty, the test results merely are reported, and one can simply make judgments about the effects (if any) of intervention on the variance of daily exchange rate changes.

The data for means and variances in tables 1-4 divide the data into four groups: days when the Fed intervened alone, days when a foreign cen-

[18]For evidence on the Bundesbank's practice of not completely sterilizing its intervention, see Neumann (1984).

[19]Because we are dealing with absolute changes, variance is measured as $\frac{1}{n}\sum_{i=1}^{n}\Delta e^2$, where n is the number of observations and e is the exchange rate.

Table 2

Mean Changes in the Absolute Value of the Yen/$ Exchange Rate (*100)

Year	$\bar{X}_1$ (n)	$\bar{X}_2$ (n)	$\bar{X}_3$ (n)	$\bar{X}_4$ (n)
1985	150.56 (9)	97.89 (18)	192.73 (11)	88.10 (201)
1986	- - - -	97.81 (47)	- - - -	86.14 (194)
1987	124.50 (6)	56.88 (33)	97.65 (37)	63.32 (167)
1988	73.50 (4)	72.12 (17)	62.31 (16)	54.03 (204)
1989	94.57 (7)	82.84 (6)	103.52 (27)	51.48 (85)
All years	117.62 (26)	82.31 (121)	104.67 (91)	70.97 (851)

Test Statistics for Equality of Mean Changes (Absolute Values)

Year	$\bar{X}_1 = \bar{X}_4$	$\bar{X}_2 = \bar{X}_4$	$\bar{X}_3 = \bar{X}_4$	$\bar{X}_1 = \bar{X}_2$	$\bar{X}_1 = \bar{X}_3$	$\bar{X}_2 = \bar{X}_3$
1985	2.02*	0.50	4.02*	0.77	0.45	1.87
1986	- - - -	0.82	- - - -	- - - -	- - - -	- - - -
1987	2.46*	0.58	3.04*	2.21*	0.74	2.40*
1988	0.71	1.19	0.58	0.02	0.33	0.31
1989	2.04*	1.38	3.51*	0.23	0.21	0.44
All years	3.09*	1.60	4.06*	1.63	0.49	1.75

Subscripts to $\bar{X}$s and null hypotheses indicate the following:

$\bar{X}_1$ = intervention only by Federal Reserve

$\bar{X}_2$ = intervention only by Bank of Japan

$\bar{X}_3$ = intervention by both the Federal Reserve and Bank of Japan

$\bar{X}_4$ = no intervention by either central bank

* = statistically significant at the 5 percent level

tral bank intervened alone, days when both intervened, and days when neither intervened. Tables 1 and 2 report means of the daily absolute changes in the DM/$ and yen/$ exchange rates, respectively, and tests for equality of means between various categories. Tables 3 and 4 repeat these categories for data on the variances of daily exchange rate movements. In all cases, the data are based on absolute values of daily changes because we do not know the specific intentions of intervention and our interest merely is in a central bank's ability to *change* the exchange rate.

In table 1, the data show that intervention was associated with a significant effect on the magnitude of the daily change in the DM/$ exchange rate in only three cases: in 1987 and 1988, when the Federal Reserve and Bundesbank both intervened on the same day and in 1985 when the Bundesbank acted alone. The two cases of significant effects when both central banks intervene is consistent with the notion that joint actions are associated with significantly larger exchange rate movements because they give signals about the future course of monetary policy and its likely effects on the exchange rate. These results also are consistent with the finding that coordinated interventions have larger effects on the exchange rate than unilateral interventions.[20]

In table 2, the effects of intervention on the yen/$ exchange rate are shown to be much

[20]See, for example, Dominguez (1990) or Loopesko (1984).

Table 3
Variances of Absolute Changes in DM/$ Exchange Rate

Year	$\hat{s}_1^2$	$\hat{s}_2^2$	$\hat{s}_3^2$	$\hat{s}_4^2$
1985	0.00018	0.00028	0.00220	0.00072
1986	------	0.00022	------	0.00030
1987	0.00021	0.00016	0.00028	0.00012
1988	0.00021	0.00013	0.00032	0.00009
1989	0.00011	0.00012	0.00018	0.00014
All years	0.00015	0.00019	0.00050	0.00030

F-statistics for Equality of Variances

Year	$\hat{s}_1^2 = \hat{s}_4^2$	$\hat{s}_2^2 = \hat{s}_4^2$	$\hat{s}_3^2 = \hat{s}_4^2$	$\hat{s}_1^2 = \hat{s}_2^2$	$\hat{s}_2^2 = \hat{s}_3^2$	$\hat{s}_1^2 = \hat{s}_3^2$
1985	4.11*	2.56*	3.04*	1.60	7.80*	12.50*
1986	---	1.37	---	---	---	---
1987	1.75	1.31	2.34*	1.33	1.78	1.34
1988	2.46	1.53*	3.70*	1.61	2.42*	1.50
1989	1.35	1.23	1.28	1.10	1.57	1.72
All years	1.97*	1.62*	1.66*	1.22	2.69*	3.27*

Subscripts to $\hat{s}^2$s and null hypotheses indicate the following:

$\hat{s}_1^2$ = intervention only by Federal Reserve

$\hat{s}_2^2$ = intervention only by Bundesbank

$\hat{s}_3^2$ = intervention by both the Federal Reserve and Bundesbank

$\hat{s}_4^2$ = no intervention by either central bank

* = statistically significant at the 5 percent level

stronger: in every year but 1988 (when intervention generally was limited), intervention either by the Fed alone or in concert with the Bank of Japan on the same day apparently was associated with significantly larger changes in the exchange rate.[21] It should be noted, however, that the significance of the Fed's unilateral interventions is based on only 26 observations during the entire 1985-89 sample period. Indeed, these tables show that the Fed intervened infrequently during the period.

Having found statistical significance for the effectiveness of intervention activities during certain periods, the potential *economic* significance of these effects is the next question to be investigated. Looking, for example, at the effects of joint intervention by the Fed and Bundesbank, the largest significant average absolute daily change in the exchange rate is found in 1988: 0.0143 pfennig. Based on an average value of 1.76 for the DM/$ exchange rate in 1988, an average absolute change of 0.0143 pfennig suggests that joint intervention is associated with average absolute changes in the exchange rate that are 0.81 percent greater than the changes that occur on days without intervention. Changes of similar magnitudes are found for the yen/$ rate. Overall, the economic significance of these results appears to be small despite the occasionally high level of statistical significance.

With respect to variances of daily changes in the exchange rate, reported in tables 3 and 4, a similar story carries through. For the DM/$ rate, most of the significant differences between

[21]For more on this story and related evidence, see Obstfeld (1991) and Dominguez (1990).

Table 4

Variances of Absolute Changes in Yen/$ Exchange Rate

Year	$\hat{s}_1^2$	$\hat{s}_2^2$	$\hat{s}_3^2$	$\hat{s}_4^2$
1985	7.96	2.01	6.32	1.37
1986	---	1.41	---	1.57
1987	2.46	0.69	1.55	0.74
1988	0.75	1.68	0.75	0.59
1989	1.58	1.47	2.13	0.51
All years	3.87	1.34	2.16	1.02

F-statistics for Equality of Variances

Year	$\hat{s}_1^2 = \hat{s}_4^2$	$\hat{s}_2^2 = \hat{s}_4^2$	$\hat{s}_3^2 = \hat{s}_4^2$	$\hat{s}_1^2 = \hat{s}_2^2$	$\hat{s}_2^2 = \hat{s}_3^2$	$\hat{s}_1^2 = \hat{s}_3^2$
1985	5.80*	1.46	4.60*	3.97*	3.15*	1.26
1986	---	1.11	---	---	---	---
1987	3.35*	1.07	2.11*	3.57*	2.25*	1.59
1988	1.28	2.87*	1.28	2.25	2.24	1.00
1989	3.09*	2.87*	4.16*	1.08	1.45	1.35
All years	3.80*	1.32*	2.12*	2.88*	1.61*	1.79*

Subscripts to $\hat{s}^2$s and null hypotheses indicate the following:

$\hat{s}_1^2$ = intervention only by Federal Reserve

$\hat{s}_2^2$ = intervention only by Japan

$\hat{s}_3^2$ = intervention by both the Federal Reserve and Japan

$\hat{s}_4^2$ = no intervention by either central bank

* = statistically significant at the 5 percent level

days of no intervention and some intervention occur when the Federal Reserve and the Bundesbank both act on the same day. For the yen/$ rate, however, significant differences are found for either the Fed or Bank of Japan acting unilaterally as well as for their joint actions. Intervention in all cases, however, seems to be associated with higher, not lower, variance of daily exchange rate changes. Again, caution should be exercised before attributing cause-and-effect to these findings: an equally plausible, but untestable, hypothesis implies that volatility might have been even greater on these days had it not been for the intervention.

CONCLUSIONS

The world's major central banks occasionally intervene in foreign exchange markets to affect the value of one currency relative to another. Since 1985, the official reasons for these activities changed from reducing the dollar's value to stabilizing it within some unspecified range of values. Because much of the related data are confidential and the stated objectives of intervention often are vague, researchers have been limited in their ability to answer a fundamental question: Does intervention work?

Using data recently released by the Federal Reserve, the answer seems to be that intervention is associated with significantly larger daily changes in the exchange rate when the Federal Reserve and a foreign central bank both intervene on the same day. This conclusion holds even though changes in the relative money supplies of two countries were described as the primary factor behind a change in the exchange rate and the Federal Reserve routinely sterilizes its intervention. Consistent with other work on coordinated intervention, it appears as if central bank actions are enhanced by the announcement of joint actions that send a stronger signal to the market about the future course of monetary policy and its possible effects on the exchange rate.

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Appendix
Is Sterilized Intervention Really Sterilized?[1]

The discussion in the text takes the conventional view that intervention is sterilized if the domestic central bank's activities have no net effect on the domestic money supply. As this appendix shows, however, actions by the Federal Reserve to leave the U.S. money supply unaffected by intervention still have the potential to affect a *foreign* money supply and both foreign and U.S. interest rates. In one case, the ratio of the foreign to U.S. money supplies will be altered, thereby opening a channel through which sterilized intervention, as conventionally defined, can affect the exchange rate. In the other case, domestic monetary policies that peg a short-run interest rate will require less-than-complete sterilization to keep interest rates unchanged.

Consider first figure A1, which extends the analysis of figure 2, panel B, in the text. New

[1]I am indebted to Manfred J.M. Neumann for making this observation and to Anatol B. Balbach and R. Alton Gilbert for developing these points in greater detail.

Figure A1

Sterilized Foreign Exchange Intervention by the Federal Reserve *with* Effects on German Money Supply: Fed Holds DM Deposits at the Bundesbank

Federal Reserve Banks (FRB)		U.S. Commercial Banks (cb)		Bundesbank (B)		German Commercial Banks (Gcb)	
Assets	**Liabilities**	**Assets**	**Liabilities**	**Assets**	**Liabilities**	**Assets**	**Liabilities**
+ DM deposits at B	+ Reserves of cb	+ Reserves			+ DM deposits of FRB	– Reserves	– DM deposits of U.S. correspondent bank
		– DM deposits at Gcb			– Reserves of Gcb		
– U.S. Treasury securities	*– Reserves of cb*	*– Reserves*					
		+ U.S. Treasury securities					

entries to this original figure are shown in italics. Recall that the point of this figure originally was to show how unsterilized intervention would affect the exchange rate by expanding the U.S. money supply relative to the German money supply.

Picking up the story at this point, the Federal Reserve could sterilize its intervention by selling U.S. Treasury securities from its portfolio to U.S. commercial banks. This would lead to all four italicized entries in the balance sheets of the Federal Reserve and U.S. commercial banks: the Fed's balance sheet would shrink with declines both in its Treasury security assets and its reserves liabilities, while commercial banks would substitute Treasury securities for reserves in their portfolios. On net, the sale of U.S. Treasury securities to commercial banks and the consequent reduction in reserves will offset the increase in reserves associated with the initial intervention action and leave the U.S. money supply unchanged. Thus, in the conventional sense, the Fed has sterilized its intervention and, again in the conventional view, the exchange rate should be unaffected.

The figure shows, however, that if the Fed merely holds its acquired DM as a deposit at the Bundesbank, the Fed's activities will have *reduced* the German money supply. This is indicated by the declines in the reserve liabilities of the Bundesbank and reduction in the deposits of German commercial banks. By reducing the German money supply relative to the U.S. money supply, the Fed's actions should lead to an increased DM/$ exchange rate even though the intervention was "sterilized" in the United States.

Holding DM deposits at the Bundesbank, however, would be somewhat unusual for the Fed; typically, it invests its non-interest-earning DM deposits in interest-earning DM-denominated securities. In this more usual case, the Fed's "sterilized" intervention will not affect the German money supply if it buys German bonds in the open market. If it were to buy them directly from the Bundesbank, however, the German money supply still would be reduced as in the earlier example.

To see the mechanics of this effect, consider figure A2. This is a reproduction of figure A1, supplemented by additional transactions shown in italics. Picking up at the point where figure A1 ended—the Fed has sterilized its intervention and is holding a DM deposit at the Bundesbank—the Fed now buys German bonds in the open market from German commercial banks. When the Fed's transaction is complete, its DM deposits at the Bundesbank fall, the bond holdings of German commercial banks fall and the reserves of the German banking system rise; on net, these machinations offset the decline in the German money supply that would occur if the Fed merely held its DM deposits at the Bundesbank. In the United States, the Fed's actions substitute interest-earning German bonds in its portfolio in place of the non-interest-earning DM

Figure A2

Sterilized Foreign Exchange Intervention by the Federal Reserve *without* Effects on German Money Supply: Purchase of German Bonds in the Open Market

Federal Reserve Banks (FRB)		U.S. Commercial Banks (cb)		Bundesbank (B)		German Commercial Banks (Gcb)	
Assets	**Liabilities**	**Assets**	**Liabilities**	**Assets**	**Liabilities**	**Assets**	**Liabilities**
+ DM deposits at B	+ Reserves of cb	+ Reserves			+ DM deposits of FRB	– Reserves	– DM deposits of U.S. correspondent bank
		– DM deposits at Gcb			– Reserves of Gcb	– *German bonds*	
– U.S. Treasury securities	– Reserves of cb	– Reserves			– *DM deposits of FRB*	+ *Reserves*	
		+ U.S. Treasury securities			+ *Reserves of Gcb*		
+ *German bonds*							
– *DM deposits at B*							

deposits and leave the U.S. money stock unaffected. Thus, in the case in which the Fed eventually holds German bonds purchased in the open market, its intervention is sterilized in the sense of causing no change in the ratio of German to U.S. money supplies.

