Q4
1999

Economic & Financial Review

Federal Reserve Bank of Dallas

The Nature and Significance of Intra-industry Trade
Roy J. Ruffin

Is There a Persistence Problem? Part 1: Maybe
Evan F. Koenig

Economic and Financial Review

Federal Reserve Bank of Dallas

Economic and Financial Review (ISSN 1526-3940), published quarterly by the Federal Reserve Bank of Dallas, presents in-depth information and analysis on monetary, financial, banking, and other economic policy topics. Articles are developed by economists in the Bank's Economic Research and Financial Industry Studies departments. The views expressed are those of the authors and do not necessarily reflect the positions of the Federal Reserve Bank of Dallas or the Federal Reserve System.

Subscriptions are available free of charge. Please direct requests for subscriptions, back issues, and address changes to the Public Affairs Department, Federal Reserve Bank of Dallas, P.O. Box 655906, Dallas, TX 75265-5906; call 214-922-5254; or subscribe via the Internet at www.dallasfed.org. *Economic and Financial Review* and other Bank publications are available on the Bank's web site, www.dallasfed.org.

Contents

The Nature and Significance of Intra-industry Trade

Roy J. Ruffin

Page 2

In this article, Roy Ruffin gives an overview of intra-industry trade for the generalist. Intra-industry trade represents international trade within industries rather than between industries. Such trade is more beneficial than inter-industry trade because it stimulates innovation and exploits economies of scale. Moreover, since productive factors do not switch from one industry to another, but only within industries, intra-industry trade is less disruptive than inter-industry trade.

Is There a Persistence Problem? Part I: Maybe

Evan F. Koenig

Page 10

Empirical studies suggest that monetary policy shocks can have a sustained impact on aggregate output. How is it possible for nominal shocks to have persistent real effects? One popular explanation centers on overlapping price contracts. However, recent theoretical work has cast doubt on the price-contract story. It turns out to be extremely difficult to obtain long-lasting output effects from policy shocks in a world with staggered price setting, except under unrealistic assumptions about household tastes.

Evan Koenig uses a simple model economy to illustrate why the popular explanation of the role of staggered price setting in generating persistence typically fails and why there is renewed interest in labor-market imperfections as a possible source of persistence. A follow-up article in a subsequent issue will examine the potential contribution of labor-market imperfections in more detail.

The Nature and Significance of Intra-industry Trade

Roy J. Ruffin

Intra-industry trade represents international trade within industries rather than between industries. Such trade is more beneficial than inter-industry trade because it stimulates innovation and exploits economies of scale.

Roy J. Ruffin is a research associate of the Federal Reserve Bank of Dallas and M. D. Anderson Professor of Economics, University of Houston.

International trade is traditionally thought to consist of each country exporting the goods most suited to its factor endowment, technology, and climate while importing the goods least suited for its national characteristics. Such trade is called *inter*-industry trade because countries export and import the products of different industries. But the top exports and imports of most industrial countries are actually similar items, such as passenger cars, electrical generators, or valves and transistors. Indeed, passenger cars are the number one export *and* import of Great Britain, Germany, and France. In the real world, international trade is largely trade within broad industrial classifications. *Intra*-industry trade occurs when a country exports and imports goods in the same industry. Intra-industry trade has been a hot topic among trade economists for several decades, but it has received scant attention among economists in general.[1] This article gives an overview of intra-industry trade for the generalist. In the debate over NAFTA, for example, commentators focused much attention on America's inter-industry trade with Mexico but none on the far more important intra-industry trade.

This article begins with a brief summary of Ricardian and factor endowment approaches to trade theory to highlight the contribution of intra-industry trade theory. Next, the article discusses the foundations of intra-industry trade theory and the significance of intra-industry trade for an economy. Finally, the U.S.–Mexico trade relationship is addressed as a pertinent example.

STANDARD TRADE THEORY

To understand why trade economists have turned their attention to intra-industry trade, it is necessary to understand the implications of inter-industry trade. Standard trade theory involves trade in homogeneous products; hence, with perfect competition there is only inter-industry trade. David Ricardo (1817) introduced standard trade theory when he formulated what we now call the theory of comparative advantage. Ricardo highlighted the key ingredient of the theory: goods are more mobile across international boundaries than are resources (land, labor, and capital). This assumption still characterizes the theory of intra-industry trade. The theory of comparative advantage deals with all those causes of international trade that are generated by the *differences* among countries. Ricardo's contribution was not simply that he noted countries are different but that he showed how those differences resulted in all countries

being internationally competitive even though they might have higher wages (for advanced countries) or lower productivity (for developing countries) than their neighbors.

Ricardo's own subtle explanation is couched in terms of the barter of exports for imports. In the practical world, trade is conducted in terms of prices: people buy homogeneous goods where they are the cheapest. Consider a world of two countries, called home and foreign. The two homogeneous goods are apples and bananas. Suppose in the home country apples cost $1 each and bananas cost $2 each, and in the foreign country bananas cost $1 and apples cost $2. For simplicity, the two countries are mirror images. Keeping with the simple theme, but without any sacrifice of insight, imagine everyone in the world spends exactly one-half his or her income on each good. Suppose each country has income of $100. Thus, before trade, the home (foreign) country consumes fifty apples (bananas) and twenty-five bananas (apples). If trade is opened between the countries and there are zero transport costs and tariffs, people will buy the homogeneous products in the country where they are the cheapest. Thus, with free trade between the two countries, the home country will buy bananas from the foreign country, and the foreign country will buy apples from the home country. The price of each product in a competitive world will be the price in the lowest cost country. Thus, without tariffs or transport costs, the prices of apples and bananas will both be $1 in a world of perfect competition.

Clearly, both countries gain from trade. This gain can be quantified. The price of the imported good (bananas for the home country, apples for the foreign country) drops by 50 percent (from $2 to $1); since half of all income is devoted to each good, the real cost of living falls by approximately 25 percent. With an income of $100, each country now consumes fifty units of each good, including twenty-five units more of the imported good.

This example has been deliberately conducted without reference to wages and productivity, but that is in the background. The same example is consistent with widely different productivities.[2] Suppose that in the home country each worker can produce two apples or one banana. If prior to trade the price of apples is $1 and bananas $2, a worker can earn $2 in either industry. Suppose that in the foreign country each worker can produce ten apples or twenty bananas. Thus, the foreign country is five times more efficient in apples and twenty times more efficient in bananas than the home country. If once again, prior to trade, in the foreign country, bananas are $1 and apples $2 (the reverse), a worker can earn $20 in either apple or banana production. When trade is opened, apples and bananas are again $1 (as in the first example), but wages are ten times higher in the foreign country than in the home country. Since apples and bananas both sell for $1, in the home country no one wants to work in banana production, and in the foreign country no one wants to work in apple production.

Trade causes a massive relocation from industries that compete with imports to export industries. In this simple example, wages are not hurt because of the simplicity of the model: there are no learning costs, and workers are homogeneous and can easily switch from, say, apple production to banana production. Trade has no downside.

The Ricardian model of trade is designed to show that every country can profitably take advantage of any differences among countries. Whether one country has higher wages or lower productivity, the competitive wage rates that prevail in a country ensure that every country will specialize in the good in which it has a comparative advantage. In our example, the home country exports apples, the good in which its disadvantage is the smallest; and the foreign country exports bananas, the good in which its advantage is the largest.

The Ricardian trade model cannot explain how trade impacts the income distribution within a country or what determines comparative advantage. For these, trade theorists turn to the Heckscher–Ohlin model of trade (Samuelson 1948).

The Heckscher–Ohlin model (developed by Swedish economists Eli Heckscher and Bertil Ohlin) describes a world in which every country faces the same technological frontiers and has productive factors with the same qualities. The only difference between countries is in terms of the physical quantities of the factors of production, so that the Heckscher–Ohlin model is an account of trade based on factor endowments.

