NBER WORKING PAPER SERIES

BUILDING BLOCKS OF MARKET CLEARING BUSINESS CYCLE MODELS

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Working Paper No. 3004

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 1989

We are grateful to Olivier Blanchard, Peter Diamond, and Larry Katz for helpful comments and to the NSF for financial support. This paper is part of NBER's program in Economic Fluctuations. Any opinions expressed are those of the author not those of the National Bureau of Economic Research.

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ABSTRACT

We compare "real business cycle" and increasing returns models of economic fluctuations. In these models, business cycles are driven by productivity changes resulting either from technology shocks or from crucial building blocks that give both types of models hope of fitting the data. These building blocks include durability of goods, specialized labor, imperfect credit and elastic labor supply. We also present new evidence on comovement of both outputs sand labor inputs across sectors and on the increasing returns model is easier to reconcile with the data than the real business cycle model.

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1. Introduction

The paper discusses market clearing real business cycle models. In these models, economic fluctuations are characterized by movements along a stable labor supply curve. As a result, real wages and labor input both move together with output. Although the procyclical behavior of real wages has been debated, the current consensus seems to be that real wages are moderately procyclical (Bils 1985, Kydland and Prescott 1988, Solon and Barsky 1988).

There are four separate classes of explanations of procyclical real wages in a decentralized market clearing framework. In the first three explanations, labor productivity is procyclical, and real wages follow productivity. These three explanations can be summarized by writing the production function:

$$y(t) = \gamma(t)\ F(K(t),L(t)), \tag{1}$$

where γ is the technological shock, K is capital, L is labor, and y is output at time t. Labor productivity at time t can be high if either (a) the productivity shock γ is high at time t, or (b) the capital stock is high at time t, or (c) the labor input is high at time t, and production function exhibits increasing returns to scale. The first explanation of high productivity in booms drives the real business cycle theories of Kydland and Prescott (1982), Long and Plosser (1983), and Prescott (1986). The second explanation is the basis of models in which booms result from increases in the capital stock. Shleifer (1986) and Kiyotaki (1988) present examples of such models where increasing returns help generate endogenous fluctuations, but the driving force behind output fluctuations over time is really the changes in the capital stock. The third explanation of procyclical productivity is increasing returns in the form of declining marginal cost, either at an industry or at an economy-wide level. Murphy, Shleifer, and Vishny (1988) is an example of such a model.

Procyclical productivity is not the only way to generate procyclical real wages; counter-cyclical markups of price over cost also give this result. In some models (Phelps and Winter 1970, Okun 1981, Stiglitz 1984, Bils 1986), demand becomes less elastic during recessions, perhaps because customers with elastic demand leave the market, and so optimal markups rise. In other models (Weitzman 1982, Solow 1984, Hammour 1988), markets are monopolistically competitive and the price is tied to the average cost which falls in a larger market. As a result, markups fall in the boom and real wages are procyclical. In yet another approach (Rotemberg and Saloner 1986), competition between oligopolists intensifies and markups fall in a boom. In all these models—whether or not they assume increasing returns—procyclical real wages result from countercyclical markups and not from procyclical marginal productivity. These models should be distinguished from those with real wages driven by procyclical productivity.

In this paper, we focus on the comparison of increasing returns (IR) and technological shock (TS) real business cycle models. We spend relatively little time on models driven by changes in the capital stock. Although additions to the capital stock probably raise productivity in the later stages of the boom, capital stock changes cannot explain all of the business cycle, particularly productivity movements during periods and in sectors of no capacity addition. We also do not spend much time on countercyclical markup stories, although we do find them attractive. The main reason for this omission is that our own work has focused on IR models. We also do not deal with models that do not fit into the market clearing framework. Some of the relevant papers (Roberts 1987, Heller 1986) replace perfectly functioning markets with market games; others (Cooper and Haltiwanger 1988) present centrally planned allocations. Finally, we do not focus on models where prices are rigid or costly to change; these models have been surveyed by Rotemberg (1987).

In comparing TS and IR models, we stress that the building blocks that are likely to make these two approaches work are similar, even though the sources of productivity movements are very different. In particular, we identify durable goods, elastic labor supply, specialized labor, and imperfect credit as key assumptions needed to make these models consistent with stylized facts. Although we occasionally criticize existing TS models, our main task is to argue that these models have many similar implications and require similar assumptions as do business cycle models with increasing returns.

To fix ideas, in section 2 we present a simple 1-sector IR model based on Murphy, Shleifer and Vishny (1988) and describe its similarities to and differences from the standard TS model. The emphasis on that section is on importance of durable goods for generating large output fluctuations without large changes in productivity. The section also shows that business cycles almost *have to* arise in a model with increasing returns, durable goods, and elastic labor supply. We conclude that the 1-sector IR model can generate the same essential predictions as the TS model, and is consistent with a broader range of evidence.

Although most research on real business cycles has focused on a 1-sector model, one of the crucial empirical challenges is to explain the significant amount of comovement of labor inputs and of outputs in different sectors. In section 3, we first document this comovement over the business cycle. We then suggest that the TS literature has not adequately explained comovement, even though this step is necessary to generate aggregate fluctuations from sectoral productivity shocks. Finally, we show how two assumptions—immobility of labor across sectors and imperfect capital markets—help generate comovement in both TS and IR models. To stress the similarities between the two approaches, we use a TS model to make many of the arguments we previously made in Murphy, Shleifer and Vishny (1988). The upshot of section 3 is that with immobile labor and imperfect capital markets TS and IR models can be extended to many sectors.