Before considering the last case, in which the Fed buys German bonds directly from the Bundesbank, we need to ask whether this intervention really is sterilized in the sense that it should produce no effect on the exchange rate. Although relative money supplies are unaffected, the relative bond holdings of the central banks and the public have been altered and these portfolio substitutions can affect U.S. and German interest rates. In the U.S. market, for example, the Fed has induced U.S. banks to increase their holdings of U.S. Treasury securities; presumably, it did so by bidding Treasury prices down, thus raising U.S. interest rates. Conversely, it bought German bonds, presumably raising their prices and lowering German interest rates. Other things the same, these changes in interest rates should make capital flow into the United States and raise the dollar's value against the DM. Thus, an intervention that was designed to reduce the dollar's value tends to raise it because of these interest rate effects—even if the U.S. and German monetary bases are unchanged.[2] In addition to showing that it is possible for "sterilized" intervention to affect the exchange rate, this example also shows the effect to be in the *opposite direction* from the intent of the intervention. As a practical matter, these interest rate effects are likely to be small, but it is worth noting their existence as a possible channel for exchange rate effects from sterilized intervention.

Finally, consider the consequences of the Fed using its DM deposits at the Bundesbank to purchase German bonds directly from the Bundesbank. This case, shown in figure A3, has the

[2]The story actually is more complicated. First, to the extent that the Fed's initial (pre-sterilization) reserves injection is associated with a "liquidity effect," the subsequent rise in U.S. interest rates discussed at the end of this story may just offset the earlier interest rate decline and leave U.S. interest rates, on net, at their initial levels.

It also is not possible to isolate whether intervention of this sort will have effects on the spot or forward exchange rate. With covered interest parity, the dollar's forward premium will be reduced through a rise in the dollar's spot rate (as discussed in the example), a decline in the forward rate, or both. If there is no signaling effect, the bulk of the change will likely occur in the spot rate. Conversely, a strong signaling effect would likely affect the forward rate while having little effect on the spot rate. Whichever case prevails, the effects on the dollar's value are unlikely to coincide with the intent of the intervention.

Figure A3

Sterilized Foreign Exchange Intervention by the Federal Reserve *with* Effects on German Money Supply: Purchase of German Bonds from the Bundesbank

Federal Reserve Banks (FRB)		U.S. Commercial Banks (cb)		Bundesbank (B)		German Commercial Banks (Gcb)	
Assets	**Liabilities**	**Assets**	**Liabilities**	**Assets**	**Liabilities**	**Assets**	**Liabilities**
+ DM deposits at B	+ Reserves of cb	+ Reserves		– *German bonds*	+ DM deposits *of FRB*	– Reserves	– DM deposits of U.S. correspondent bank
		– DM deposits at Gcb			– Reserves of Gcb		
– U.S. Treasury securities	– Reserves of cb	– Reserves			– *DM deposits of FRB*		
		+ U.S. Treasury securities					
+ *German bonds*							
– *DM deposits at B*							

Bundesbank exchanging German government bonds for its DM deposit liabilities to the Fed. This exchange, however, leaves in place the decline in deposits and reserves at German commercial banks originally shown in figure A1 and, hence, the German money stock also declines as it did in that first example. And, as before, the exchange rate would be expected to change because the ratio of U.S. to German money supplies will be affected. The upshot of these three cases is that what is typically called "sterilized" intervention has a variety of channels through which the exchange rate could be affected.

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Are Small Rural Banks Credit-Constrained? A Look at the Seasonal Borrowing Privilege in the Eighth Federal Reserve District

A TRADITIONAL belief about rural credit markets, particularly agricultural credit markets, is that small rural banks have limited access to sources of funding and limited opportunities to lend outside their immediate communities. Rural banks' ability to meet local loan demand, so the theory goes, is constrained by a relatively inelastic supply of local deposits and insufficient access to nonlocal or national credit markets. Moreover, such institutions tend to experience deposit outflows during periods of high seasonal loan demand as individuals with a seasonal need for funds (like farmers) draw down their deposit balances. To meet the seasonal loan demand of such industries as agriculture and tourism, many observers argue that rural banks must keep a relatively high proportion of their assets in low-interest-bearing, highly liquid securities during other times of the year.

The Seasonal Borrowing Privilege (SBP), one of three Federal Reserve discount window programs, was designed to address this problem by permitting banks with strong seasonal patterns in loans or deposits to obtain funds from Federal Reserve Banks. Although the program is highly popular among participants, some observers have questioned a key historical feature of the SBP, as well as the program's justification itself. Noting that seasonal loans were made at a below-market rate of interest (the discount rate), critics have argued that the lack of credit availability, even if it were a problem, was no

reason for the Fed to step in and provide credit at a subsidized rate.[1] Other critics, citing the tremendous innovations in financial markets since the program began in 1973, have questioned whether rural banks continue to face funding constraints today or whether they are still the only source of credit for their communities.[2] The criticism has increased with the volume of lending through the SBP.

This article describes the seasonal borrowing program and examines its usage by banks in the Eighth Federal Reserve District from 1984 through 1990.[3] The Eighth District has a large number of agricultural banks; in some years, District banks have accounted for as much as one-third of all borrowings under the SBP. A key question to be addressed is the extent to which the program has fulfilled the objectives set out by the Federal Reserve Board in 1973. The article then presents an analysis of the program's continued necessity.

DEFINING THE PROGRAM

Purpose of the Program

The seasonal borrowing program was established in April 1973 by the Board of Governors of the Federal Reserve System (hereafter, the Board) to help member banks meet seasonal funding requirements. The program was adopted as part of amendments to Regulation A, "Advances and Discounts by Federal Reserve Banks," which became effective April 19, 1973. Under Section 201.2 of the revised Regulation A, "General Principles," the Board outlined its rationale for the program:

> Extending credit to member banks to accommodate commerce, industry, and agriculture is a principal function of Reserve Banks. . . . Federal Reserve credit is available for longer periods (than adjustment credit) to assist a member bank that lacks reasonably reliable access to national money markets in meeting seasonal needs for funds arising from a combination of expected patterns of movement in its deposits and loans.[4]

The Board's decision to establish the SBP was based in large part on the findings of a 1971 Federal Reserve study of the discount window. In evaluating the sources and uses of funds at small rural banks, the study found that

> the available information supports the view that small rural banks, concentrated in the sixth through eleventh Federal Reserve districts, have serious disadvantages relating to their organizational structure. In many cases the prohibition of branching precludes growth to large size. This restriction on growth and geographic expansion frequently results in a high degree of deposit and asset specialization that promotes variability in deposits and loans. Such variability may be accommodated by holding relatively large volumes of liquid assets or by borrowing. If liquid assets are relied on, substantial portions of bank assets may be unavailable for local loans and the cost of lending will be correspondingly higher.[5]

The study found that small unit banks in rural areas, even those affiliated with correspondents, faced limited access to funding from the federal funds market and the certificate of deposit (CD) market, largely because of information asymmetry among large and small banks in these markets. In the study's own words, the

> lack of readily available information about smaller banks would, in general, tend to make them higher-risk investments to potential lenders. In particular, their lack of diversification would increase the likelihood of problems as seen by lenders, without any offset that might be warranted by more detailed but costly investigation.[6]

Program developers thought that providing a reliable source of loanable funds would make it easier for these banks to manage their assets and liabilities, enabling them to better meet the credit demands of their communities throughout the year, that is, increase local lending. Before the program's inception, banks with strong seasonal fluctuations in loans relative to deposits would accommodate seasonal needs by liquidat-

[1]This argument lost most of its force in early 1992, when banks that borrow seasonal credit began paying a market-related interest rate.

[2]See, for example, Graham (1979) and Stevens (1990). Stevens has also raised another issue: that unpredictable shifts in seasonal borrowings have complicated the implementation of monetary policy. See Stevens (1990) for a discussion of this issue.

[3]The Eighth District includes Arkansas, eastern Missouri, the southern portions of Illinois and Indiana, the western portions of Kentucky and Tennessee, and northern Mississippi.

[4]See Board (1973) for a reprint of the revised Regulation A.

[5]See Board (1971), pp. 64-65.

[6]Board (1971), p. 54.

How the SBP Works

As illustrated in the "before" and "after" balance sheets at right, the SBP allows a bank to maintain a stable securities portfolio while simultaneously increasing its loan portfolio. Before the hypothetical bank obtains a seasonal credit line with its local Reserve Bank, its first- and third-quarter balance sheets might look something like the left-hand panels of the figure. Seasonal loan demand is assumed to be low in the first quarter and peak in the third quarter. With stable core deposits and insufficient access to purchased funds, the bank's asset portfolio in the first quarter would be composed of $50 in securities and $50 in loans ($20 in loans to seasonal businesses and $30 in other loans). To meet peak loan demand in the third quarter, the bank would sell $20 of its securities portfolio to fund an additional $20 of loans to businesses that need seasonal loans (loans to seasonal businesses increase from $20 to $40, while securities holdings fall from $50 to $30). The bank's loan-to-deposit ratio rises from 50 percent in the first quarter to 70 percent in the third quarter.

After a bank becomes a seasonal borrower, it can increase its loans to seasonal businesses in the peak period of demand without shrinking other assets (loans to seasonal businesses increase from $20 to $40 while securities holdings stay constant); it can now fund seasonal loans while increasing the bank's total assets and liabilities by the amount of the credit extension ($20). More importantly, the bank is able to increase other loans at all periods of the year: in both the first quarter and the third quarter, the bank is able to carry $50 in other loans compared with $30 before the bank becomes a seasonal borrower. Its loan-to-deposit ratio rises from 70 percent in the first quarter to 90 percent in the third quarter. Note that these ratios are both higher than those obtainable before the bank became a seasonal borrower.

Also note that, in this example, the bank's ratio of seasonal loans to total loans actually *declined* after the bank became a seasonal borrower, because it did not use the SBP to increase loans to seasonal businesses. It instead increased the proportion of loans to nonseasonal borrowers. Other outcomes, including an increase in the proportion of loans to seasonal businesses, are possible because a bank presumably allocates seasonal borrowings to maximize the return on its asset portfolio. The composition of the asset portfolio after borrowing, therefore, will vary by bank. Most importantly, a borrowing bank is making more loans than it did before using the SBP.

ing some of their securities holdings. In periods of seasonal loan demand, these banks would sell securities, using the proceeds to fund loans. When seasonal loans were repaid, securities holdings would rise again.[7] A description of how the program affects asset and liability management appears in the shaded insert above.

Program Administration

Although the program has undergone a number of changes since 1973, much of its structure remains the same.[8] To qualify, banks must be small (less than $500 million in total deposits) and able to demonstrate sizable and recurring seasonal swings in net funds availability, defined as total deposits less total loans. After satisfying a portion of the seasonal need from their own resources—that is, after meeting a deductible—eligible banks may borrow funds from their Federal Reserve Bank to bridge the remaining gap for up to nine months each year, paying a variable rate of interest.[9] All seasonal

[7]See Graham (1979) and Stevens (1990) for more detail on the historical rationale for the program.

[8]In 1980, for instance, the program was open to nonmember institutions as a result of the Monetary Control Act. The amount of seasonal loan funding that banks are required to meet from their own resources (the deductible) and the maximum size of an eligible institution have changed several times over the years. See Appendix A of Board (1990) for more detail.

[9]The interest rate on outstanding seasonal credit is computed as the average of the federal funds rate and the secondary market rate on 90-day large CDs over the previous reserve maintenance period, rounded to the nearest five basis points. This formula became effective January 9, 1992. In prior years, banks participating in the SBP paid the basic discount rate on outstanding credit, which afforded users a subsidy when the discount rate was below market rates of interest. The rationale for changing the interest rate charged on seasonal credit can be found in Board (1990), pp. 14-18.

Balance Sheet of a Hypothetical Bank Before and After Becoming a Seasonal Borrower

BEFORE

First Quarter

Assets		Liabilities	
Cash	10	Deposits	100
Securities	50		
Loans		Capital	10
Loans to Seasonal Businesses	20		
Other Loans	30		
		Total Liabilities	
Total Assets	110	and Capital	110

Third Quarter

Assets		Liabilities	
Cash	10	Deposits	100
Securities	30		
Loans		Capital	10
Loans to Seasonal Businesses	40		
Other Loans	30		
		Total Liabilities	
Total Assets	110	and Capital	110

AFTER

First Quarter

Assets		Liabilities	
Cash	10	Deposits	100
Securities	30		
Loans		Capital	10
Loans to Seasonal Businesses	20		
Other Loans	50		
		Total Liabilities	
Total Assets	110	and Capital	110

Third Quarter

Assets		Liabilities	
Cash	10	Deposits	100
Securities	30	Borrowings	20
Loans		Capital	10
Loans to Seasonal Businesses	40		
Other Loans	50		
		Total Liabilities	
Total Assets	130	and Capital	130

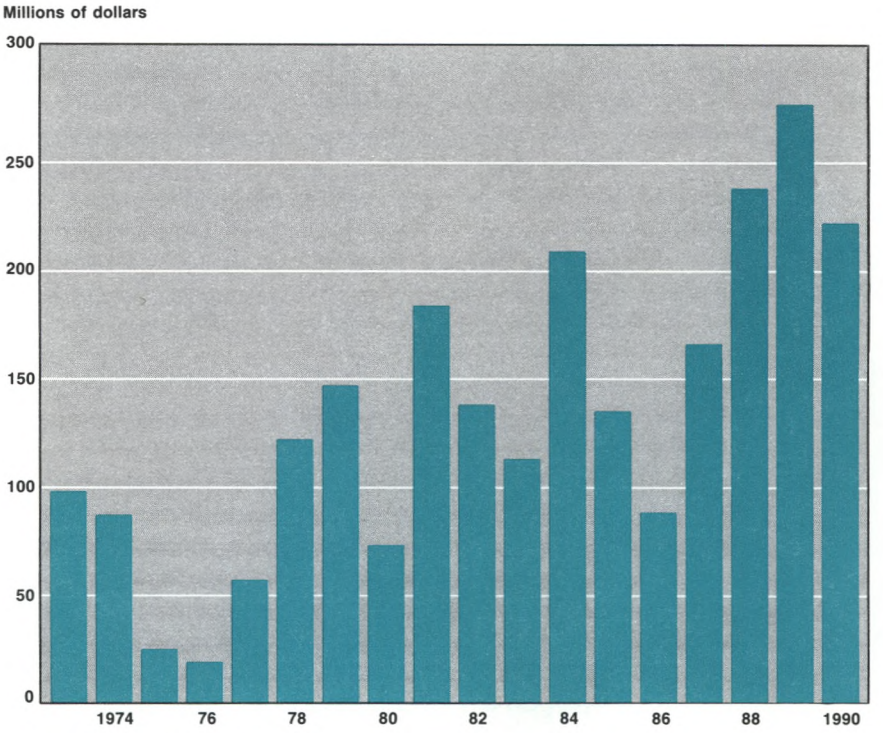
borrowings must be fully collateralized and most have weekly or 30-day maturities; seasonal loans can be rolled over provided program requirements are being met. Program users are permitted to sell federal funds while they are borrowing seasonal credit, as long as net fed funds sales (fed funds sold less fed funds purchased) do not exceed the bank's normal operating pattern, that is, the pattern that existed before the bank became a seasonal borrower.[10] A more detailed description of the qualifying process and the technical aspects of the program is provided in the appendix.