This theory has three fundamental features. First, each country exports goods that are intensive in the country's relatively abundant factors. Using Ricardian insights, we could express this as well by saying a country exports those goods in which its abundant factors have a comparative advantage. Thus, the United States is richly endowed with high-technology skills and farmland, so it is not surprising that we export high-tech products and agricultural

The Stolper–Samuelson Theorem

One of the classic theorems in international trade theory is the Stolper–Samuelson theorem, named after Wolfgang Stolper and Nobel prize winner Paul Samuelson (Stolper and Samuelson 1941). The theorem is celebrated because it indicates that an increase in the price of labor-intensive goods raises the real return to labor independently of all considerations of how labor spends it income. The key is this: if the price of labor-intensive goods rises, resources will be drawn out of other industries into the labor-intensive industries. But the other industries are not labor-intensive; they may be land-intensive. If this is the case, then, relative to demand, labor becomes more scarce and land less scarce, driving up the price of labor and driving down the price of land. Moreover, for every 1 percent increase in the price of the labor-intensive good, the price of labor rises by more than 1 percent. The reason is simple: the cost of the product is made up of both land and labor. If land falls in price and labor rises in price, the wage rate must rise by more than the price of the labor-intensive good. Suppose labor is 75 percent of total costs. If the price of the labor-intensive good rises by 10 percent, the price of labor must rise by more than 10 percent to increase total costs by 10 percent.

The implication of Stolper–Samuelson is that if a country imports labor-intensive goods, international trade lowers the price of such goods and so makes laborers worse off. While the economy as a whole gains, workers lose out. If a country exports labor-intensive goods, both the economy as a whole and workers gain from more international trade.

goods. Our number one export is aircraft, which requires a great deal of technological expertise. Countries like Argentina and Australia, which are rich in land, are big exporters of beef and wool.

The second feature is that trade based on factor endowments benefits abundant factors and hurts scarce factors. When the United States exports wheat, the owners of wheat land benefit; but when the United States imports textiles, the unskilled workers in the textile industry are hurt. This is all a question of pricing. If the price of anything rises or falls, those productive factors with a comparative advantage in that product find their incomes rising or falling, respectively. (See the box entitled "The Stolper–Samuelson Theorem.")

The last feature of the Heckscher–Ohlin model is that international trade results in a tendency toward factor price equalization. This can be explained with a slight modification of the Ricardian example. Suppose the world has two types of workers, type A and type B. Type A workers can produce two apples or one banana, and type B workers can produce four bananas or two apples. It is clear that type A workers will produce apples and type B workers, bananas. Now suppose all countries are the same except that they have different numbers of type A and type B workers. When trade is established between two countries, apples and bananas will sell for, say, $1 each. Then type A workers, regardless of their location, will produce apples and earn $2; type B workers, regardless of their location, will produce bananas and earn $4. The identical production conditions around the world guarantee the same wages for A people or B people as long as apples and bananas fetch the same price. Countries will export apples or bananas, depending on whether they have relatively more A people or B people.[3]

In the Heckscher–Ohlin model, economies export the services of their abundant factors and import the services of their scarce factors. But empirical investigations of the Heckscher–Ohlin model have not had much success (Trefler 1995). In particular, it has been found that the estimated trade in factor services is less than the actual factor endowments around the world would predict (Trefler 1995, 1032).

If this is the case, we should not expect international trade to have much of an impact on income distribution. The Heckscher–Ohlin model suggests that since labor is the scarce factor in the United States, international trade should hurt labor and help capital. Table 1 presents statistics on trade and income distribution in the United States from 1972 to 1997. During this period the ratio of imports to GDP doubles from 6 percent to 13 percent. Yet the ratio of wages to national income falls insignificantly from 73 percent in 1972 to 71 percent in 1997. While this reduction may be disturbing to some, we must remember that during this period transfer payments to individuals increase substantially, from 12.4 percent to 16.3 percent of personal income (Executive Office of the President 1999, 360–61). This could account for a slight reduction in the importance of wages. However, it can be argued that international trade should help skilled workers and hurt unskilled workers since unskilled workers are the scarce factor in the United States. The average wage data do not capture this. During the same period the overall level of income inequality in the United States rises. The Gini coefficient (1 = perfect inequality; 0 = perfect equality) climbs from .401 in 1972 to .459 in 1997.[4] This change is largely due to the rising ratio of skilled to unskilled wages, which reflects not so much trends in international trade but trends toward technology that favors skilled workers (Juhn, Murphy, and Pierce 1993). Note that from 1972 to 1977, the importance of trade to the U.S. economy jumps dramatically with virtually no change in the Gini coefficient. The major changes in the Gini coefficient occur with small or no changes in the amount of trade. Thus, it is difficult to conclude that international trade has had an unfavorable impact on income distribution in the United States.

A major reason international trade does not have the predicted impact on income distri-

bution is that most international trade is intra-industry. When international trade takes place, there is not a massive reallocation of factors of production from labor-intensive industries to capital-intensive industries. Instead, factors of production are reallocated within industries, and this does not have the same impact as inter-industry trade.

Table 1
Trade and Income Distribution

Year	Imports/GDP	Wages/National Income	Gini Coefficient
1997	.13	.71	.459
1992	.11	.73	.451
1987	.11	.72	.426
1982	.09	.74	.412
1977	.09	.72	.402
1972	.06	.73	.401

SOURCE: *Economic Report of the President*; U.S. Census Bureau.

FOUNDATIONS OF INTRA-INDUSTRY TRADE

The above description of the basic causes of inter-industry trade focuses on the differences between countries. But a great deal of international trade can take place between similar countries. Consider two countries that produce watches and radios. Let the products be homogeneous and the countries identical. But assume economies of scale so that production costs fall with greater output. Clearly, it would be beneficial if one country produced watches and the other produced radios. But this is still not intra-industry trade. A simple example involves transportation costs, or what is called border trade, where two countries share a border but some towns are best served by a nearer plant in the adjacent country because of transport costs. Now modify the economies of scale discussion. Let watches be differentiated. Wouldn't there be specialization within the category of watches, with one country producing more sports watches and another more luxury watches? Larger markets open up more possibilities of producing a larger number of varieties (think of the tremendous variety of passenger cars existing in the world today).

A monopolistically competitive industry is one that produces the same generic good. However, each firm occupies a particular position or niche by virtue of product differentiation (quality, location, color, size, and so on). There is free entry of new firms selling differentiated products, and the seller of each variety has some control over price. The automobile industry may be thought of as a prototypical monopolistically competitive industry. The number of products produced in the industry may be supposed to be equal to the number of abstract firms, although several of such firms may belong to the same conglomeration, such as Ford or General Motors. There may not be free entry for the conglomerates, but there certainly is for the niches they choose. It is relatively easy for any of the large automobile companies to produce a particular type of sport utility vehicle, for example.

Think of an industry as consisting of "resources" that must be allocated among different versions of the same generic product.[5] For simplicity, identify a firm with producing a particular variety. On the average, the number of varieties must be equal to the resources devoted to the industry divided by the average resources used by a typical firm. This is our first principle.

The second principle is that the resources used by the firm (each product) equal fixed costs plus variable costs. Fixed costs (F) do not vary with output (x), and variable costs vary with output. We suppose variable costs are proportional to output by the constant c. Thus, the resources used by the firm are represented by $F + cx$. The quantity c is incremental or marginal cost. If the total resources devoted to an industry are denoted by R, the first principle implies that the number of products, n, is

$$n = R/(F + cx). \quad (1)$$

The third principle is that every firm in the industry exercises some monopoly power and so can charge a price above incremental or marginal cost. We simplify by supposing each firm has the same marginal cost and charges the same markup over cost. Thus, the price (P), where k is the price markup (>1) is

$$P = kc. \quad (2)$$

The fourth principle is that firms enter the industry as long as there are economic profits; that is, the price of the product exceeds the average (opportunity) cost of producing the good. The average cost of the good is $F/x + c$, so entry occurs until the price equals average cost:

$$P = F/x + c. \quad (3)$$

If we put Equations 2 and 3 together, we can solve for x since $kc = F/x + c$:

$$x = F/c\,(k - 1). \quad (4)$$

We can substitute Equation 4 into Equation 1 to solve for the number of products:

$$n = R\,(k - 1)/Fk. \quad (5)$$

The number of products in an industry rises as resources devoted to industry rise, pricing power (k) falls, or fixed costs fall.

Since the price of every good in this simplified case is the same, we can measure the total output of the industry as simply nx. Thus,

$$Q = nx = R/ck. \quad (6)$$

Equation 6 is very interesting because it shows that fixed costs do not affect total output, only the number of products. Thus, lowering fixed costs keeps output the same but spreads the output over a greater number of products, thus allowing more customization.

Now imagine we have two industries, one with resources R_1 and the other with resources R_2. Measure total resources in the economy as 1. We want to relate all this to international trade between two countries, the home and foreign (denoted by an asterisk). In the home country, $R_1 = 1 - z$ and $R_2 = z$. The foreign country is precisely the opposite, where $R_1^* = z$ and $R_2^* = 1 - z$. It follows from Equation 6 that

$$Q_1/Q_1^* = (1 - z)/z \text{ and } Q_2/Q_2^* = z/(1 - z). \quad (7)$$

In other words, the relative size of an industry across countries exactly reflects the relative amounts of industry resources across countries. This rather trivial fact follows from the assumptions that preferences are uniformly spread over all equally costly products selling at the same price.

The world resources devoted to each industry also equal 1. Moreover, each country may be thought of as having income of 1. To make things even simpler, suppose each country spends exactly half its income on the products of each industry. Since the proportion z of industry 1 is produced in the foreign country and the proportion $1 - z$ in the home country and these are all different varieties of the same good, the home country is importing $(1/2)z$ of industry 1 products from the foreign country while the foreign country is importing $(1/2)(1 - z)$ of industry 1 products from the home country. The home country is simultaneously exporting $(1/2)(1 - z)$ units of industry 1 products and importing $(1/2)z$ units of industry 1 products. The same holds for industry 2 products. If $z = 1/2$, so the two countries are identical, all trade is intra-industry, and each country's exports and imports of each good are the same. If $z < 1/2$, the home country has more resources devoted to industry 1 than industry 2.[6]

The closer z is to one-half, the more intra-industry trade there is; the closer z is to 0 or 1, the less intra-industry trade there is. When $z = 1/2$, both countries have the same endowments of resources, and all trade is intra-industry. When z is not equal to one-half, the two countries are different and some trade is inter-industry. We may measure the intra-industry trade (IIT) in industry 1 products by home exports minus home imports:

$$\text{IIT}_1 = (1/2)(1 - z) - (1/2)z = (1/2)(1 - 2z). \quad (8)$$

Clearly, if $z < 1/2$, the home country exports more industry 1 products than it imports. Its intra-industry trade in industry 2 products will be the opposite: it will import more than it exports. Thus, net exports of industry 1 are paying for net imports of industry 2. This is *inter*-industry trade.

SIGNIFICANCE OF INTRA-INDUSTRY TRADE

In 1996, 57 percent of U.S. trade took place within rather than between four-digit Standard International Trade Classification (SITC) industries (Executive Office of the President 1998, 218). Intra-industry trade constitutes more than 60 percent of European trade and about 20 percent of Japanese trade. The preceding theory tells us Japan has less intra-industry trade because its factor endowment is significantly different from those of other advanced countries; another reason is Japan does not experience much border trade. Moreover, the ratio of population to land area is about 365 people per square kilometer, compared with, for example, 108 for France. Thus, it is not surprising that Japan imports more raw materials than do most other developed countries. With more raw materials, there are fewer differentiated manufactured products and less intra-industry trade.

The significance of intra-industry trade arises from its basic character: it need not be based on comparative advantage. To a large extent intra-industry trade arises from the facts that products are differentiated and the production of any particular product requires some fixed costs. Thus, the more sport utility vehicles Ford makes, the lower the unit cost; the more Mercedes-Benz convertibles produced, the lower the unit cost. Some elements of comparative advantage may be involved; for example, Germany may have a comparative advantage in producing high-quality cars. However, the automobile industry is now a world industry (mergers between Daimler-Benz and Chrysler, Ford and Volvo, and so forth). To the extent that comparative advantage is not involved, the pattern of trade is indeterminate. When economies of scale

are involved, who exports what can be determined by the accident of history.

One of the great benefits of intra-industry trade is that international trade need not cause the dislocations associated with inter-industry trade. The Stolper–Samuelson theorem (see box) suggests that international trade can cause a redistribution of income from scarce factors to abundant factors. But if most international trade is intra-industry, the impact on internal income distribution should be relatively minor. If trade is not based on scarce and abundant factors of production, it does not result in reduced demand for the scarce factors and increased demand for the abundant factors; thus, trade expansion need not result in large changes in the distribution of income. As pointed out earlier (*Table 1*), trade does not appear to have negative consequences for income distribution in the United States.

Intra-industry trade enhances the gains from trade through better exploitation of economies of scale—rather than through comparative advantage—as trade leads countries to concentrate on a limited number of products within any particular industry. This leads to an expansion of world output because of the saving of fixed costs.

Specialization within industrial categories may also stimulate innovation. Producing a greater variety and number of goods increases our general knowledge about technology, and greater knowledge implies smaller costs of knowledge accumulation. For example, U.S. importation of Japanese cars and trucks has led to improvements in U.S. car and truck manufacturers. Adam Smith pointed out that the division of labor itself promoted innovation:

> The invention of all those machines by which labour is so much facilitated and abridged seems to have been originally owing to the division of labour. Men are much more likely to discover easier and readier methods of attaining any object when the whole attention of their minds is directed towards that single object than when it is dissipated among a great variety of things. But in consequence of the division of labour, the whole of every man's attention comes naturally to be directed towards some one very simple object. (Smith 1937, Book I, Chapter 1).

Substantial evidence suggests international trade is more beneficial than the standard theory of inter-industry trade implies. According to standard theory, opening international trade causes an increase in the level of GDP but no long-run increase in the *rate* of economic growth. When we classify countries according to their degrees of protectionism, economies with open trade regimes appear to grow their per capita incomes from 1 percent to 2 percent faster *per year* (Gould and Ruffin 1995). This can be explained by the theory of endogenous growth: trade stimulates innovation, and innovation begets more innovation (Gould and Ruffin 1993).

Finally, intra-industry trade reduces the demands for protection because in any industry there are both exports and imports, making it difficult to achieve unanimity among those demanding protection (Marvel and Ray 1987).

Intra-industry trade need not give rise to a justification for a strategic trade policy, that is, giving export subsidies to correct for departures from perfect competition. It is true that much intra-industry trade takes place under imperfect competition, but monopolistic competition is for all practical purposes efficient. Indeed, it is easy to construct examples in which monopolistic competition provides optimal product diversity (Dixit and Stiglitz 1977). Two basic, necessary—but not sufficient—conditions for a strategic trade policy are (1) foreign monopoly or oligopoly and the ability to shift foreign profits to domestic residents and (2) externalities, in which the promotion of certain industries benefits others in a way that cannot be captured by private markets.[7] However, these are not key parts of the intra-industry story.