Pattern of Borrowing

Seasonal borrowings in the Eighth District (and elsewhere) have generally followed the agricultural credit cycle, because most banks that use the program face seasonal loan demand from farmers. The amount of seasonal borrowings outstanding typically rises during the

[10]A related indicator of a rural bank's dependence on local investments is its volume of sales in the federal funds market. With limited local lending opportunities, small rural banks may find the federal funds market to be their best alternative use of deposits. While this behavior would seem counter to the logic of the SBP, the program permits banks, simultaneously, to sell fed funds and borrow from the discount window. According to Melichar (1980), the Board decided in 1976 to allow the sale of fed funds while borrowing seasonal credit because most small banks had become year-round sellers of fed funds. A great proportion of these banks were keeping secondary reserves in fed funds rather than Treasury bills at the same time their overall liquidity was declining. In this context, fed funds were being used to manage reserve requirements, rather than as an alternative investment to loans. In addition, because the bulk of the fed funds market consists of one-day (or overnight) loans, program officials do not view it as a perfect substitute for the long-term borrowing privilege provided under the SBP.

Figure 1
Average U.S. Weekly Seasonal Borrowings Outstanding, 1973-90[1]



[1]Annual averages of weekly data
SOURCE: Board of Governors of the Federal Reserve System

spring when crops are planted, reaching a peak in late summer when crops are harvested; they decline during the fall and winter as farmers receive payments for their crops and repay their loans.

Program changes since the mid-1970s have greatly expanded the number of banks that qualify for seasonal credit, the time frame for borrowing, and the size of seasonal lines that qualifying banks can obtain.[11] A key factor influencing the growth of the SBP during the 1980s was the passage of the Monetary Control Act of 1980, which extended access to the discount window to nonmember depository institutions. Taken together, these changes led to an increase in the number of banks participating in the program (from 205 in 1973 to 615 in 1988), and an increase in the amount of average weekly credit outstanding (which rose from $89 million to $235 million over the period). Figure 1 illustrates the trend in borrowings over the period 1973-90. These liberalizations in program restrictions on net seem to have increased aggregate seasonal borrowing by increasing the number of borrowers rather than the amount of credit extended to each borrower; average borrowing per institution has remained almost constant over time.[12] Still, actual program usage

[11]See Board (1990), Appendix B, Attachment A.

[12]Though the level of borrowing peaked in 1988, the number of seasonal borrowers peaked in 1989, when 721 banks received seasonal borrowings. The amount of credit outstanding reached an all-time high of $513 million during the week ending July 26, 1989. Program usage subsequently declined in 1990 and 1991. Although the reasons for declining usage are not known precisely, the slowing economy and weak loan demand, combined with the Board's announcement that a market rate of interest would be charged on seasonal borrowings beginning in 1992, probably have been contributing factors.

remains low relative to the number of banks potentially qualified to use it.[13]

SEASONAL BORROWING IN THE EIGHTH DISTRICT

Because the SBP is designed for relatively small banks in areas dominated by a seasonal industry, like agriculture or tourism, the midwestern Federal Reserve districts—Chicago, Kansas City, Minneapolis and St. Louis—host the vast majority of program users. In the late 1980s, Eighth District banks (St. Louis District banks) were among the SBP's largest users of seasonal credit.[14] The amount of credit extended to these banks has risen substantially in recent years as the number of banks eligible for the program and efforts to increase awareness of the program by discount window officers have increased.[15] Since 1984, the Federal Reserve Bank of St. Louis' Credit Office has maintained a database on all District institutions applying for discount window credit, including seasonal credit. These data may help provide an answer to the question: Is the program meeting its objectives?

Table 1 provides some descriptive statistics on District banks that participated in the program from 1984 to 1990. In 1984, the first year for which complete weekly data on seasonal borrowers are available, 42 District banks participated in the program. The number of banks using the program steadily increased through the rest of the decade. By 1988, the number of participants had more than tripled to 137. The number of borrowers peaked at 151 in 1989, although the average weekly amount of seasonal credit outstanding for that year was down from the previous year. The average amount of borrowings outstanding per week rose from $18.8 million in 1984 to $94.9 million in 1988, while the average size of the borrowing banks peaked at $75.6 million in deposits in 1987, then declined to $57.5 million in 1990.

The annual average loan-to-deposit ratio for seasonal borrowers was relatively constant over the seven-year period, varying between 65 and 70 percent. Within any given year, however, this ratio fluctuated substantially, ranging by as many as 20 percentage points between its minimum and maximum value. The loan-to-deposit ratio typically climbed several percentage points during the peak period of borrowing (defined in table 1 as a five-week period around the week where borrowings outstanding peaked), as banks funneled a great proportion of these borrowings into loans. The intra-year relationship between seasonal borrowings and the loan-to-deposit ratio for 1989-90 (the year of peak usage) is illustrated in figure 2. This pronounced seasonal pattern and the close correlation between the loan-to-deposit ratio and seasonal borrowings are consistent with one justification for the program: a class of small banks with strong seasonal loan and deposit flows does exist.

A number of other characteristics of seasonal borrowers are consistent with the rationale and current application of the program. The ratio of agricultural production loans to total loans, for example, is not only higher for seasonal borrowers than comparably sized nonborrowers, but also shows considerably more intra-year variability. In 1989, for example, the agricultural loan ratio for program users showed a range of almost 5 percentage points compared with the 1.3 percentage point range for nonborrowers. Evidence of a seasonal shortfall of funds can also be gleaned from data on fed funds purchases and sales. Fed funds purchased tend to be higher and fed funds sales tend to be lower during the peak period of seasonal borrowing than their average values over the course of the year, indicating that banks face a liquidity shortfall in the summer months.

These results are reinforced by comparing seasonal borrowers with comparably sized nonborrowers. Table 2 compares selected third

[13]Graham (1979) notes that the portion of eligible Ninth District banks borrowing seasonal credit declined from 19 percent in 1974 to 11 percent in 1978. Yorke and Herman (1982) note that, in the Tenth District, less than one-half of eligible member institutions used the program (on average) over the 1974-80 period. And Stevens (1990) estimates that in 1988, when the level of seasonal borrowing reached its peak, less than 20 percent of eligible banks nationwide sought and obtained seasonal credit.

[14]See Graham (1979) and Yorke and Herman (1982) for analyses of seasonal borrowing during the 1970s in the Ninth and Tenth Federal Reserve Districts, respectively.

[15]These efforts were launched with a Board press release dated March 12, 1985, which stated: "Reserve Banks will be making special efforts to acquaint depository institutions with both the regular and temporary seasonal credit facilities." Subsequently, the St. Louis Credit Office sent general information mailings about the SBP to all Eighth District banks and targeted mailings to certain institutions with strong seasonal swings in deposits and loans. In addition, an annual renewal letter is sent to all banks that qualified for seasonal credit in the previous year, where data show a continued seasonal pattern.

Table 1

Descriptive Statistics, Eighth District Seasonal Borrowing Program, 1984-90 (dollar amounts in millions)

	1984	1985	1986*	1987	1988	1989	1990
Number of participants	42	47	51	88	137	151	124
Average deposits (annual)	$61.3	$63.7	$71.8	$75.6	$74.6	$62.3	$57.5
Loan/deposit ratio (annual)	.68	.70	.65	.68	.68	.68	.66
Minimum (week)	.63	.65	.63	.62	.66	.65	.64
Maximum (week)	.73	.85	.68	.71	.71	.72	.70
Peak five-week period	.72	.74	.67	.70	.71	.71	.69
Seasonal borrowings							
Minimum outstanding (week)	$3.0	$3.5	$0.1	$0.3	$1.7	$15.2	$6.1
Maximum outstanding (week)	49.2	47.9	47.3	89.5	209.8	188.1	167.4
Mean outstanding (week)	18.8	19.0	14.1	44.4	94.9	88.5	76.6
Agricultural loans/ total loans (annual range)							
Borrowers	15.6-19.8%	12.4-16.2%	10.5-13.6%	8.8-11.4%	8.0-12.6%	8.4-13.3%	11.2-16.8%
Nonborrowers[1]	11.4-12.7%	10.0-11.9%	9.4-11.0%	8.0-9.5%	7.6-9.0%	7.2-8.5%	7.4-8.6%
Net fed funds purchased[2] (mean week)	$31.5	$27.5	$52.4	$66.3	$18.8	$0.2	–$121.9

*53 observations (53 Wednesdays)

[1] District banks with total deposits of less than $500 million.

[2] A negative sign indicates that banks, on average, were net sellers of fed funds.

SOURCES: Credit Office, Federal Reserve Bank of St. Louis; FFIEC Reports of Condition for All Insured Commercial Banks, 1984-90.

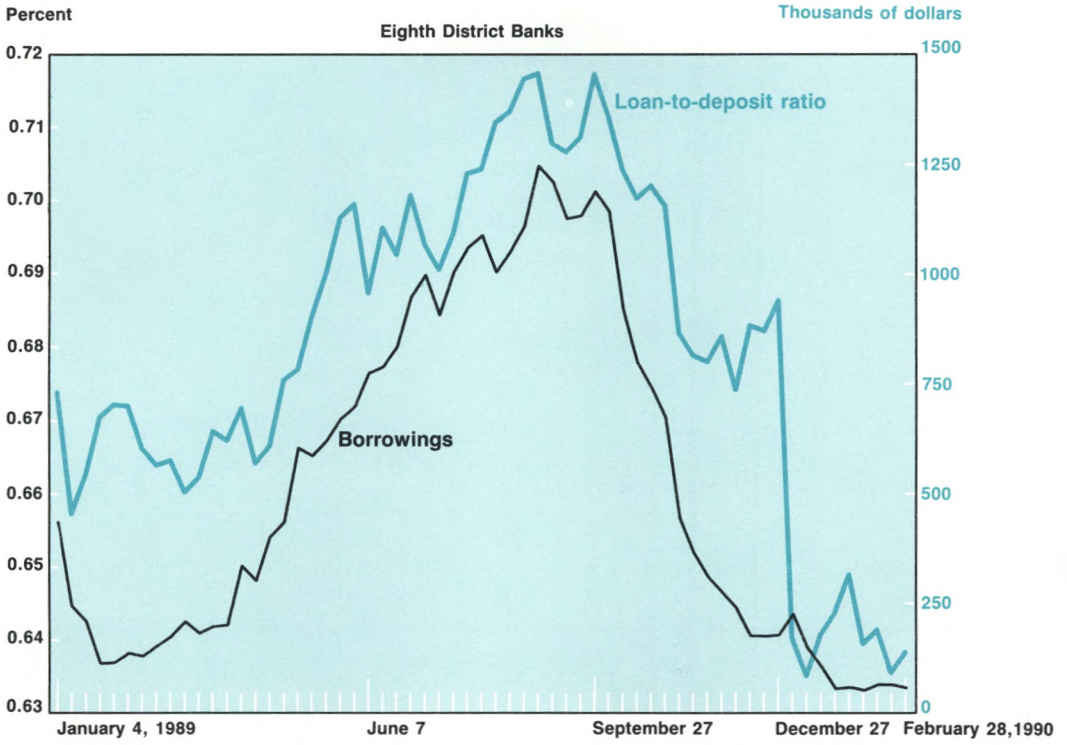
quarter 1989 average balance sheet ratios for Eighth District seasonal borrowers with those of nonborrowers.[16] In general, the composition of program users' assets and liabilities differs from that of their nonborrowing peers (other District banks with total deposits of less than $500 million). Seasonal borrowers have significantly higher ratios of loans to deposits (68 percent vs. 59.1 percent) and have a higher portion of their loan portfolio invested in agricultural production loans (13.3 percent vs. 8.6 percent) than do nonborrowers.[17] As a result, seasonal borrowers are less liquid than their peers, as measured by the ratio of fed funds sold to assets, the ratio of securities and fed funds sold to assets and the ratio of total securities to deposits. In addition, the higher purchased liabilities ratios (fed funds purchased to total liabilities and purchased liabilities to total liabilities) for seasonal borrowers are consistent with the notion that they have a funding need that is not being met by local core deposits.

Another way to assess whether the SBP is meeting its objectives is to examine changes in the way banks operate after they begin using the program. "Before borrowing" and "while borrowing" balance sheet ratios of 42 District banks that borrowed in both 1988 and 1989, but not in 1986 or 1987, are presented in table 3 (first-quarter data) and table 4 (third-quarter data). As predicted from our earlier hypothetical bank model, banks that borrow seasonal credit do record higher loan-to-deposit ratios than they recorded in prior years, both in periods of low loan demand and periods of peak loan demand. For example, the average first quarter loan-to-deposit ratio for this group of borrowers rose from 57.5 percent before using the program to 61 percent while using the program.

[16]The data are taken from the quarterly Reports of Condition filed by all U.S. commercial banks.

[17]The differences in mean values of the ratios for borrowers and nonborrowers are statistically significant from zero at the 99 percent confidence level.

Figure 2
Average Weekly Seasonal Borrowings and the Loan-to-Deposit Ratio, 1989-90



SOURCE: Federal Reserve Bank of St. Louis Credit Office

Before becoming seasonal borrowers, this group of banks increased its average loan-to-deposit ratio by about 3.5 percentage points between the first quarter and the third quarter. They apparently funded this increased loan ratio by rearranging their balance sheets, reducing fed funds sold and securities holdings (from 36.7 percent of assets in the first quarter to 34.7 percent in the third quarter) and by increasing fed funds purchased (from 1.6 percent of total liabilities in the first quarter to 1.9 percent in the third quarter).

Once these banks began using the SBP, they were able to record higher loan-to-deposit ratios year-round and were able to increase the ratio by almost 6.5 percentage points between the first and third quarters. Correspondingly, these banks held fewer liquid assets in periods of slack loan demand, as predicted by the hypothetical bank model outlined in the shaded insert on pages 54 and 55.

Based on the analysis outlined above, it appears that the SBP is meeting the objectives specified by the Board in establishing the program: providing a reliable line of credit to small institutions with seasonal loan demand to allow them to extend more loans to their communities throughout the year. It seems clear that these banks used the SBP to increase their loan-to-deposit ratios.[18] What remains unclear is whether they would have been able to accomplish this without the SBP.

[18]Despite these results, which appear to show that the program is working, care should be taken in interpreting them. Because of factors such as changes in economic conditions over the 1986-89 period, it is uncertain how much change in the "before borrowing" and "while borrowing" ratios can be attributed to the SBP. In other words, it is possible that the banks' behavior in the 1988 and 1989 period would have been the same in the absence of the SBP.

Table 2

Average Values of Eighth District Bank Balance Sheet Ratios, Third Quarter 1989

	Seasonal borrowers	Non-users of seasonal credit[1]	t-statistic
Loans/deposits	68.04%	59.10%	−7.97**
Agricultural loans/loans	13.32	8.55	−4.25**
Fed funds sold/assets	2.04	4.95	10.11**
Fed funds purchased/total liabilities	1.75	0.96	−3.12**
Purchased liabilities/total liabilities	1.78	0.98	−3.16**
Real estate agricultural loans/loans	6.55	7.73	1.93
Securities and fed funds sold/assets	31.97	37.71	6.17**
Commercial and industrial loans/loans	17.21	15.41	−2.07*
Total securities/deposits	34.97	37.35	2.00*
	n=149	n=1,089	

NOTE: t-statistics are for non-zero differences between means.

[1] With total deposits of less than $500 million

* Significant at the 5 percent level

** Significant at the 1 percent level

SOURCE: FFIEC Reports of Condition for All Insured Commercial Banks, 1989.

IS THE SBP NECESSARY?

Financial markets have changed dramatically since the SBP was started in 1973. Most of these changes have given banks greater access to purchased funds. For example, the removal of interest rate ceilings and the introduction of new deposit instruments, such as NOW accounts and MMDAs, have allowed banks to be more competitive with both each other and other financial institutions in bidding for funds.[19] Changes in market structure, especially the absorption of independent banks into one- or multibank holding companies and the growth in statewide branching, together with innovations like bankers' banks, have provided additional sources of funds to small banks, both urban and rural.[20] These changes have made rural banks less dependent on local sources of funds.

In addition, the expanded availability of agricultural credit from nonagricultural bank sources such as cooperatives, the Farmers Home Administration, a revamped Farm Credit System and farm equipment companies, has diminished the role of local banks in meeting the funding needs of rural enterprises.[21] Thus, whether

[19]See Mishkin (1989), pp. 243-53, for a discussion of financial innovation at commercial banks since the early 1970s.

[20]Between 1980 and 1990, the proportion of small District banks associated with holding companies rose from 12 percent to 70 percent; at the national level, the share rose from 20 percent to 60 percent. Since 1975, 16 bankers' banks (in 16 states) have opened their doors. These cooperative depository institutions carry out many of the services typically provided by correspondent banks, including the provision of federal funds to their members. The Eighth District has four bankers' banks, one each in Arkansas, Illinois, Kentucky and Missouri. More recently, a number of U.S. banks eligible for seasonal credit have become members of the Federal Home Loan Bank (FHLB) System, another potential source of short- and long-term funds for credit-strapped institutions.

[21]See, for example, Barkema and Drabenstott (1991), Sullivan (1990) and Melichar (1984).

Table 3

Two-Year Average Balance Sheet Ratios of Banks Before and While Using the SBP

	Low Loan Demand Period (first quarter)		
	Before borrowing (1986-87)	While borrowing (1988-89)	t-statistic
Loans/deposits	57.52%	61.03%	2.94**
Agricultural loans/loans	8.95	7.46	-3.14**
Fed funds sold/assets	6.29	3.54	-4.36**
Fed funds purchased/total liabilities	1.58	1.76	0.59
Purchased liabilities/total liabilities	1.58	1.76	0.59
Real estate agricultural loans/loans	6.18	6.45	0.65
Securities and fed funds sold/assets	36.72	35.47	-1.25
Commercial and industrial loans/loans	23.09	20.38	-2.75**
Other loans/loans	61.78	65.71	3.48**
	n = 42	n = 42	

NOTE: t-statistics are for non-zero differences between means.

* Significant at the 5 percent level

** Significant at the 1 percent level

SOURCE: FFIEC Reports of Condition for All Insured Commercial Banks, 1986-89.

looking at the rural lender or borrower, financial innovations during the past 20 years suggest at least some relaxation in any constraints that might exist, which therefore leads to questions about the continuing necessity of the SBP.

One development in program usage that raises questions about the program's continued necessity in the St. Louis District is the composition of the borrowing banks. Although the program was designed for small, unit banks in rural areas, a significant portion of District seasonal borrowers in recent years have been located in metropolitan areas, and a clear majority have been part of a holding company structure.[22] Table 5 shows the composition of seasonal borrowers by location and structure from 1985 through 1990. Approximately one-quarter of all program users were located in metropolitan statistical areas (MSAs).[23] Twenty of the 37 urban banks that borrowed in 1989 were located in the St. Louis metropolitan area. The diversified nature of the economic base of MSAs like St. Louis makes it less likely that local banks are dependent on any single industry for lending opportunities or that borrowers are dependent on a single source for credit. Urban banks may choose to specialize in a particular category of loans that exhibit seasonality, such

[22]This latter development is not unique to the Eighth District. Graham (1979) found that a significant portion of seasonal borrowers in the Ninth District over the 1974 to 1978 period were affiliates of multibank holding companies. While the language of Regulation A does not preclude holding company and urban banks from participating in the SBP, studies completed in the early 1970s outlining a rationale for the program indicate the program was targeted toward small, rural unit banks. See Board (1971).

[23]The proportion of urban-affiliated banks would no doubt be higher if rural banks that were part of a holding company with affiliates in metropolitan areas were included in the figures.

Table 4

Two-Year Average Balance Sheet Ratios of Banks Before and While Using the SBP

	Peak Loan Demand Period (third quarter)		
	Before borrowing (1986-87)	While borrowing (1988-89)	t-statistic
Loans/deposits	61.00%	67.40%	4.89**
Agricultural loans/loans	11.55	12.17	0.75
Fed funds sold/assets	3.80	2.31	−3.10**
Fed funds purchased/total liabilities	1.86	2.10	1.13
Purchased liabilities/total liabilities	1.90	2.11	0.99
Real estate agricultural loans/loans	6.30	6.12	−0.43
Securities and fed funds sold/assets	34.74	32.92	−2.25*
Commercial and industrial loans/loans	21.24	18.80	−2.66**
Other loans/loans	60.91	62.90	2.20*
	n = 42	n = 42	

NOTE: t-statistics are for non-zero differences between means.

* Significant at the 5 percent level

** Significant at the 1 percent level

SOURCE: FFIEC Reports of Condition for All Insured Commercial Banks, 1986-89.

as construction loans. It is not clear that the SBP was designed to provide assistance to banks that make this choice, however. It is even less clear that loan specialization should be encouraged, since it makes banks vulnerable to large losses should the industry suffer a downturn.[24] Moreover, urban banks would likely have access to regional if not national funding markets.

Independent banks (those not affiliated with a holding company) have accounted for less than 20 percent of the District's seasonal borrowers since 1986. In contrast, just under one-third of seasonal borrowers over the 1985-90 period were affiliated with multibank holding companies. Table 6 shows the composition of bank holding companies with District seasonal borrowing subsidiaries, by size. While the majority of these holding companies were small, with two or three banks and consolidated deposits of less than $500 million, a number of them were very large, with five to 39 affiliates and consolidated deposits in the $1-billion-to-$10-billion range. Banks that belong to a holding company, especially a large one, are thought to have better access to funding and capital markets, and studies have shown that holding companies are net suppliers of credit to their bank subsidiaries.[25] If this is the case, some of these borrowing banks may have alternatives to the SBP.

Further support for the notion that the seasonal borrowers in the latter half of the

[24]See, for example, Belongia and Gilbert (1987).

[25]See, for example, Rose and Talley (1983). It is also interesting to note that, over the period, several holding company banks (as many as five) had brokered deposit liabilities on their balance sheets in years when they borrowed seasonal credit. In some years, a few independent banks were able to tap the brokered deposit market, too.

Table 5

Composition of Seasonal Borrowers by Location and Structure, 1985-90

	1985	1986	1987	1988	1989	1990
Banks in metropolitan areas	12	15	31	40	37	28
Percent of total	(25.5)	(29.4)	(35.2)	(29.2)	(24.5)	(22.6)
Independent banks	12	8	14	24	30	17
Percent of total	(25.5)	(15.7)	(15.9)	(17.5)	(19.9)	(13.7)
One-bank holding company banks	25	28	45	73	74	71
Percent of total	(53.2)	(54.9)	(51.1)	(53.3)	(49.0)	(57.3)
Multibank holding company banks	10	15	29	40	47	36
Percent of total	(21.3)	(29.4)	(33.0)	(29.2)	(31.1)	(29.0)
Total banks	47	51	88	137	151	124

SOURCE: FFIEC Reports of Condition for All Insured Commercial Banks, 1985-90.

Table 6

U.S. Bank Holding Companies with Eighth District Seasonal Borrowing Subsidiaries

Consolidated deposits	1985	1986	1987	1988	1989	1990
Less than $200 million	28	32	55	83	92	86
Percent of total	(87.5)	(80.0)	(83.3)	(83.8)	(86.8)	(88.7)
$200 million-$500 million	1	4	7	9	6	6
Percent of total	(3.1)	(10.0)	(10.6)	(9.1)	(5.7)	(6.2)
$500 million-$1 billion	0	1	1	2	2	2
Percent of total	(0)	(2.5)	(1.5)	(2.0)	(1.9)	(2.1)
Greater than $1 billion	3	3	3	5	6	3
Percent of total	(9.4)	(7.5)	(4.6)	(5.1)	(5.7)	(3.1)
Total holding companies	32	40	66	99	106	97

SOURCE: FFIEC Reports of Condition for All Insured Commercial Banks, 1985-90.

1980s had better access to nonlocal sources of funds than the institutions targeted by the program is found in table 7, which outlines the branching status of seasonal borrowers from 1985 through 1990. Less than one-third of all borrowers over the period were unit (nonbranching) banks, and in each year, at least 40 percent of these banks had multiple branches. Branching allows banks to diversify geographically, expanding their deposit-taking and loan-making capabilities. Banks with both urban and rural branches presumably can shift funds within the banking organization to meet loan demand and maximize profits. Banks with a small-scale branching network—where all branches are in one county or other local economic area—may have no more access to nonlocal credit or diversified lending opportunities, however, than a unit bank.

The effectiveness of a holding company structure or branching network in alleviating the asset-liability problems the SBP was designed to address are clearly institution-specific. Similarly, the location of a bank in an urban area does not automatically mean it can

Table 7

Branching Status of Eighth District Seasonal Borrowers

	1985	1986	1987	1988	1989	1990
Independent banks						
No branches	2	3	4	6	8	5
One branch	5	2	6	10	11	6
Multiple branches	5	3	4	8	11	6
Bank holding company banks						
No branches	4	9	16	24	28	32
One branch	7	11	23	30	36	29
Multiple branches	24	23	35	59	57	46
All banks						
No branches	6	12	20	30	36	37
Percent of total	(12.8)	(23.5)	(22.7)	(21.9)	(23.8)	(29.8)
One branch	12	13	29	40	47	35
Percent of total	(25.5)	(25.5)	(33.0)	(29.2)	(31.1)	(28.2)
Multiple branches	29	26	39	67	68	52
Percent of total	(61.7)	(51.0)	(44.3)	(48.9)	(45.0)	(41.9)
Total seasonal borrowers	47	51	88	137	151	124

SOURCE: FFIEC Reports of Condition for All Insured Commercial Banks, 1985-90.

tap national markets for purchased liabilities. Taken together, however, the evidence on the location, structure and branching status of Eighth District seasonal borrowers raises the possibility that the program is being used by banks that have access to alternative sources of credit.

CONCLUSION

The Federal Reserve's seasonal borrowing program was enacted in 1973 to help small rural banks fund seasonal loan demand, thereby ensuring that local credit needs were being met, especially in agriculture. Program use increased dramatically in the 1980s, as the number of eligible institutions and awareness of the program increased. Within the Eighth District, the number of banks using the program almost quadrupled between 1984 and 1989, before declining in 1990 and 1991. While financial innovations during the last 20 years have provided both borrowers and lenders with a wider array of funding opportunities, the program continues to operate because of a belief that small rural banks still find it difficult to accommodate seasonal loan demand.

An analysis of differences in balance sheet composition between Eighth District banks that use the SBP and those that do not was generally supportive of the program. Seasonal borrowers had higher loan-to-deposit ratios, higher ratios of fed funds purchased to total liabilities and lower ratios of fed funds sold to assets than nonborrowing banks. An analysis of balance sheet ratios for a group of banks that used the program in both 1988 and 1989, but not in 1986 or 1987, showed that, in general, banks behaved as expected while borrowing: they recorded higher loan-to-deposit ratios in both low and peak demand periods.

The evidence of success is not unqualified, however, because no one can be sure how these banks would have behaved in the absence of the seasonal borrowing program. Moreover, it is impossible to say whether SBP users still lack reliable access to national credit markets. Given the relatively high proportion of recent program users that are located in urban areas, have branches and are holding company affiliates, a closer look at their alternative sources of credit seems warranted. The recent introduction of a market-related interest rate that reduces or eliminates the interest rate subsidy to borrowing banks, however, may weed out banks that have ready access to alternative sources of credit.