U.S. TRADE WITH MEXICO

Contrary to popular belief, the top U.S. imports from Mexico are not clothing, fruits, and vegetables. These represent only 10 percent of U.S. imports. Table 2 lists the top seven exports and imports to and from Mexico for 1998. Electrical machinery and equipment (and related parts) ranks first, representing 27 percent of U.S. imports from Mexico. Vehicles rank second, and nuclear reactors, boilers, and related items are third.

Interestingly, the United States' top three exports to Mexico are these same three categories. However, only 48 percent of U.S. exports to Mexico consist of these big, capital-intensive items, compared with 57 percent for imports from Mexico. Not only are Mexico's exports to the United States quite similar to its imports (intra-industry trade), but Mexico's exports are more concentrated in those big items of intra-industry trade.

Table 2
U.S. Trade With Mexico, 1998

Imports from Mexico	Billions of dollars	Percent
All commodities	94.7	100
Electrical machinery and equipment and related parts	25.8	27
Vehicles, other than railway	16.7	18
Nuclear reactors, boilers, machinery and mechanical	11.6	12
Mineral fuels, mineral oils	5.3	6
Articles of apparel and clothing accessories	3.8	4
Insulated wiring sets for vehicles, ships, and aircraft	3.7	4
Optical, photographic, cinematic, measuring	3.3	3
Total for top seven imports	**70.2**	**74**
Exports to Mexico		
All commodities	79.0	100
Electrical machinery and equipment and related parts	18.8	24
Nuclear reactors, boilers, machinery and mechanical	11.2	14
Vehicles, other than railway	8.0	10
Plastics and articles thereof	5.0	6
Optical, photographic, cinematic, measuring	2.3	3
Parts and accessories for vehicles	1.9	2
Paper and paperboard	1.9	2
Total for top seven exports	**49.1**	**61**

SOURCE: U.S. Department of Commerce.

The products listed in Table 2 represent 61 percent of all exports and 74 percent of all imports in U.S. trade with Mexico. Of these imports and exports, about 80 percent represent intra-industry trade—perhaps the most important point regarding U.S.–Mexico trade. The United States exports automobile parts to Mexico, where the cars are assembled, and some are shipped back. But the flow of automobile parts is actually heavier from Mexico into the United States. Indeed, vehicle parts account for only about 6 percent of U.S. exports to Mexico, whereas they make up 20 percent of U.S. imports from Mexico. These parts are assembled in the United States, and the vehicles are shipped back to Mexico.

Much U.S. trade with Mexico involves the maquiladora industries along the U.S.–Mexican border. The maquiladora ("twin plant or production sharing") program has opened the 2,000-mile border region into a rapidly developing industrial zone for American firms involved in labor-intensive manufacturing. Under the program, equipment, machinery, supplies, and raw materials can be temporarily imported into Mexico duty-free. Products are assembled and/or manufactured using inexpensive Mexican labor and exported back to the United States, where duty is paid only on the "Mexican value-added," or shipped to other foreign countries. Such trade may appear to reduce the demand for labor by U.S. industries. But molded plastics, packaging material, electronic components, and wire constitute a large part of the materials purchased by the maquiladoras. If they were purchasing the products of capital-intensive industries, the effect might be to reduce U.S. labor demand. But the maquiladoras are buying and selling labor-intensive products. Thus, U.S. trade with Mexico does not fit into a neat scarce-factor/abundant-factor explanation of trade.

CONCLUSIONS

Intra-industry trade represents international trade within industries rather than between industries. Such trade is more beneficial than inter-industry trade because it stimulates innovation and exploits economies of scale. Moreover, since productive factors do not switch from one industry to another, but only within industries, intra-industry trade is less disruptive than inter-industry trade. About 60 percent of U.S. trade or European trade is intra-industry. By comparison, about 80 percent of U.S. trade with Mexico is intra-industry, and thus concern that trade with Mexico will harm unskilled workers is based on an erroneous view of the nature of that trade.

NOTES

The author wishes to thank David Gould for comments. The author is responsible for all errors and omissions.

1 The classic treatise is Grubel and Lloyd (1975).

2 As Ricardo put it: "The labour of 100 Englishmen cannot be given for that of 80 Englishmen, but the produce of the labour of 100 Englishmen may be given for the produce of the labour of 80 Portuguese, 60 Russians, or 120 East Indians."

3 The setup in this paragraph follows Ruffin (1988).

4 The Gini coefficient is calculated from the Lorenz curve and is approximately the proportion by which the distribution of income differs from perfect equality.

5 The theory that follows is a simplified version of a paper by Krugman (1981), which is in turn an extension and simplification of Dixit and Stiglitz (1977).

6 This argument is in Dixit and Norman (1980) and Krugman (1981).

7 For a wide-ranging collection of articles, see Krugman (1986).

REFERENCES

Dixit, A., and V. Norman (1980), *Theory of International Trade* (Cambridge: Cambridge University Press).

Dixit, A., and J. Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity," *American Economic Review* 67 (June): 297–308.

Executive Office of the President (1998), *Economic Report of the President* (Washington, D.C.: Government Printing Office).

——— (1999), *Economic Report of the President* (Washington, D.C.: Government Printing Office).

Grubel, H. G., and P. J. Lloyd (1975), *Intra-Industry Trade: The Theory and Measurement of International Trade in Differentiated Products* (New York: John Wiley).

Gould, David, and Roy Ruffin (1993), "What Determines Economic Growth?" Federal Reserve Bank of Dallas *Economic Review,* Second Quarter, 25–40.

——— (1995), "Human Capital, Trade, and Economic Growth," *Weltwirtschaftliches Archiv* 131: 425–45.

Juhn, C., K. Murphy, and B. Pierce (1993), "Wage Inequality and the Rise in the Returns to Skill," *Journal of Political Economy* 101 (June): 410–42.

Krugman, Paul (1981), "Intraindustry Specialization and the Gains from Trade," *Journal of Political Economy* 89 (October): 959–73.

Krugman, Paul, ed. (1986), *Strategic Trade Policy and the New International Economics* (Cambridge: MIT Press).

Marvel, H. P., and E. Ray (1987), "Intra-industry Trade: Sources and Effects on Protection," *Journal of Political Economy* 95 (December): 1278–91.

Ricardo, David (1817), *Principles of Political Economy and Taxation* (London: John Murray).

Ruffin, Roy (1988), "The Missing Link: The Ricardian Approach to the Factor Endowment Theory of Trade," *American Economic Review* 78 (September): 759–72.

Samuelson, Paul (1948), "International Trade and the Equalisation of Factor Prices," *Economic Journal* 58 (June): 163–84.

Smith, Adam (1937), *An Inquiry into the Nature and Causes of the Wealth of Nations* (New York: Modern Library).

Stolper, Wolfgang, and Paul Samuelson (1941), "Protection and Real Wages," *Review of Economic Studies* 9 (November): 58–73.

Trefler, Daniel (1995), "The Case of Missing Trade and Other Mysteries," *American Economic Review* 85 (December): 1029–46.

Is There a Persistence Problem? Part 1: Maybe

Evan F. Koenig

It would seem that staggered price adjustment must delay the economy's approach to market-clearing equilibrium following a monetary shock. But a key ingredient in this story is the assumption that each firm wants to keep its price close to the average price.

Evan Koenig is a senior economist and assistant vice president in the Research Department at the Federal Reserve Bank of Dallas.