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Appendix
Qualifying and Using Seasonal Credit

Banks with sizable and recurring seasonal movements in their loans or deposits are eligible to apply for seasonal credit. Potentially eligible banks supply their local Reserve Bank with several years of monthly deposit and loan data. From these data, the estimated net funds availability (NFA) is calculated by subtracting total deposits from total loans for each month and each year of data supplied. A monthly average NFA (based on two to five years of monthly data) is then computed. The seasonal funding need for each month is calculated as the difference between the average monthly NFA and the largest, or peak, average monthly NFA.

A graduated deductible is then applied to determine the amount of credit the borrowing bank can obtain on a month-to-month basis. The deductible is equal to 2 percent of the first $100 million of average deposits of the preceding calendar year, 6 percent of the next $100 million, and 10 percent of the excess over $200 million. For example, a bank with average annual deposits of $150 million in the previous year would have a deductible equal to $5 million [($100 million × .02) + ($50 million × .06)]. Because of this graduated formula, few institutions with deposits of more than $200 million have a seasonal need that surpasses the deductible, so they rarely qualify to borrow.

Normally, seasonal borrowings are advanced with maturities up to 30 days. At maturity, the borrowing bank pays all interest accrued on the outstanding loan. Provided it still qualifies for a seasonal credit line, the bank may renew the loan, and continue to do so for up to nine months. Seasonal borrowings are usually collateralized with U.S. Treasury or agency securities. Some larger borrowers (with more than $100 million in deposits) secure their credit lines with municipal securities or one-to-four-family mortgages.

At the time the seasonal credit line is approved, the borrowing bank is advised of its maximum net fed funds position and its net investment position. The net fed funds position is calculated as the difference between fed funds sold and fed funds purchased over the seasonal period. The net investment position is calculated by adding the bank's average securities held to the daily average net fed funds sold during the season. The net investment position gives a borrowing bank flexibility in managing its liquid assets, as long as its overall liquidity

position stays the same. Banks that exceed their limit are contacted by discount window officers when such violations are considered excessive. Banks that knowingly and continuously violate their limits face, among other penalties, non-renewal of seasonal lines in subsequent years.

In addition to their net fed funds and net investment limits, seasonal borrowers are also advised that the borrowed funds are not to be used to purchase out-of-territory loans or loan participations from other institutions. In addition, affiliates of multibank holding companies are advised that seasonal credit is not to be used to fund operations of the parent holding company or any other affiliate.

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Samuelson's Model of Money with *n*-Period Lifetimes

PAUL SAMUELSON'S OVERLAPPING generations model is a classic in modern economic literature. It has enjoyed a renaissance in the last decade or so as a framework for analyzing fundamental issues in many areas of economics, including pure theory, public finance and, of special concern for this paper, monetary theory.[1] Samuelson's (1958) model continues to attract interest in the latter field because it has the potential to offer a convincing explanation of why unbacked paper currency has value without resort to special assumptions.[2] This paper will focus on the value of paper currency in a generalized version of Samuelson's original approach.

Samuelson's essential insight was to introduce demographic structure. The economic actors in the model actually die, so that people have finite planning horizons even though the economy itself continues without end. This is in stark contrast to the immortal people that occupy the chief rival models in use in macroeconomics today, most of which are sophisticated versions of growth models pioneered by Ramsey (1928) and Solow (1956). Yet, while these rivals in the 1980s have begun confronting the data directly, the overlapping generations approach for the most part remains the province of theorists.[3] This is so primarily because a "time period," instead of being interpretable as a month or a quarter, has a biological basis as a fraction of an adult human lifetime; in standard two-period formulations, it would be interpreted literally as something on the order of 25 or 30 years. Conventional data sets preclude most empirical analysis on such a time scale. This fact forms the foundation for a great deal of criticism of the overlapping generations approach.

The purpose of this paper is to argue that some of the key results from conventional overlapping generations models in which agents live for two periods extend surprisingly well to the case where agents live for many periods—at least for the example studied here. Consequently, some of the typical criticisms of Samuelson's model of money should exert less force on economists than they commonly do. In addition, the *n*-period approach opens the possibility,

[1] See, for instance, Wallace (1980).

[2] Special assumptions that have been used include placing money in the utility function, or imposing a cash-in-advance constraint on the purchase of some goods. For discussions of these alternative approaches, see Sargent (1987).

[3] See Kydland and Prescott (1982) for an example of comparing the predictions of a Ramsey-Solow model with data.

already pursued by some researchers, of confronting overlapping generations models with available data from macroeconomic time series.

Recent general theoretical results on *n*-period overlapping generations models are developed in Kehoe, *et al.* (1991) and Aiyagari (1988, 1989).[4] This paper illustrates some key points developed by these authors. Some results are new, however, especially those concerning the conditions for fiat currency to have value in equilibrium.

In particular, previous studies have suggested that, if the people in the model discount the future, letting the number of periods in the model become arbitrarily large implies that fiat money cannot be valued in equilibrium.[5] Since most economists believe that people in real economies do discount the future, this result seemed to sink hopes that the overlapping generations approach could convincingly explain why unbacked paper currency has value. The results presented here suggest, in contrast, that discounting the future is actually less important than the previous research seemed to suggest. The condition for fiat currency to have value in equilibrium in the *n*-period model is instead found to be analogous to the condition in the two-period model. In fact, there is a sense in which adding periods to a model with discounting makes it easier, instead of more difficult, to satisfy the condition.

Whether fiat currency has value in equilibrium also depends on the lifetime productivity profiles of the economic actors in the model.[6] A standard result from the two-period model is that this profile would have to be declining over a person's lifetime in order for fiat currency to be valued in equilibrium.[7] In actual economies, however, productivity tends to rise with age, dropping off quickly only near retirement. A key result of the present paper is that in the *n*-period model fiat money can still be valued when the lifetime productivity profile is plausibly hump-shaped.

The results described above, it should be emphasized, are based entirely on an example in which the preferences of the people in the model are described by particularly simple functions.[8] This allows key results to be derived algebraically. The model will be described in the following section. The results concerning the existence of stationary equilibria and the conditions for fiat currency to be valued are described subsequently, and will be contrasted and compared to the conventional two-period case.

SAMUELSON'S MODEL OF MONEY

Some Advantages

Given a disturbing disadvantage such as an inappropriately long time period, one might wonder if retaining the overlapping generations framework is worthwhile. But Samuelson's approach has important advantages that have induced continuing interest in the model, time period problems notwithstanding. A few of these positive aspects will be reviewed here.

In Samuelson's model, a new generation is born in every period, at the same time that the oldest generation dies. This structure implies a certain heterogeneity among individuals, where younger people have a relatively long horizon in which to work and save, and older people have a relatively short horizon. One can infer that this will affect the way these people behave. Although heterogeneity of this type is a feature of observed economies, it is absent from most competing models.[9]

As has already been emphasized, fiat money—intrinsically worthless pieces of paper issued by the government—can have value in equilibrium in Samuelson's model without resort to special assumptions. This is the primary reason monetary theorists have paid close attention to the model. In contrast, the Ramsey-Solow model generally does not admit equilibria with valued fiat money unless special assumptions are invoked.

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[4] Strictly speaking, the Kehoe, *et al.* (1991) results apply to "large square economies," that is, those with many goods and many participants, but where consumers live for only two periods. However, they argue that, analytically speaking, these models are equivalent to those with, say, a single good and *n*-period lifetimes.

[5] This is an oversimplification; more exact statements will be made in the next section.

[6] These are represented by the endowment patterns in the subsequent analysis.

[7] This is also an oversimplification, the meaning of which will be clarified in the discussion of the model.

[8] People will be endowed with logarithmic, time-separable utility functions.

[9] There are some models in which all people have infinite lives but heterogeneity of a similar type plays a role. See, for instance, Becker and Foias (1987).

There are two stationary equilibria in conventional versions of Samuelson's two-period model.[10] One is the monetary steady state, where fiat currency has value and the price level is constant (provided the currency stock is constant). The other is the autarkic (no trade) steady state, where fiat currency has no value (currency is not held) and the price level grows without bound. One concern about n-period versions of the overlapping generations model has been that the number of stationary equilibria might multiply uncontrollably as n increased to a value that would allow researchers to interpret a time period as, say, a quarter. Presumably, if one thinks of adult lifetimes as 55 or 60 years, n would have to be 220 or 240 for such an interpretation to be valid. It is therefore somewhat surprising that the version of the n-period model examined here has only two stationary equilibria, and that these are the analogs of the two steady states that exist when $n=2$.[11]

The fact that two steady states can exist is important, because the conventional overlapping generations model also serves as a classic example of a framework that may produce inefficient equilibria.[12] The monetary steady state can be an improvement (that is, everyone in the model can be made better off) over the autarkic equilibrium. Therefore, the introduction of fiat currency by the government can represent a welfare-improving intervention. Hence, there is scope in Samuelson's model for a discussion of a policy role for the government—another contrast with generic versions of the Ramsey-Solow model. An analysis of welfare will not be undertaken in this paper, however.

Some Criticisms

Many critics of Samuelson's model have argued that the two-period lifetime assumption, or aspects related to it, make it an unsatisfactory model of money. One critic is Tobin (1980), who lists several reasons why, in his opinion, the two-period overlapping generations model is a "parable," not a serious model of money. Among Tobin's reasons is that identifying money as an asset that would be held for 25 years is "slightly ridiculous," in part because "the average holding period of a dollar of demand deposits is about two days." He also suggests that the real world analog of the asset in the model might be better viewed as land. Social security schemes, in Tobin's view, would be better mechanisms for accomplishing intergenerational transfers between the old and the young. In short, the "money" in the overlapping generations model, according to Tobin, "is not the money of common parlance." Since all of these criticisms are tied to the notion that the time period in the model is very long, an n-period model in which the period could be much shorter, but could share conclusions similar to the two-period model, presumably would allay some of these concerns.

Another aspect of the time period problem and its treatment in the literature deserves mention. Some authors have argued that many of the central insights would carry over from the two-period case to the n-period case and that, for clarity's sake, the two-period model should be the version of choice. Thus, McCallum (1983) asserted that "some properties of two-period overlapping generations models will carry over to versions in which a larger number of phases of life are recognized." Similarly, Friedman and Hahn (1990) state that

> [O]verlapping generations models are both more robust and more interesting than is sometimes believed.... Of course, the postulate of two-period lives is highly unrealistic. On the other hand, it is difficult to think of a *qualitative* conclusion of these models...that is plausibly at risk from more realistic life times.... There may...be a difference in qualitative conclusions as one passes from finitely to infinitely lived agents. It takes, however, a peculiar perception of the world to regard the latter as the more "realistic" approach.[13]

From this perspective, it is valuable to find out to what extent such assertions are correct,

[10] Stationary equilibria will be defined in the next section.

[11] More general versions of this result can be found in Kehoe, *et al.* (1991).

[12] That is, there may be Pareto suboptimal competitive equilibria.

[13] Friedman and Hahn (1990), p. xiv. Italics in original.

and thus to what extent two-period models can be viewed as elegant representations of n-period models.[14]

An Overlapping Generations Model with n-Period Lifetimes

The model economy that will be studied in this paper endures forever.[15] It consists of agents who live for a fixed number of periods and are endowed at each of these dates with various amounts of a consumption good. The model economy consists only of these endowments—there is no production.[16] The agents have a government that endures forever. A new generation of agents is born each period, at the same time the oldest generation dies.

The agents make decisions about how much to consume and save. There are $a = 1 \ldots q_t$ agents within a generation, so that q_t is the population size of the generation born at time t. Population sizes of generations born in previous periods are denoted by $q_{t-1}, q_{t-2}, \ldots q_{t-n+1}$, where $n \geq 2$ is the number of periods in an agent's life. The total population alive at time t is given by $\sum_{j=0}^{n-1} q_{t-j}$. The (exogenously given) gross rate of population growth is denoted by α, so that $\sum_{j=0}^{n-1} q_{t-j} = \alpha \sum_{j=1}^{n} q_{t-j}$.

An agent born at time t is said to be "of generation t." Birth dates are denoted by subscript time.[17] The single consumption good is perishable, so that agents are unable to store it for future sale. The endowments of agent a of generation t are denoted by $w_t^a(t)$ at time t, $w_t^a(t+1)$ at time $t+1$, ..., and $w_t^a(t+n-1)$ at time $t+n-1$. Endowments cannot be negative. Lifetime consumption of agent a of generation t is denoted by $c_t^a(t), c_t^a(t+1), \ldots, c_t^a(t+n-1)$.

The agents pay lump sum taxes (receive transfers if $\tau > 0$) of $\tau_t^a(t), \tau_t^a(t+1), \ldots, \tau_t^a(t+n-1)$. After-tax endowments, defined as endowments less taxes, are denoted by $\tilde{w}_t^a(t), \tilde{w}_t^a(t+1), \ldots, \tilde{w}_t^a(t+n-1)$. Later in the analysis, these taxes will be set to zero, but for now they serve to motivate a role for government. The agents are not connected in any way; they care only about their own lifetime consumption and they do not leave bequests to future generations.[18]

The market for loans is the heart of this model economy. Agent a of generation t could borrow from or lend to agents in the same cohort or the government. In addition, an individual agent could borrow from or lend to agents in other cohorts living at date t, except for the agents that are in their last period of life. Because those agents will die, they will not be able to repay debts or collect loans—hence, they will not participate in the loan market. The government could lend or borrow on a multiperiod basis, instead of limiting itself to one-period instruments, even when agents live for only two periods. For instance, a young agent might buy a multiperiod bond from the government, even though the maturity date is beyond the agent's lifetime, because there may be a secondary market in bonds. Similarly, multiperiod loans could exist in the private market, either because both agents involved will be alive for the duration of the contract or because a secondary market exists for private loans. Despite all of these possibilities, the loan market in this paper will be restricted to one-period contracts. This assumption is made for two reasons. One is that, in the two-period version of this model, the existence of multiperiod government bonds does not change the analysis. The other is simply a desire to keep the discussion focused.[19]

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[14] Many authors have considered modifications of the overlapping generations approach in order to reinterpret the time period in the model or avoid the time period problem altogether. See, for instance, Blanchard (1985) and Woodford (1989). Some authors have worked directly on extending versions of the overlapping generations model to a large number of periods, although not usually with money included. A prominent example is the work of Auerbach and Kotlikoff (1987), who have simulated 55-period models, interpreting the time period as a year, in order to analyze fiscal policies. Altig and Carlstrom (1991) have used a similar strategy to analyze certain aspects of monetary policy. Their model does not include fiat currency via the standard approach. Rios-Rull (1991) calibrates an n-period overlapping generations model without money.

[15] That is, time in the model runs from the infinite past to the infinite future.

[16] Considerable literature exists on overlapping generations models with production, but this paper is limited to a discussion of endowment economies.

[17] The notational convention used throughout this paper is that subscripts denote birthdates, while parentheses denote real time. For an exposition of the two-period model in similar notation, see Sargent (1987).

[18] Bequest motives and storage, both of which are ignored in this paper, are studied in detail in the literature on two-period overlapping generations models.

[19] See McCandless and Wallace (1991) for a discussion of multiperiod bonds in a two-period model.

An agent is said to save (supply loans) in a particular period if the after-tax endowment in that period plus previous period savings and interest, less consumption in that period, is non-zero. The agent has no incentive to save in the n^{th} period of life, since death occurs in period $n+1$, but may elect to save in any other period of life. The savings of agent a of generation t is denoted by $l_t^a(t)$ at time t, $l_t^a(t+1)$ at time $t+1$, and so on up to $l_t^a(t+n-2)$ at time $t+n-2$.

In order to find the aggregate savings in the economy at a point in time, it is easiest to look at the amounts each living generation is saving at that point in time. These amounts are given by

$$\sum_{a=1}^{q_t} l_t^a(t) = \sum_{a=1}^{q_t}\left[\tilde{w}_t^a(t) - c_t^a(t)\right]$$

for generation t, and

$$\sum_{a=1}^{q_j} l_j^a(t) = \sum_{a=1}^{q_j}\left[\tilde{w}_j^a(t) - c_j^a(t)\right] + R(t-1)\sum_{a=1}^{q_j} l_j^a(t-1)$$

for generation j, where $j=t-1, \ldots, t-n+2$. Aggregate savings at time t is the sum of these sums weighted by the relative size of each generation. Since the population growth rate is exogenous and constant, the size of the time $t-1$ generation relative to the size of the time t generation is $1/\alpha$. In this paper, the convention is adopted that the date $t=0$ generation has size one. Therefore, aggregate savings can be written as

$$(1)\quad S(t) = \sum_{j=0}^{n-2} \alpha^{t-j} l_{t-j}(t).$$

Much of the subsequent analysis will be in terms of aggregate savings.

The government makes purchases of $G(t) \geq 0$ units of the good and collects the lump-sum taxes of $\tau_t^a(t)$ from agent a of generation t at time t. The government lends $L^g(t)$ (borrows if $L^g(t)$ is negative) via one-period loans at time t. Government loans are repaid $R(t)\,L^g(t)$ at time $t+1$, where $R(t)$ is the gross rate of interest on loans at time t. The government also holds $H(t) > 0$ units of paper currency at time t.

The price in currency units of the single good at time t is denoted $P(t)$. The government budget constraint is given by

$$G(t) + L^g(t) = \sum_{j=t-n+1}^{t}\sum_{a=1}^{q_j}\tau_j^a(t) + R(t-1)\;L^g(t-1) + [H(t) - H(t-1)]/P(t).$$

This equation states that government purchases plus government lending (borrowing) must be equal to previous lending plus interest earned (borrowing less interest paid), plus total taxes collected at date t, plus seigniorage revenue.

Arbitrage requires that the rate of return on loans is equal to the rate of return to holding currency, that is, $R(t) = P(t)/P(t+1)$.[20] Loan market equilibrium requires that

$$S(t) = H(t)/P(t) - L^g(t);$$

in other words, aggregate savings is equal to real money balances less government lending or borrowing.

Denoting real per capita government indebtedness as

$$h(t) = \frac{H(t)/P(t) - L^g(t)}{\sum_{j=0}^{n-1} q_{t-j}}$$

and the per capita deficit as

$$d(t) = \frac{G(t) - \sum_{j=t-n+1}^{t}\sum_{a=1}^{q_j}\tau_j^a(t)}{\sum_{j=0}^{n-1} q_{t-j}},$$

the model can be written as a two-equation system:

$$(2)\quad h(t) = \frac{S(t)}{\sum_{j=0}^{n-1} q_{t-j}}$$

$$(3)\quad h(t) = \frac{R(t-1)}{\alpha} h(t-1) + d(t).$$

The right-hand side of equation 2 is per capita savings. The system described by equations 2 and 3 can be written as

[20] This assumption causes the rate of return on two riskless assets, loans to the government and currency, to be equal. In actual economies, currency is dominated in rate of return by alternative riskless assets. Eliminating this problem would require that additional features be added to the model. Those features will not be pursued in this paper.

(4) $S(t) = R(t-1)S(t-1)$

if $d(t) = 0$ at every date t. This is the equation of concern in the remainder of the paper. Fixing the deficit, if not to zero, at least to a constant, is a common way to proceed in analyzing this system when $n = 2$. The usual interpretation of a fixed deficit is that this provides a way to analyze outcomes holding fiscal policy constant.

Sargent's (1987) definition of equilibrium will be employed:

Definition *An equilibrium is a set of infinite sequences for population, endowments, taxes, consumption, private loans, interest rates, government expenditures and government loans such that*

(i) Given a sequence of interest rates, the consumption allocation and the loan amounts satisfy the agent's maximization problem,
(ii) The government budget constraint is satisfied,
(iii) The loan market clears.

As the introduction emphasized, the value of fiat currency is the primary focus of this paper. Because of this focus, government loans, government purchases and taxes will be set to zero for the remainder of the analysis. The term $h(t)$ is then the real value of currency holdings per capita, and is equal to aggregate savings per capita. Government loans, government purchases and taxes have been included up to now to illustrate that the extension of the model to n periods does not depend on setting these variables to zero. For many purposes, such as the analysis of tax effects, one might want to set H equal to zero instead. That would be a model without currency. The derivation of the aggregate savings function $S(t)$ in the next portion of the paper would be equally valid for that model.

The Aggregate Savings Function

According to equation 1, aggregate savings depends on all of the endowments, both within and across generations, of all of the agents living at time t, except those born in period $t-n+1$. In addition, aggregate savings depends on the immediate past interest rate $R(t-1)$, and past savings, while the past savings depended themselves on past interest rates. Therefore, aggregate savings depends also on the past interest rates $R(t-2)$, ..., $R(t-n+1)$. But these are not the only variables determining aggregate savings. In analyzing an agent's maximization problem, the choice of a consumption plan at time t will be shown to depend on the agent's endowments from time t to time $t+n-1$, as well as all interest rates from time t to time $t+n-2$. The aggregate savings function can therefore be summarized by saying that it is a function of interest rates and endowments, both within and across the lifetimes of the generations alive at time t.

The fact that so many endowments and interest rates enter into the aggregate savings function, coupled with the fact that the aggregate savings function plays a key role, as indicated by equation 4, seems to make manageable versions of the model unlikely without resorting to sophisticated mathematical machinery. Such a view, while generally correct, is overly pessimistic. Some simplifications can be employed to reduce the complexity of the aggregate savings function.

One starting point is to assume that all generations are alike at birth in that they possess the same set of preferences and the same lifetime endowment patterns. This assumption seems at least superficially reasonable since it is difficult to argue that any two generations, one born right behind the other, would differ importantly in their preferences over available goods or their lifetime productivity profiles, which can be taken as the interpretation of the endowment pattern. In many applications, generations are assumed to be identical.

Another simplifying assumption—one that is somewhat less attractive—is that all agents *within* a generation are identical. This does not quite amount to a "representative agent" assumption for the model, because at any point in time there would still be differences among agents, in the sense that some are nearer death than others. In contrast, many representative agent models literally have only one agent who lives forever. Nevertheless, this assumption does reduce the extent of diversity among agents considerably.

In order to make progress in writing out an expression for aggregate savings, then, all agents within a generation are assumed to be identical, and all generations are assumed to be exactly alike in terms of utility functions and endowment patterns. Furthermore, a particular utility function will be employed, namely, a time-separable logarithmic utility function given by

$$u_t^a\left[c_t^a(t),\ \ldots,\ c_t^a(t+n-1)\right] = \ln\, c_t^a(t) + \beta\, \ln\, c_t^a(t+1) + \ldots + \beta^{n-1}\, \ln\, c_t^a(t+n-1),$$

where $\beta > 0$ is a discount factor equal to $1/(1+\delta)$, and $\delta \geq 0$ is the rate of time preference, also known as the discount rate, of the agent.[21]

Under these assumptions, aggregate savings can be written as[22]

$$S(t) = \sum_{i=0}^{n-2} \alpha^{t-i} w_t(t+i) + \sum_{i=0}^{n-3} \sum_{j=1}^{n-2-i} \alpha^{t-i-j} w_t(t+i) \prod_{k=1}^{j} R(t-k) - \alpha^t W_1 - \sum_{i=1}^{n-2} \sum_{j=0}^{i} \alpha^{t-i} \beta^j W_{1-i} \prod_{k=1}^{i} R(t-k)$$

where

$$W_k = \left[\sum_{i=0}^{n-1} \beta^i\right]^{-1} \left[w_t(t) + \sum_{i=1}^{n-1} w_t(t+i) \prod_{j=k-1}^{k+(i-2)} R(t+j)^{-1}\right].$$

Aggregate savings therefore depends on a myriad of endowments and interest rates, as expected. As written above, it consists of two positive and two negative terms. The discount factor β enters only in the negative terms. A convenient feature of this function is that it is linear in the endowments $w_t(t)$, $w_t(t+1)$, ..., $w_t(t+n-1)$. That is, suitably rearranged, the function can be written as a sum of the endowments with coefficients, and each coefficient can be viewed as having a positive part and a negative part. This fact will now be exploited to interpret the n-period model.

THE NATURE OF EQUILIBRIA IN THE n-PERIOD MODEL

The artificial economy is described compactly by equation 4, which is

$$S(t) = R(t-1)S(t-1).$$

As has just been shown, $S(t)$ and $S(t-1)$ are actually complicated functions of interest rates and endowments. The system described by this equation therefore involves interest rates extending into the past as well as expected interest rates extending into the future, but no other variables. If one assumes that agents possess perfect foresight or "rational expectations," expected interest rates can be replaced with actual interest rates, and equation 4 becomes a high-order difference equation in interest rates. Perfect foresight—the assumption that agents can predict with perfect precision the future path of interest rates—is an extreme assumption but is also an important benchmark for solutions under alternative assumptions about how expectations are formed. In the remainder of the paper the perfect foresight assumption will be maintained.

Existence and Uniqueness of Stationary Equilibria

Under the perfect foresight assumption, then, equation 4 can be viewed as a high-order difference equation in interest rates, and stationary solutions will be those where (4) is satisfied and $R(t) = R$ for all t. These stationary solutions will be stationary equilibria if they also satisfy the definition of equilibrium given in the previous section. Suppose that the interest rate is constant. Then if $R = \alpha$, $S(t) = \frac{1}{\alpha} S(t-1)$, so that the system described by (4) has a stationary solution at $R = \alpha$. This stationary solution is one in which fiat currency could have value, provided aggregate savings is positive at that point.[23] There are also stationary solutions whenever interest rates are constant and $S = 0$. These other solutions involve aggregate savings equal to zero and thus could not be equilibria with valued fiat currency. The difference equation that describes the system is of order $2n-3$; it therefore has as many as $2n-3$ zeros. Along with the solution at $R = \alpha$, the system has $2n-2$

[21] The assumption of time-separable logarithmic utility implies that the goods in the model (actually the same good at different dates) are gross substitutes (roughly, an increase in the price of one good increases the demand for all other goods) and simplifies the discussion of the aggregate savings function without reducing the number of arguments. In the two-period case, gross substitutes implies that savings is an increasing function of the rate of interest. If one relaxes this assumption on the utility function in the two-period model, so that an increase in the rate of interest might lead to *less* savings by the young, cycles and chaos are possible (see Grandmont, 1985). An important aspect of this result is that eliminating the gross substitutes assumption still leaves one with an acceptable utility function according to standard theory, so that imposing the assumption, in a sense, is an *ad hoc* restriction. Kehoe, *et al.* (1991) develop all of their general results under the gross substitutes condition and discuss the limitations of the approach at some length.

[22] The derivation of this expression is given in appendix 1. To obtain the aggregate savings function when $n = 2$, ignore the second and fourth terms.

[23] See equation 2. This is so because L^g has been set to zero.