The average post–World War II recession has lasted eleven months. This fact suggests that if monetary policy has contributed significantly to the business cycle, policy changes must have a prolonged impact on real economic activity. Although results from vector autoregression studies typically indicate monetary policy shocks have not, in fact, been a major source of post-war business-cycle fluctuations, these same studies suggest that money is *capable* of large and persistent output effects.[1]

Among economists who regard monetary policy as potentially important for real activity, there is little agreement about the underlying cause of monetary nonneutrality. However, one popular explanation for nonneutrality is sluggish price adjustment.[2] There are two major strands in this literature. The menu-cost strand assumes that firms must pay a small fixed cost whenever they change their prices. The individual firm must decide whether the gains from changing its price more than offset the cost. A key result is that even small menu costs can lead to large departures from market-clearing equilibrium in response to monetary policy shocks (Akerlof and Yellen 1985a, b; Mankiw 1985). In the second strand of the literature, firms are able to change their prices costlessly at predetermined intervals. This approach is sometimes motivated by the fact that many real-world prices are preset in contracts. An important result is that even if the interval between each individual firm's price adjustments is quite short, the average price level may react slowly to policy shocks if price adjustments are not synchronized across firms.[3] Sluggish adjustment of the average price level is sufficient to generate persistent movements in aggregate output.

How might frequent but staggered adjustment of individual prices lead to slow movement in the average price level? For concreteness, consider an economy with thirty identical firms, each of which changes its price once a month. Now suppose that the money supply doubles. The increase is a complete surprise and is expected to be a one-time event. Under these circumstances, in the absence of nominal rigidities, all prices would immediately double. There would be no other economic effects. More generally, if the thirty firms change prices synchronously, it would take fifteen days, on average (and never more than thirty days), for the price level to double and market-clearing equilibrium to be restored.[4] Suppose, instead, price adjustment is staggered, so that every day one of the thirty firms has the opportunity to

change its price. Suppose further that each firm—perhaps out of fear of losing customers to competitors—doesn't want to stray far from the prevailing average price level. Suppose, in particular, that when it has a chance to adjust its price, each firm moves to a point somewhere between the prevailing average price and the long-run, market-clearing price. Because, on day 1, firm 1 sets a price below the long-run price, the new average price on day 1 will also be below long-run equilibrium. With each passing day, the firm free to reset its price will charge a little more than the previous firm but less than it would in market-clearing equilibrium. Hence, the average price remains below its long-run equilibrium level. In particular, after thirty days every firm's price will be higher but less than twice the original price. Price adjustment will still be incomplete.

It would seem that staggered price adjustment must delay the economy's approach to market-clearing equilibrium following a monetary shock. But a key ingredient in the above story is the assumption that each firm wants to keep its price close to the average price. Chari, Kehoe, and McGrattan (1996)—hereafter CKM—question this assumption. They argue it is very difficult to find plausible specifications of household tastes for which the assumption holds. Consequently, it is extremely difficult to obtain long-lasting output effects from policy shocks in a world with staggered price setting. CKM dub this difficulty "the persistence problem."

This article illustrates and explains CKM's results using a simple model economy.[5] The explanation that emerges from the analysis is as follows: In economies with sluggish price adjustment, a positive monetary shock drives up the demand for output, hence the demand for labor. Meantime, households, feeling wealthier, reduce the supply of labor. To clear the market, the wage rate must rise. At a higher wage, the price firms want to charge for their products increases. For realistic household tastes, the wage increase is so great that firms with the opportunity to respond raise their prices *more* than proportionately to the original money shock—not less than proportionately, as required to generate persistence.

Promising potential solutions to the persistence problem rely on labor-market frictions to short-circuit the wage increase that would otherwise accompany a monetary expansion. Some of these solutions will be examined in a subsequent issue of *Economic and Financial Review*.

A MODEL ECONOMY

Household Decision Making

Households are assumed to be identical, so we need only look at the decisions of a representative household. Suppose this household has a utility function of the form

$$U(C, L) = (C^{1-\sigma} - 1)/(1 - \sigma) - L^{1+1/\xi}/(1 + 1/\xi) \quad (1)$$

each period, where C and L are the levels (not logged) of output consumed and labor supplied and where σ and ξ are both positive constants.[6] Assuming a competitive labor market, household utility maximization requires that the marginal rate of substitution between leisure and consumption equal the real wage: $-U_L/U_C = W/P$, where W and P denote the money wage and average price of output, respectively. For the utility function given above, this condition yields a log-linear labor-supply relationship:[7]

$$l = \xi(w - p) - \sigma\xi c. \quad (2)$$

The supply of labor is increasing in the real wage (with elasticity ξ) and decreasing in household consumption (with elasticity $\sigma\xi$), reflecting households' reduced willingness to work as their wealth rises. Realistic values for σ and ξ are 0.5 and 0.25, respectively.[8]

Finally, we assume that households' desired money balances are determined by their consumption expenditures:

$$m - p = c. \quad (3)$$

Firm Decision Making

The output market is monopolistically competitive. Firms are identical except for the timing of their pricing decisions. CKM assume each firm's price can be changed only at certain times. These times are staggered across firms. Holding the price of a product fixed over an interval might make sense if price changes are costly per se. The costs associated with printing and/or publicizing price lists are germane. These are the sorts of costs emphasized in the menu-cost literature. We assume, instead, that each firm chooses a price *path*. It is this path that is adjusted only at discrete times, staggered across firms. For example, each firm's executives might meet quarterly to reevaluate their pricing plans. Predictable changes in demand for the firm's product or in production costs might lead the executives to decide, at a particular meeting, to schedule a series of, say, price increases stretching over coming months. Presetting a price path this way makes sense if menu costs are small relative to the costs of

gathering and processing information about current and future demand and cost conditions.

Allowing executives the flexibility of choosing a price path rather than a fixed price greatly simplifies their decision making. Further simplification is achieved by assuming there are no durable goods (and, in particular, no capital investment) and that the monetary policy shock is a one-time, completely unexpected event. These conditions do not alter the essential character of the persistence problem.[9]

I begin by considering the decision making of a particular firm—firm *f*, say. Under the above assumptions, as soon as it has a chance to respond to the policy shock, firm *f* selects the price it will charge for its product in each future period. The price in any particular period only affects the firm's profit in that period. Hence, to maximize its profits, the firm chooses a price path that will equate marginal cost to marginal revenue, period by period.

Marginal cost depends on factor prices, the production technology, and (in general) how much output is produced. I adopt the simplest possible production technology:

$$y_f = l_f, \tag{4}$$

where y_f is the amount of output that firm *f* produces using l_f units of labor. It follows that the firm's marginal cost schedule is horizontal and that its height equals the prevailing wage rate, *w*.

Marginal revenue depends on the demand schedule the firm faces and on the firm's production level. I assume a constant elasticity of substitution between the products of different firms, so that the demand for firm *f*'s output is given by

$$y_f = y - (p_f - p)/(1 - \Theta), \tag{5}$$

where *y* and *p* are the average aggregate output level and price level, respectively; p_f is the price charged by firm *f*; and $0 < \Theta < 1$. Equation 5 says the higher firm *f*'s price is relative to the economywide-average price, the lower the firm's sales will be relative to economywide-average sales.[10] Perfect competition is obtained in the limit as $\Theta \to 1$. I assume the firm is small enough that it takes *y* and *p* as given. In this case, the firm's marginal revenue is easily shown to be $p_f + \theta$.[11]

Recall that, given the opportunity, firms equate marginal cost and marginal revenue period by period. In the present case, this means setting price as a markup over the wage rate:

$$p_f = w - \theta. \tag{6}$$

It follows that what occurs in the labor market is critical for determining whether output prices adjust slowly toward long-run equilibrium or tend to overshoot.

Closing the Model

With each firm's production tightly linked to its hiring, a similarly tight link exists between average aggregate output and average aggregate labor hours:

$$y = l. \tag{7}$$

Also, absent a government sector and capital investment, all output must be consumed:

$$y = c. \tag{8}$$

There is some ambiguity about how the quantity of output is determined outside of market-clearing equilibrium. I assume that firms adjust their production to match their sales. This behavior is sensible as long as each firm's output price exceeds the marginal cost of production (*w*).

Once each firm has responded to the policy shock, Equations 4, 5, and 6 will apply to all. Hence, all firms will charge the same price, hire the same amount of labor, and produce the same amount of output in long-run, market-clearing equilibrium. With this result in mind, a little algebraic manipulation of Equations 2, 3, 4, 6, 7, and 8 establishes that

$$y^* = c^* = l^* = \theta\xi/(1 + \sigma\xi), \tag{9}$$

$$w^* = m + \theta - \theta\xi/(1 + \sigma\xi), \tag{10}$$

and

$$p^* = m - \theta\xi/(1 + \sigma\xi), \tag{11}$$

where an asterisk indicates a variable is evaluated in long-run, market-clearing equilibrium. Note that long-run equilibrium output, consumption, and labor are all independent of the money supply, as are the long-run levels of the real wage and real money balances. The long-run, market-clearing *nominal* wage and *nominal* price of output are proportional to the money supply.

SHORT-RUN PRICE ADJUSTMENT

Individual Firms

When they first have a chance to respond to a monetary policy shock, do firms move only part way toward the long-run, market-clearing price level—as required for persistence? Or do they, instead, overshoot long-run equilibrium? We have already established that firms seek to

maintain a constant markup over the wage rate (*Equation 6*). So whether individual firms' prices adjust gradually or overshoot is determined by how strongly the wage rate responds to an unexpected change in the money supply. If the wage rate responds less than proportionately, so will the price charged by any firm free to adjust its price. If the wage rate responds more than proportionately, the prices individual firms charge will overshoot long-run equilibrium.

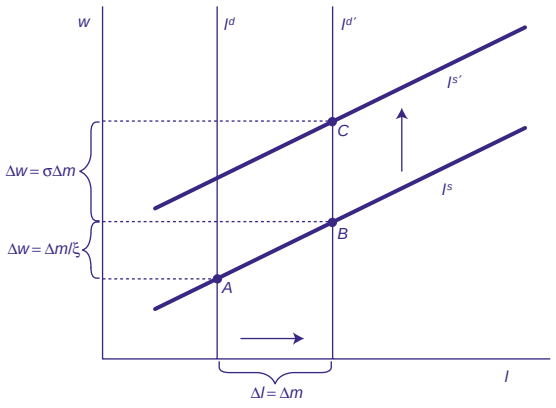
To determine how the wage responds to monetary shocks, we need only substitute from Equations 3, 4, and 8 into the labor-supply relationship (*Equation 2*):

$$(12) \qquad w = p + (1/\xi + \sigma)(m - p).$$

Equation 12 says that the real wage rate varies in the same direction as the real money supply. In fact, for reasonable parameter values, the real wage can be expected to increase about 4.5 percent for each 1 percent increase in real money balances. (Recall that $\sigma \approx 0.5$ and $\xi \approx 0.25$.) Since, with staggered price setting, the economywide-average price level is essentially fixed immediately following a money-supply shock, Equation 12 also says that a sudden 1 percent increase in the *nominal* money supply will trigger an immediate 4.5 percent increase in the *nominal* wage. Thus, the nominal wage overshoots its long-run equilibrium level.

Figure 1 illustrates the labor market's initial response to a monetary shock. In the figure, the labor-supply schedule has slope $1/\xi$ (*Equation 2*). The labor-demand schedule is drawn as a vertical line because in the short run firms are assumed to adjust production to match their sales and aggregate sales are determined solely by the money supply (*Equation 3*). The pre-shock equilibrium is point A. When the money supply suddenly increases, the labor-demand schedule shifts to the right by the same amount. If this were the end of the story, the economy would move to point B, where the (log) wage is $\Delta m/\xi$ higher than before. But the increase in their real money balances makes households feel wealthier, so the labor-supply schedule shifts up by $\sigma\Delta m$. The net result is that the economy ends up at point C. Employment rises by the same amount as the money supply: $\Delta l = \Delta m$. The wage rises by substantially more than the money supply: $\Delta w = (1/\xi + \sigma)\Delta m$.

Figure 1
Short-Run Effects of an Increase in the Money Stock



Since the wage rate rises by more than the money supply, there is a tendency for individual firms' prices to overshoot the long-run equilibrium price level, p^*. To see this overshooting, use Equation 12 to eliminate the wage rate from Equation 6 and use Equation 11 to eliminate the money supply. These substitutions yield

$$(13) \qquad \begin{aligned} p_f &= p + (1/\xi + \sigma)(p^* - p) \\ &= p^* + (1/\xi + \sigma - 1)(p^* - p). \end{aligned}$$

Hence, an increase in the market-clearing price (p^*) relative to the prevailing average aggregate price level (p) leads to overshooting by firms that are free to change their prices if, and only if, $1/\xi + \sigma > 1$. Empirical estimates of ξ and σ suggest this overshooting condition is likely to be satisfied.

Micro-overshooting and Aggregate Persistence

Figures 2 and 3 show how the price charged by firms that have had a chance to reevaluate their pricing (p_f) and the overall average price level (p) vary over time in response to an unexpected doubling of the money supply, under alternative assumptions about the value of the "overshooting parameter," $\omega \equiv 1/\xi + \sigma$. The policy shock is assumed to hit at time $t = 0$, when all firms are charging the price $p(0)$. The length of the unit time interval is chosen so that at $t = 1$, every firm has had a chance to reset its price path. Thus, t is not only an index of time but also measures the fraction of firms that have had a chance to respond to the monetary policy change. Suppose, for example, that firms reset their price paths every three months, so that the unit time interval is ninety-one days. After one month ($t = \frac{1}{3}$), one-third of all firms will be charging $p_f(\frac{1}{3})$ and two-thirds of firms will still be charging $p(0)$; after two months ($t = \frac{2}{3}$), two-thirds of all firms will be charging $p_f(\frac{2}{3})$, and only one-third will still be charging $p(0)$; and so on. (For further details, see the box entitled "The Analytics of Short-Run Price Adjustment.")

When $\omega = 1$, Figure 2 says that firms with

Figure 2

An Individual Firm's Price Response to a Money-Supply Increase

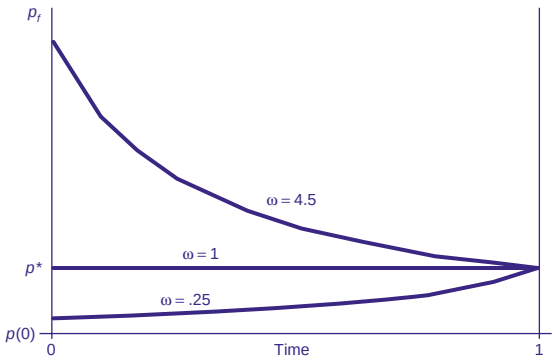
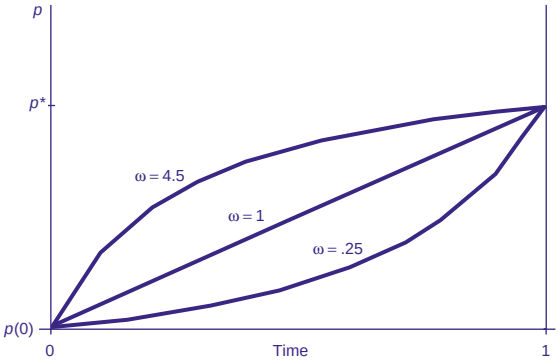


Figure 3

Response of the Aggregate Price Level to a Money-Supply Increase



a chance to adjust their price paths immediately increase their prices from $p(0)$ all the way to p^* and hold them there. As a result, the average price level rises steadily from $p(0)$ to p^* as more and more firms respond to the policy change (*Figure 3*). Price adjustment is neither front-loaded nor back-loaded. It is half complete at $t = ½$.