Table 1

The Aggregate Savings Function When Interest Rates Are Stationary

$$
\begin{aligned}
S(R) = {} & w_t(t)\left[\left[1 + \frac{R}{\alpha} + \ldots + \frac{R^{n-2}}{\alpha^{n-2}}\right] - \left[\frac{1 + \frac{(1+\beta)R}{\alpha} + \frac{(1+\beta+\beta^2)R^2}{\alpha^2} + \ldots + \frac{(1+\ldots+\beta^{n-2})R^{n-2}}{\alpha^{n-2}}}{1 + \beta + \beta^2 + \ldots + \beta^{n-1}}\right]\right] \\
& + w_t(t+1)\left[\frac{1}{\alpha}\left[1 + \frac{R}{\alpha} + \ldots + \frac{R^{n-3}}{\alpha^{n-3}}\right] - \left[\frac{1 + \frac{(1+\beta)R}{\alpha} + \frac{(1+\beta+\beta^2)R^2}{\alpha^2} + \ldots + \frac{(1+\ldots+\beta^{n-2})R^{n-2}}{\alpha^{n-2}}}{R(1 + \beta + \beta^2 + \ldots + \beta^{n-1})}\right]\right] \\
& + w_t(t+2)\left[\frac{1}{\alpha^2}\left[1 + \frac{R}{\alpha} + \ldots + \frac{R^{n-4}}{\alpha^{n-4}}\right] - \left[\frac{1 + \frac{(1+\beta)R}{\alpha} + \frac{(1+\beta+\beta^2)R^2}{\alpha^2} + \ldots + \frac{(1+\ldots+\beta^{n-2})R^{n-2}}{\alpha^{n-2}}}{R^2(1 + \beta + \beta^2 + \ldots + \beta^{n-1})}\right]\right] \\
& \qquad \vdots \\
& + w_t(t+n-3)\left[\frac{1}{\alpha^{n-3}}\left[1 + \frac{R}{\alpha}\right] - \left[\frac{1 + \frac{(1+\beta)R}{\alpha} + \frac{(1+\beta+\beta^2)R^2}{\alpha^2} + \ldots + \frac{(1+\ldots+\beta^{n-2})R^{n-2}}{\alpha^{n-2}}}{R^{n-3}(1 + \beta + \beta^2 + \ldots + \beta^{n-1})}\right]\right] \\
& + w_t(t+n-2)\left[\frac{1}{\alpha^{n-2}} - \left[\frac{1 + \frac{(1+\beta)R}{\alpha} + \frac{(1+\beta+\beta^2)R^2}{\alpha^2} + \ldots + \frac{(1+\ldots+\beta^{n-2})R^{n-2}}{\alpha^{n-2}}}{R^{n-2}(1 + \beta + \beta^2 + \ldots + \beta^{n-1})}\right]\right] \\
& - w_t(t+n-1)\left[\frac{1 + \frac{(1+\beta)R}{\alpha} + \frac{(1+\beta+\beta^2)R^2}{\alpha^2} + \ldots + \frac{(1+\ldots+\beta^{n-2})R^{n-2}}{\alpha^{n-2}}}{R^{n-1}(1 + \beta + \beta^2 + \ldots + \beta^{n-1})}\right]
\end{aligned}
$$

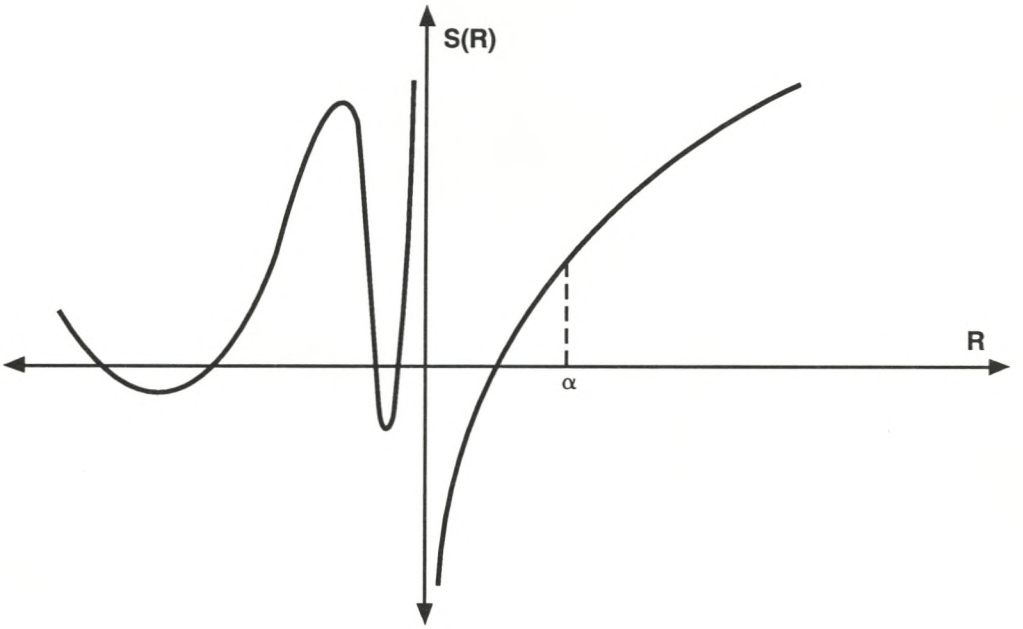
"candidate equilibria." It is therefore remarkable that all but two of these can be ruled out as equilibria of the model.

One way to find the zeros is to set $R(t+i)=R$ for every i and find the roots of the resulting high-order polynomial. Such a procedure would normally require numerical techniques since no known analytical method for finding the roots of high-order polynomials exists. Considerable progress can be made, however, without explicitly finding all these solutions. To see this, refer to table 1, which shows the expansion of the aggregate savings function when $R(t)=R$ for all t. At the risk of upsetting the notation somewhat, this function will be denoted $S(R)$.

Any zero of $S(R)$ that involves a negative stationary interest rate is not an equilibrium of the model, so attention can be restricted to $R > 0$. If aggregate savings is strictly increasing in stationary interest rates $R > 0$, then there can be at most one zero of the aggregate savings function for $R > 0$. It turns out that this is indeed the case. First, consider $S(R)$ as R approaches zero from the positive side. Inspection of table 1 shows that this limit is negative infinity. Next, consider $S(R)$ as R becomes very large. The limit in this case is positive infinity. Thus, $S(R)$ tends to increase with increases in R. It may, however, decrease over some ranges of R. To show that this is not the case, consider the derivative of $S(R)$ with respect to R, which is given in appendix 2. This derivative is always positive, and thus aggregate savings is strictly increasing in stationary interest rates $R > 0$.

The above argument is summarized in figure 1, which shows a graph of $S(R)$ against R. Since

Figure 1
The Existence of Steady-State Equilibria



$S(R)$ is strictly increasing in R, for $R > 0$, only one of the zeros of the aggregate savings function can occur at a point where the interest rate is positive. All $2n-4$ of the remaining zeros, if they exist, must occur at points where the interest rate is negative. Therefore, exactly one stationary equilibrium exists in this model where $S=0$. A second equilibrium, a stationary monetary equilibrium, may exist if aggregate savings is positive when $R=\alpha$. This condition is the subject of the next portion of the paper.

Conditions for Valued Fiat Currency

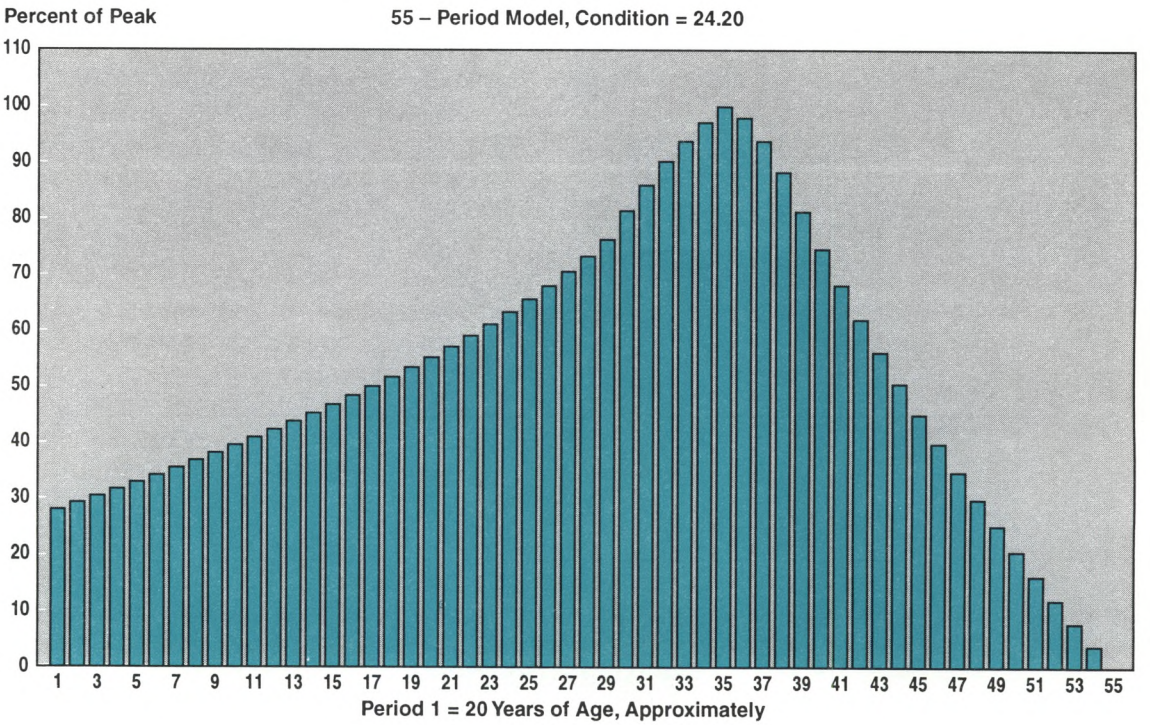
In the system described by equation 4, there is always a candidate equilibrium at $R=\alpha$. If savings is positive at this steady state, then fiat currency has positive value, and the definition of equilibrium is satisfied. The condition for fiat currency to be valued in equilibrium in this model is therefore found by evaluating $S(R)$ at $R=\alpha$ and comparing the result to zero. When there is no population growth ($\alpha=1$) and no discounting ($\beta=1$), this condition is

$$(5)\quad \sum_{i=1}^{n} w_t(t+i-1)\left[(n-i)-\frac{(n-1)}{2}\right] > 0.$$

As an example, let $n=2$. Then the condition for valued fiat currency is that $w_t(t) > w_t(t+1)$, which is a standard result from analogous two-period lifetime models.

The condition given in inequality 5 is simple and symmetric. Endowments received in the first half of agents' lives contribute positively to satisfying the condition, while endowments received in the second half detract from that satisfaction. The endowment receiving the largest weight is the one received by agents in their first period of life, $w_t(t)$, and the weights fall linearly with the endowments received in later periods of life. The weight on the endowment received in the last period of life, $w_t(t+n-1)$, is the smallest (it is a large negative weight). The endowment received by agents at the midpoint of their lives receives zero weight in the condition.

Figure 2
An Endowment Pattern with Valued Money



A common criticism of the two-period overlapping generations model is that the condition for valued fiat currency is $w_t(t) > w_t(t+1)$, which implies declining endowments through an agent's lifetime. If the endowment stream is interpreted as a lifetime productivity profile, most economists would have hump-shaped patterns in mind to represent the empirical reality. Productivity is low when people first enter the work force but rises steadily through life before dropping off sharply at retirement. The condition for valued fiat currency in the n-period model can in fact accommodate the hump-shaped endowment pattern many have in mind. In figure 2, an illustrative case is presented, where, in a 55-period model, the condition for valued fiat currency is met and the lifetime endowment pattern is plausibly hump-shaped.

The Effects of Discounting

Both the discount factor β and the gross rate of population growth α have a role to play in the condition for valued fiat currency. First, consider the situation in which agents discount the future ($\beta < 1$), but in which there is no population growth. Results due to Aiyagari (1988, 1989) suggest that, if the number of periods is large (n is large), fiat currency cannot be valued in equilibrium in this situation. As mentioned in the introduction, this is a rather negative conclusion, since most economists believe that people do discount the future. It is therefore important to see that discounting does not play such a large role, even when n is large.

The condition in this case is

$$(6)\quad \sum_{i=1}^{n} w_t(t+i-1)\left[(n-i)-B\right] > 0,$$

where

$$B=\frac{1+(1+\beta)+(1+\beta+\beta^2)+\ldots+(1+\beta+\beta^2+\ldots+\beta^{n-2})}{1+\beta+\beta^2+\ldots+\beta^{n-1}}$$

Table 2

Values of B When n Is Large, Choosing β Appropriately

	Appropriate β	Value of B	B if $\beta = 1$	Percentage increase
$n = 2$	.54	.65	.5	30.0%
$n = 10$	.86	5.71	4.5	26.9
$n = 30$	.95	18.35	14.5	26.6
$n = 55$	.97	34.14	27.0	26.4
$n = 220$	.9926	138.36	109.5	26.4
$n = 660$	.9975	416.28	329.5	26.3

The effects of discounting can be found by considering B, since β enters the condition only through this term. When $\beta = 1$, this ratio of sums is $(n-1)/2$. When $\beta < 1$, the present case, the value of B will be greater than $(n-1)/2$, and one can immediately conclude that discounting will make the condition for valued fiat currency more difficult to satisfy than if there were no discounting.

When $\beta = 0$, which represents the extreme case in which agents discount the future completely and care only about today's consumption, the value of B is $n-1$. An examination of inequality 6 shows that all the weights on all the endowments would be less than or equal to zero in this case, and thus that the condition for valued fiat currency could never be satisfied, no matter what the endowment pattern. This fact is important because, for values of β between zero and one, B tends to $n-1$ when n is large. Hence, a version of Aiyagari's (1988) result is illustrated: if n is large enough and agents discount the future, fiat money cannot have value in equilibrium. There is more to this condition, however.

In particular, the similarity between the extreme case of complete discounting ($\beta = 0$) and the case of some discounting (β between zero and one) with n large is not accidental. In the overlapping generations model, n periods constitute a human lifetime. When n is made larger and larger, the lifetime is measured in smaller and smaller units of time. In fact, one motivation for considering n-period overlapping generations models was to get to a time period that could be interpreted as a quarter or a month. The discount factor β is therefore not independent of n. Keeping β fixed and allowing n to approach infinity has the same effect as letting β approach zero. Some simple calculations bear this fact out.

The discount factor β is equal to $1/(1+\delta)$, where δ is the discount rate. Many economists think the annual discount rate is about .03, so that β would be about .97. But this is only on an annual basis; on a quarterly or monthly basis, a new value of β must be calculated. Otherwise, one would be saying that people discount the future at a rate of 3 percent per quarter or 3 percent per month—in other words, at a much more rapid rate. In the limit, a discount rate of 3 percent per day or hour or minute would be implied. Agents would be discounting the future completely. This is why letting n become large with a fixed $\beta < 1$ approximates the case where $\beta = 0$.

Table 2 shows values of B for various values of n when β is chosen to appropriately reflect the length of a time period implied by the choice of n. The case of $n = 55$ is taken to represent a model where a time period is a year, and hence the discount factor is set at .97. Other values of β are chosen relative to this standard, so that $n = 220$ represents a quarterly model and $n = 660$ represents a monthly model. Values of n less than 55 involve time periods longer than a year. The second column in the table shows the value of B under discounting, while the third column shows the value of B for the no-discounting case ($\beta = 1$). The final column shows the increase in B due to discounting. Since B represents a negative part in the condition for fiat currency to be valued (see inequality 6), the figures in the final column give some sense of the effect of discounting on the condition for valued fiat currency. In particular, B is about 26 percent larger under discounting than it is in the no-discounting case, as n gets large.

Remarkably, smaller values of n overstate this effect, so that in models with large n it is actually somewhat easier to meet the condition for valued fiat currency.

According to the inequality in (6), B affects all of the endowments equally. The weight on the endowment that agents receive in the first period of their lives, $w_t(t)$, is still positive, although less so than in the no-discounting case. Similarly, the weight on the endowment that agents receive in the last period of life is now more negative. In fact, the weights still decline linearly with endowments received in later periods of life, but the point at which the weight on an endowment is zero occurs, not at midlife, but somewhat before midlife. Hence, the endowment pattern will have to involve larger endowments earlier in life if fiat currency is to have value, relative to the no-discounting case. In terms of hump-shaped endowment patterns, the peak endowment would have to occur earlier in an agent's lifetime.