When $\omega < 1$, firms with a chance to adjust their price paths don't find it desirable to deviate much from the prices other firms charge. Consequently, they set a price path that starts off low—close to $p(0)$—and increases gradually as more and more firms are free to respond to the money-supply shock. The path of the average price level is similar: most of the adjustment occurs near the end of the period. When $\omega = 0.25$, for example, price adjustment isn't half complete until $t = 0.8$.

Finally, when $\omega > 1$, the real wage initially rises so sharply in response to the money-supply shock that firms with an opportunity to raise their prices do so with a vengeance: $p_f(0)$ is well above p^*. As the average price level increases, cutting into the demand for output, marginal production costs fall. So does $p_f(t)$. Adjustment of the average price level is front-loaded in this case. When $\omega = 4.5$, for example, price adjustment is half complete at $t = 0.18$.

Staggered Price Setting: Part of the Solution or Part of the Problem?

Is aggregate price adjustment slower in an economy where the pricing decisions of individual firms are staggered than in an otherwise identical economy in which these decisions are synchronized? For concreteness, suppose firms reevaluate their price paths quarterly (that is, once every ninety-one days). A positive money-supply shock suddenly hits, increasing the market-clearing price level from $p(0)$ to p^*. With synchronized decision making, aggregate price adjustment is an all-or-nothing proposition: either all firms charge $p(0)$ or all firms charge p^*. If the policy shock's timing is random relative to that of price adjustment, the probability that all firms will move to p^* the same day as the shock is 1/91. The probability that all firms will move to p^* the first day *after* the shock is also 1/91, so the probability that firms will move to p^* within two days of the shock is 2/91. More generally, the probability that all firms will be charging p^* within N days of the policy shock is $N/91$, for $N = 1, 2, \ldots, 91$. Hence, the expected aggregate price level, as a function of time, is

$$E[p(t)] = p(0) + t[p^* - p(0)], \tag{14}$$

where $t = N/91$ is the fraction of the quarter that has passed since the money supply increased. Equation 14 says that the expected price level is $p(0)$ at the instant the policy shock hits and rises linearly to p^* one quarter later.

Figure 4

Staggering May Speed or Slow the Price Level's Response to a Money-Supply Increase

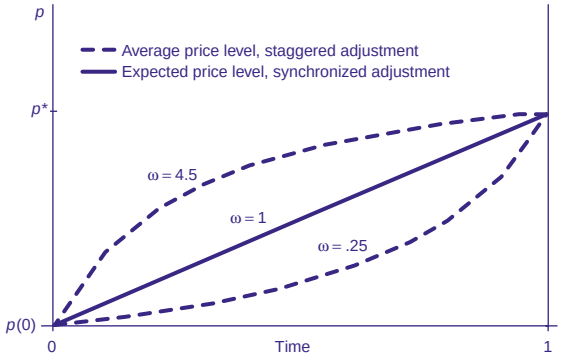


Figure 4 plots the expected aggregate price level under synchronous price adjustment. For comparison, it also reproduces plots of the average aggregate price level from Figure 3, for various values of the overshooting parameter, ω. These latter plots assume, of course, that pricing decisions are staggered across firms. It is apparent that when $\omega = 1$, the rate of aggregate price adjustment is the same, on average, whether price decisions are staggered or not. When $\omega < 1$, aggregate price adjustment is slower when decisions are staggered than when they are synchronized. However, in the most realistic case ($\omega > 1$), staggered price adjustment reduces persistence.

DISCUSSION

At first glance, staggered price setting seems to provide a simple explanation for monetary policy's persistent effects on the real economy. In principle, staggering allows aggregate price adjustment to be slow even if individual firms reevaluate their prices frequently. However, this result is valid only if firms that are free to react to a policy change don't want their prices to differ much from the prices others charge. Chari, Kehoe, and McGrattan forcefully argue that in the real world, the typical household's labor-supply schedule is sufficiently inelastic and wealth-sensitive that the wage rate must rise sharply following a monetary injection, if aggregate labor supply and labor demand are to be equated. This rise in the wage rate drives up firms' marginal production costs and gives firms with the opportunity to do so a powerful incentive to increase prices. So firms do *not* act as though they want to stay close to the prices others charge but instead as though they want to move away from those prices. As a result, aggregate price adjustment is actually swifter when pricing decisions are staggered than when they are synchronized.

Should we, therefore, write off staggered contracts as a possible solution to the persistence problem? There are at least two reasons to think that doing so would be premature. First, models in which staggered price contracts reduce persistence have counterfactual implications in other areas—suggesting these models fail to capture some important features of real-world economies. For example, CKM-style contracting models predict that a money-induced inflation will always be "cost push": the wage rate always rises first in response to a monetary injection, cutting into profit margins. Only gradually do output prices respond.[12] In the real world, there is no clear lead–lag relationship between wages and prices (Mehra 1990). CKM-style models are also arguably unrealistic in predicting that monetary policy changes will have markedly different effects on different firms, depending on the timing of their pricing decisions. For example, these models predict that an unexpected increase in the money supply, although it increases aggregate output, will cause some firms' sales (those of firms able to raise their prices quickly) to fall.[13] Moreover, according to these models, the firms whose sales fall the most will have the highest profits.

Another reason not to write off staggered contracts as a possible solution to the persistence problem is that the CKM results are sensitive to frictions in the labor market. The idea

The Analytics of Short-Run Price Adjustment

This box details the connection between individual firms' pricing decisions and the evolution of the aggregate price level following a money-supply shock. It formalizes the notion that the more advantageous individual firms find it to stay close to the aggregate price level, the slower that level responds to policy shocks.

Without any loss of generality, we can define a unit time interval as the period between each firm's pricing decisions. For example, if each firm decides once per quarter how its price will vary over the coming three months, our unit time interval is one quarter. I assume the timing of different firms' pricing decisions is staggered uniformly over the unit interval, so that the same fraction of firms pick a price path on the first day of the quarter as on the last day of the quarter, or on any other day during the quarter. I also assume each firm is infinitesimally small relative to the economy. (This condition is consistent with the requirement that each firm takes the prevailing average price as given.) Finally, for simplicity, I assume the preshock market-clearing equilibrium is one in which the money supply (and, hence, each firm's price) is constant. I denote this initial price level by $p(0)$.

Because each firm picks a price path rather than a fixed price level, at any point t during the unit interval following a money-supply shock, there are only two different prices in the marketplace. Firms that have not had a chance to reset their price paths charge $p(0)$. From Equation 13, firms that *have* had a chance to reset their price paths charge a price $[p_f(t)]$ that is a weighted average of the prevailing aggregate price level $[p(t)]$ and the long-run, market-clearing price level (p^*):

(B.1) $$p_f(t) = \omega p^* + (1 - \omega)p(t),$$

where $\omega \equiv 1/\xi + \sigma > 0$. Since pricing decisions are staggered uniformly over the unit interval, the average price level at time t is[1]

(B.2) $$p(t) = tp_f(t) + (1 - t)p(0).$$

Equations B.1 and B.2 are readily solved for $p_f(t)$ and $p(t)$ as functions of $p(0)$ and p^*:

(B.3) $$p_f(t) = p(0) + \left[\frac{\omega}{(\omega - 1)t + 1}\right][p^* - p(0)];$$

(B.4) $$p(t) = p(0) + \left[\frac{\omega t}{\omega t + (1 - t)}\right][p^* - p(0)].$$

Figures 2 and 3 show plots of $p_f(t)$ and $p(t)$ for different values of ω.

NOTE

[1] Equation B.2 is a linear approximation of the exact formula, which, from Note 10, is

$$p(t) = [(\Theta - 1)/\Theta]ln\{t \cdot \exp[p_f(t)\Theta/(\Theta - 1)] + (1 - t) \cdot \exp[p(0)\Theta/(\Theta - 1)]\}.$$

that staggered contracts can contribute to persistence in the presence of labor market frictions is explored in Part 2 of this article, which will appear in an upcoming issue of *Economic and Financial Review*.