In summary, while discounting makes the condition for valued fiat currency more stringent, this effect has a limit once it is recognized that the discount rate is not independent of the number of periods in this model.

The Effects of Population Growth

It has long been recognized in research on overlapping generations models of money that including population growth (sometimes interpreted as a model in which the economy is growing) mitigates the effects of discounting on the condition for valued fiat currency. In fact, in the two-period case, these effects cancel exactly when the discount rate is equal to the rate of population growth (that is, when $\beta = \alpha^{-1}$). Of course, because the time period in this model is a fraction of a human lifetime, population growth rates, like discount rates, are not independent of n.

In the present model with n periods, the condition for valued fiat currency when both population growth ($\alpha > 1$) and discounting ($\beta < 1$) are allowed is given by

$$(7)\quad \sum_{i=1}^{n} w_t(t+i-1)\alpha^{1-i}\left[(n-i)-B\right] > 0.$$

Thus, the weight on the endowment received by agents in the first period of their lives is unchanged relative to the case with no population growth, but the weights on endowments received in successive periods are reduced by ever greater powers of α. Since interest centers on the case in which population is growing, $\alpha > 1$, and since the endowments received in the middle and later periods of life receive negative weights, one conclusion is that allowing population growth makes it somewhat easier to satisfy the condition for valued fiat currency.

In a special situation, the negative effects of discounting and the positive effects of population growth on the condition for valued fiat currency cancel out exactly. In particular, if all of the endowments received by agents in each period of their lives are exactly equal, then the condition for valued fiat currency when $\beta = \alpha^{-1}$ is the same as the condition when $\beta = \alpha = 1$. In other words, setting the population growth rate equal to the discount rate produces no net effects only in the special case when the endowment stream is constant. The details of this argument are given in appendix 3. This result is a small departure from standard results for the two-period model. When $n = 2$, the condition for valued fiat currency is $\alpha\beta w_t(t) > w_t(t+1)$, so that setting the rate of population growth equal to the discount rate always produces exactly offsetting effects, regardless of the endowment pattern. This effect generalizes to the n-period case only when all the endowments are equal.[24]

SUMMARY AND CONCLUSIONS

Samuelson's model of money, which has generally been formulated in terms of two-period lifetimes, is often criticized as being un-

[24] One final comment is appropriate on the condition for fiat currency to have value. Aiyagari (1989) has claimed that the intertemporal elasticity of substitution is important and must be larger than one for fiat currency to have value if the discount rate is less than the rate of population growth (and n is large). In the present example with logarithmic utility, the elasticity of substitution is constant and equal to unity. But it is still a simple matter to find plausible endowment patterns that will permit fiat currency to have value.

realistic, since a time period in the model is on the order of 25 years. A basic version of an n-period model is investigated in this paper. The key assumptions are that agents are identical within and across generations, and that they possess time-separable logarithmic utility functions. The fact that agent lifetimes are divided into n periods instead of two periods induces a complicated aggregate savings function that depends on a plethora of interest rates and endowments.

Although the economy analyzed in this paper, assuming agents possess perfect foresight, is characterized by a high-order difference equation which has $2n$-2 candidate stationary equilibria, there are at most two stationary equilibria of the model. Furthermore, these stationary equilibria are the same two, the autarkic equilibrium and the monetary equilibrium, that may exist in the two-period model. The welfare properties of these equilibria were not analyzed.

The condition for fiat currency to have value in the n-period case allows for plausibly hump-shaped endowment patterns. When the agents in the model discount future consumption, the condition for valued fiat currency becomes more difficult to meet. There is a limit to this effect, however, and monetary steady states can exist even when the number of periods in the model is large. An allowance for population growth makes the condition for valued fiat currency easier to meet. These results, taken together, suggest that Samuelson's framework, at least in a broad sense, is robust to extensions in the number of time periods in the model.

At least four central concerns about Samuelson's model of money are distinct from, and perhaps more important than, the time period problem addressed in this paper. The first is that the analysis in this paper places heavy reliance on the arbitrage condition which equated rates of return across alternative assets. In actual economies, money is dominated in rate of return by alternative risk-free assets. A second central concern is that the role of storage has not been considered. In addition, the agents in this model do not leave bequests to future generations. Finally, production has not been considered. These deficiencies require remedies and extensions other than those discussed here.

Finally, it is perhaps useful to distinguish the interpretation of the n-period model used in this paper from interpretations based on the idea of "long-lived agents." In some research, agents with two-period lifetimes have been viewed as living a short time, and n-period models, letting n approach infinity, have been regarded as approximations to models with agents who possess infinite planning horizons. In the interpretation offered in the present paper, the agents in the model do not really live any longer, their lifetimes are just divided up into smaller fragments.

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Appendix 1
Derivation of the aggregate savings function

Denoting $l_t^a(t)$ as the amount of one-period loans made by agent a of generation t at date t, an individual agent faces the following problem, assuming n is large:

$$\text{Max } u_t^a\left[c_t^a(t),\ c_t^a(t+1),\ldots,\ c_t^a(t+n-1)\right]$$

subject to

$$c_t^a(t)+l_t^a(t) \le w_t^a(t)$$

$$c_t^a(t+1)+l_t^a(t+1) \le w_t^a(t+1)+R(t)l_t^a(t)$$

$$c_t^a(t+2)+l_t^a(t+2) \le w_t^a(t+2)+R(t+1)l_t^a(t+1)$$

$$\vdots$$

$$c_t^a(t+n-2)+l_t^a(t+n-2) \le w_t^a(t+n-2)$$
$$+R(t+n-3)l_t^a(t+n-3)$$

$$c_t^a(t+n-1) \le w_t^a(t+n-1)+R(t+n-2)l_t^a(t+n-2).$$

The constraints in this problem can be written more concisely by eliminating l_t^a, which yields

$$c_t^a(t)+\sum_{i=1}^{n-1} c_t^a(t+i)\prod_{j=0}^{i-1}R(t+j)^{-1} \le w_t^a(t)$$
$$+\sum_{i=1}^{n-1} w_t^a(t+i)\prod_{j=0}^{i-1}R(t+j)^{-1}.$$

For the logarithmic utility function given in the text, the first-order conditions are given by

$$c_t^a(t)^{-1}=\mu$$

$$c_t^a(t+1)^{-1}=\mu\beta^{-1}R(t)^{-1}$$

$$c_t^a(t+2)^{-1}=\mu\beta^{-2}[R(t)R(t+1)]^{-1}$$

$$\vdots$$

$$c_t^a(t+n-2)^{-1}=\mu\beta^{2-n}\prod_{j=0}^{n-3}R(t+j)^{-1}$$

$$c_t^a(t+n-1)^{-1}=\mu\beta^{1-n}\prod_{j=0}^{n-2}R(t+j)^{-1}.$$

These first-order conditions can be combined into the budget constraint to yield

$$c_t^a(t)\sum_{i=0}^{n-1}\beta^i=w_t^a(t)+\sum_{i=1}^{n-1} w_t^a(t+i)\prod_{j=0}^{i-1}R(t+j)^{-1}.$$

To construct an expression for aggregate savings, define

$$W_k^a=\left[\sum_{i=0}^{n-1}\beta^i\right]^{-1}\left[w_t^a(t)+\sum_{i=1}^{n-1} w_t^a(t+i)\prod_{j=k-1}^{k+(i-2)}R(t+j)^{-1}\right],$$

which is equal to $c_t^a(t)$ when $k=1$. The savings of agent a period by period can be written as

$$l_t^a(t) = w_t^a(t) - c_t^a(t)$$
$$l_t^a(t+1) = w_t^a(t+1) + R(t)\, l_t^a(t) - c_t^a(t+1)$$
$$l_t^a(t+2) = w_t^a(t+2) + R(t+1)\, l_t^a(t+1) - c_t^a(t+2)$$
$$\vdots$$
$$l_t^a(t+n-3) = w_t^a(t+n-3) + R(t+n-4)\ l_t^a(t+n-4) - c_t^a(t+n-3)$$
$$l_t^a(t+n-2) = w_t^a(t+n-2) + R(t+n-3)\, l_t^a(t+n-3) - c_t^a(t+n-2).$$

The savings of agent a can be defined in terms of W_1^a by recursive substitutions as

$$l_t^a(t) = w_t^a(t) - W_1^a$$
$$l_t^a(t+1) = w_t^a(t+1) + R(t)\, w_t^a(t) - (1+\beta)\, R(t) W_1^a$$
$$l_t^a(t+2) = w_t^a(t+2) + R(t+1)\, w_t^a(t+1) + R(t+1) R(t)\, w_t^a(t) - (1+\beta+\beta^2) R(t) R(t+1) W_1^a$$
$$\vdots$$
$$l_t^a(t+n-2) = w_t^a(t+n-2) + R(t+n-3)\, w_t^a(t+n-3) \ldots + w_t^a(t) \prod_{j=0}^{n-3} R(t+j) - (1+\beta+\ldots+\beta^{n-2}) W_1^a \prod_{j=0}^{n-3} R(t+j).$$

Since all agents are the same, these equations represent the savings of every agent in the economy over the life of the agent. By back-dating these loan amounts to time t, a set of loan amounts can be found that describes the savings of each generation held at time t. Here the assumption of identical endowment profiles, which implies that, for instance, $w_t^a(t+1) = w_{t-1}^a(t)$, is employed. Back-dating therefore implies

$$l_t^a(t) = w_t^a(t) - W_1^a$$
$$l_{t-1}^a(t) = w_t^a(t+1) + R(t-1)\, w_t^a(t) - (1+\beta) R(t-1) W_0^a$$
$$l_{t-2}^a(t) = w_t^a(t+2) + R(t-1)\, w_t^a(t+1) + R(t-2) R(t-1)\ w_t^a(t) - (1+\beta+\beta^2) R(t-2) R(t-1) W_{-1}^a$$
$$\vdots$$
$$l_{t-n+2}^a(t) = w_t^a(t+n-2) + R(t-1)\, w_t^a\,(t+n-3) + \ldots + w_t^a(t) \prod_{j=1}^{n-2} R(t-j) - (1+\beta+\ldots+\beta^{n-2})\ W_{3-n}^a \prod_{j=1}^{n-2} R(t-j).$$

Aggregate savings is the sum of these amounts, weighted appropriately for the number of agents in each generation. Since the gross rate of population growth, α, is constant, the generation born at date $t-1$ is always smaller by a factor of $1/\alpha$ relative to the generation born at date t. Normalizing population of the date $t=0$ generation to one yields the following expression for aggregate savings ($n \geq 3$):

$$S(t) = \sum_{i=0}^{n-2} \alpha^{t-i} w_t(t+i) + \sum_{i=0}^{n-3} \sum_{j=1}^{n-2-i} \alpha^{t-i-j} w_t(t+i) \prod_{k=1}^{j} R(t-k) - \alpha^t W_1 - \sum_{i=1}^{n-2} \sum_{j=0}^{i} \alpha^{t-i} \beta^j W_{1-i} \prod_{k=1}^{i} R(t-k)$$

as given in the text.

Appendix 2
Derivative of S(R)

The derivative is given by

$$\frac{dS}{dR} = w_t(t)\left[\frac{1}{\alpha} + \frac{2R}{\alpha^2} + \frac{3R^2}{\alpha^3} + \ldots + \frac{(n-2)R^{n-3}}{\alpha^{n-2}} - \left[\frac{\frac{(1+\beta)}{\alpha} + \frac{(1+\beta+\beta^2)2R}{\alpha^2} + \ldots + \frac{(1+\beta+\ldots+\beta^{n-2})(n-2)R^{n-3}}{\alpha^{n-2}}}{1+\beta+\beta^2+\ldots+\beta^{n-1}}\right]\right]$$
$$+ w_t(t+1)\left[\frac{1}{\alpha^2} + \frac{2R}{\alpha^3} + \frac{3R^2}{\alpha^4} + \ldots + \frac{(n-3)R^{n-4}}{\alpha^{n-2}} + \frac{1}{R^2\sum_{i=0}^{n-1}\beta^i} - \left[\frac{\frac{(1+\beta+\beta^2)}{\alpha^2} + \frac{(1+\beta+\beta^2+\beta^3)2R}{\alpha^3} + \ldots + \frac{(1+\beta+\ldots+\beta^{n-2})(n-3)R^{n-4}}{\alpha^{n-2}}}{1+\beta+\beta^2+\ldots+\beta^{n-1}}\right]\right]$$
$$+ w_t(t+2)\left[\,.\,\right] + \ldots - w_t(t+n-1)\left[\,.\,\right].$$

By inspection, it is apparent that potentially negative portions of this derivative are offset by larger positive terms. For instance, the term $-\frac{(1+\beta+\beta^2)2Rw_t(t)}{\alpha^2}\left[\sum_{i=0}^{n-1}\beta^i\right]^{-1}$ is offset by the positive term $2Rw_t(t)/\alpha^2$. Hence, the derivative is positive.

Appendix 3
When Do Discounting Effects Exactly Offset Population Growth Effects on the Condition for Valued Fiat Currency?

When the endowments received by agents in each period are equal, setting $\beta=\alpha^{-1}$ implies no net effect on the condition for valued fiat currency. Equal endowments implies that the condition is

$$\sum_{i=1}^{n}\alpha^{1-i}\left[(n-i)-B\right] > 0.$$

If this sum is exactly zero, it would be equivalent to the condition with no discounting and no population growth, that is, $\alpha=\beta=1$. The sum is exactly zero when $\beta=\alpha^{-1}$. To see this, write the sum as

$$\left[(n-1)+\frac{(n-2)}{\alpha}+\frac{(n-3)}{\alpha^2}+\ldots+\frac{1}{\alpha^{n-2}}\right]$$

$$-B\left[1+\frac{1}{\alpha}+\frac{1}{\alpha^2}+\ldots+\frac{1}{\alpha^{n-2}}\right]>0.$$

The term multiplying B cancels with the denominator of B (see the text) when $\beta=\alpha^{-1}$. The first sum is simply the numerator of B when $\beta=\alpha^{-1}$. Hence, this sum is zero when $\beta=\alpha^{-1}$.

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