NOTES

This article has benefited from comments offered by Nathan Balke and Mark Wynne and from the careful editing of Monica Reeves.

[1] See, for example, Leeper, Sims, and Zha (1996). For evidence on how much monetary policy shocks have contributed to the business cycle, one must look at historical decomposition results. For evidence on the *potential* influence of monetary policy shocks, impulse-response functions are relevant. It is possible, of course, that if policymakers tried to vigorously exploit their potential influence, private agents would adapt their behavior in such a way that policy effects would be diminished.

[2] Other explanations include price confusion (Lucas 1972, 1973) and asset-market imperfections (Lucas 1990; Fuerst 1992; Christiano and Eichenbaum 1992, 1995). For an overview of the literature, see Gordon (1990).

[3] See Blanchard (1983). The argument was originally formulated in the context of overlapping wage contracts (Taylor 1980).

[4] In making this statement, I implicitly assume that the model economy has only nondurable goods.

[5] By no means is the analysis presented here exhaustive. CKM's benchmark model is considerably more realistic than that developed below, and CKM explore several variants of the benchmark model to establish that their results are robust to plausible changes in specification. Variants considered include models with endogenous capital accumulation, inelastically supplied specific factors of production, and intermediate producer goods. Here, as many complicating factors as possible are stripped from the CKM analysis, to highlight the basic mechanisms driving their results.

[6] The assumption that utility this period depends only on current consumption and current hours of work is standard but open to question. See Hall (1998).

[7] Throughout, lowercase letters denote the logarithms of their uppercase counterparts. I assume the number of households and firms is equal, eliminating the need to distinguish between, for example, average output per firm and average output per household.

[8] For evidence supporting this calibration of household tastes, see Pencavel (1986), Attanasio and Weber (1994), and Ogaki and Reinhart (1998). In principle, labor indivisibilities (Rogerson 1988) and non-time-separable preferences (Hall 1998) can increase the wage elasticity of the labor supply (ξ). The larger ξ is, the weaker the CKM argument.

[9] However, when firms choose a price path rather than a fixed price level, an upper bound is placed on persistence: price adjustment will always be complete by the time every firm has had a chance to respond to the policy shock. If there are thirty firms, each of which can adjust its price path once per month, aggregate price adjustment cannot take more than one month. When firms choose a fixed price level, price adjustment can, in principle, take longer than one month.

[10] A demand curve of this form is consistent with household utility maximization if the output variable, C, that enters the representative household's utility function is a composite of the goods different firms produce. In particular, if there is a continuum of firms indexed by $f \in [0, 1]$, Equation 5 is obtained if

$$C \equiv [\int C_f^{\Theta} df\,]^{1/\Theta},$$

and

$$P \equiv [\int P_f^{\Theta/(\Theta-1)} df\,]^{(\Theta-1)/\Theta},$$

where C_f is the amount of firm f's output consumed by the household (Blanchard and Kiyotaki 1987). Similarly,

$$Y \equiv [\int Y_f^{\Theta} df\,]^{1/\Theta},$$

and

$$L \equiv [\int L_f^{\Theta} df\,]^{1/\Theta}.$$

[11] Since $0 < \Theta < 1$, we know $\theta \equiv ln(\Theta) < 0$.

[12] According to Equation 6, the wage rate varies one-for-one with p_f. With this in mind, a comparison of Figures 2 and 3 shows the wage rate rises sharply relative to the price level in response to a monetary injection (especially when $\omega > 1$). Alternatively, subtract Equation B.3 from Equation B.4.

[13] Equations 5 and 13 (with a little help from Equations 3, 8, and 11) imply that $y_f - y^* = (p^* - p)(1 - \Theta - \omega)/(1 - \Theta)$, where y_f is the output of a firm that has had a chance to respond to the policy shock. The necessary and sufficient condition for y_f to fall below y^* is $\Theta + \omega > 1$. A sufficient condition, obviously, is $\omega > 1$.

REFERENCES

Akerlof, George A., and Janet L. Yellen (1985a), "Can Small Deviations from Rationality Make Significant Differences to Economic Equilibria?" *American Economic Review* 75 (September): 708–20.

——— (1985b), "A Near-Rational Model of the Business Cycle, with Wage and Price Inertia," *Quarterly Journal of Economics* 100 (Supplement), 823–38.

Attanasio, Orazio P., and Guglielmo Weber (1994), "Is Consumption Growth Consistent with Intertemporal Optimization? Evidence from the Consumer Expenditure Survey," NBER Working Paper Series, no. 4795 (Cambridge, Mass.: National Bureau of Economic Research, July).

Blanchard, Olivier J. (1983), "Price Asynchronization and Price Level Inertia," in *Inflation, Debt, and Indexation*, ed. Rudiger Dornbusch and Mario Henrique Simonsen (Cambridge: MIT Press), 3–24.

Blanchard, Olivier Jean, and Nobuhiro Kiyotaki (1987), "Monopolistic Competition and the Effects of Aggregate Demand," *American Economic Review* 77 (September): 647–66.

Chari, V. V., Patrick J. Kehoe, and Ellen R. McGrattan (1996), "Sticky Price Models of the Business Cycle: Can the Contract Multiplier Solve the Persistence Problem?" NBER Working Paper Series, no. 5809 (Cambridge, Mass.: National Bureau of Economic Research, October).

Christiano, Lawrence J., and Martin Eichenbaum (1992), "Liquidity Effects and the Monetary Transmission Mechanism," *American Economic Review* 82 (May): 346–53.

——— (1995), "Liquidity Effects, Monetary Policy, and the Business Cycle," *Journal of Money, Credit, and Banking* 27 (November): 1113–36.

Fuerst, Timothy S. (1992), "Liquidity, Loanable Funds, and Real Activity," *Journal of Monetary Economics* 29 (February): 3–24.

Gordon, Robert J. (1990), "What Is New-Keynesian Economics?" *Journal of Economic Literature* 28 (September): 1115–71.

Hall, Robert E. (1998), "Labor-Market Frictions and Employment Fluctuations," NBER Working Paper Series, no. 6501 (Cambridge, Mass.: National Bureau of Economic Research, April).

Leeper, Eric M., Christopher A. Sims, and Tao Zha (1996), "What Does Monetary Policy Do?" *Brookings Papers on Economic Activity,* no. 2: 1–63.

Lucas, Robert E. Jr. (1972), "Expectations and the Neutrality of Money," *Journal of Economic Theory* 4 (April): 103–24.

——— (1973), "Some International Evidence on Output–Inflation Tradeoffs," *American Economic Review* 63 (June): 326–34.

——— (1990), "Liquidity and Interest Rates," *Journal of Economic Theory* 50 (April): 237–64.

Mankiw, N. Gregory (1985), "Small Menu Costs and Large Business Cycles: A Macroeconomic Model of Monopoly," *Quarterly Journal of Economics* 100 (May): 529–39.

Mehra, Yash P. (1990), "Real Output and Unit Labor Costs as Predictors of Inflation," Federal Reserve Bank of Richmond *Economic Review*, July/August, 31–39.

Ogaki, Masao, and Carmen M. Reinhart (1998), "Measuring Intertemporal Substitution: The Role of Durable Goods," *Journal of Political Economy* 106 (October): 1078–98.

Pencavel, John (1986), "Labor Supply of Men: A Survey," in *Handbook of Labor Economics*, ed. Orley Ashenfelter and Richard Layard (Amsterdam: North-Holland), 3–102.

Rogerson, Richard (1988), "Indivisible Labor, Lotteries and Equilibrium," *Journal of Monetary Economics* 21 (January): 3–16.

Taylor, John B. (1980), "Aggregate Dynamics and Staggered Contracts," *Journal of Political Economy* 88 (February):1–23.