In section 4, we deal with the crucial ingredient of both the IR and the TS models: elastic labor supply. We discuss some plausible and implausible reasons why the assumption of elastic labor supply might be valid and the relevance of micro-econometric evidence for this debate.

In section 5 we present some evidence on the behavior of relative prices over the business cycle. We find that the relative prices of finished goods are much less procyclical than those of raw materials and intermediate goods. Among finished goods, durables appear to have countercyclical relative prices. Finally, output prices are strongly countercyclical relative to input prices. Our evidence for the postwar period basically replicates the findings of Mills (1936) and Means et al. (1939) for the Great Depression, except that real wages in the postwar period have been procyclical and in the 1930s they were countercyclical. This evidence on relative prices is problematic for the view that recessions result from adverse shocks to production functions or prices of common inputs, such as oil or steel. The evidence favors models based on increasing returns in distribution or on countercyclical markups on finished durables.

Section 6 concludes.

2. A 1-Sector Real Business Cycle Model with Increasing Returns

In this section we outline a one sector general equilibrium model of the economy where production is subject to increasing returns to scale. The model is taken from Murphy, Shleifer and Vishny (1988), hereafter MSV88, which is both more formal and contains considerably more material. After presenting the model, we compare it to the standard TS model.

The model describes fluctuations in a single durable good industry subject to *industry-wide* increasing returns. Because the good is durable, short run demand for it is extremely elastic, since consumers can easily substitute purchases over time. The industry-wide increasing returns assumption amounts to saying that productivity is high at high industry output and low at low industry output, and that no individual firm can by itself energize the industry and move it to high output and low costs.

The combination of flat short run demand and downward sloping supply naturally leads to instability in the system. It is efficient for this industry to produce at capacity some of the time and to rest other times, rather than to always produce at a constant output level. More interestingly, even though some output fluctuations are efficient, *equilibrium* output fluctuations are not. Because the industry cannot coordinate the end of a slump, in equilibrium firms often get stuck at the low output level for periods of time that are much longer than is necessary to take advantage of increasing returns. The fact that the economy gets stuck at a low output level is the essence of the IR theory of economic fluctuations.

A. Demand and Supply

We consider a model with a representative consumer maximizing the utility function given by:

$$\int_0^\infty e^{-rt}(u(S(t)) - L(t))dt, \tag{2}$$

where $S(t)$ is the stock of durables the consumer owns at time t, and $L(t)$ is his labor supply. The assumption that labor is perfectly (or at least highly) substitutable over time is important; we return to it in section 4.

The evolution of the stock of durable goods is given by

$$\dot{S}(t) = X(t) - \delta S(t), \tag{3}$$

where $X(t)$ is output at time t and δ is the depreciation rate.

The durability of the good leads to an important distinction between the long run and the short run demand curves. The long run demand curve for the good, $D(X)$, is given by:

$$u'(X/\delta) = (r + \delta)p, \tag{4}$$

where p is the price of the durable in utility units or leisure units. This demand curve is downward sloping. In the long run, at a lower price the consumer demands a higher constant stock of durables.

In the short run, in contrast, the stock of durables is essentially fixed, since the supply and depreciation over an instant are trivial relative to the stock. To calculate the short run demand curve, we assume that consumers take all future purchases as given. The short run demand curve is then horizontal, at the level of prices $p(S(t))$ given by the present value of future rental rates $u'(S(\tau))$:

$$p(S(t)) = \int_t^\infty e^{-(r+\delta)\tau}u'(S(\tau))d\tau. \tag{5}$$

At any price above $p(S(t))$, the consumer buys nothing at time t and consumes leisure; at any price below $p(S(t))$, his instantaneous demand is infinite. This demand curve relies on perfect intertemporal substitutability of leisure.

For simplicity, we consider an industry subject to Marshallian external economies. Assume that there is a unit interval of competitive firms in this industry, each with a production function:

$$x = l \cdot f(X), \tag{6}$$

where x is firm's output, X is industry output, and l is the firm's labor input. We assume that each firm faces a capacity constraint, so $l \leq \bar{l}$. We also assume that $f(0) > 0$, and $f' > 0$. The latter is the increasing returns assumption that makes the productivity of each firm an increasing function of *industry* output.

The Marshallian externalities formulation enables us to treat firms as price takers while incorporating increasing returns into the model. We use a competitive formulation both because it is relatively simple and because it underscores the fact that movements in productivity are responsible for fluctuations. Several recent papers (Hall 1986, 1988*a*; Cooper and John 1988; Cooper and Haltiwanger 1988) have stressed empirically and theoretically the importance of imperfect competition for macroeconomic fluctuations. The assumption of imperfect competition seems to us to serve two functions. First, it can be the source of coordination problems that lead to multiple equilibria. Second, it can be the source of countercyclical markups that lead to procyclical behavior of real wages and therefore to procyclical labor input. Since Marshallian externalities themselves generate coordination problems, and since we focus on productivity movements rather than countercyclical markups as the source of real wage changes, we do not need the assumption of imperfect competition in the exposition, although its inclusion might make the model more realistic.

In a competitive equilibrium of our industry, it must be the case that:

$$x = X, \tag{7}$$

$$f(X) = w/p, \tag{8}$$

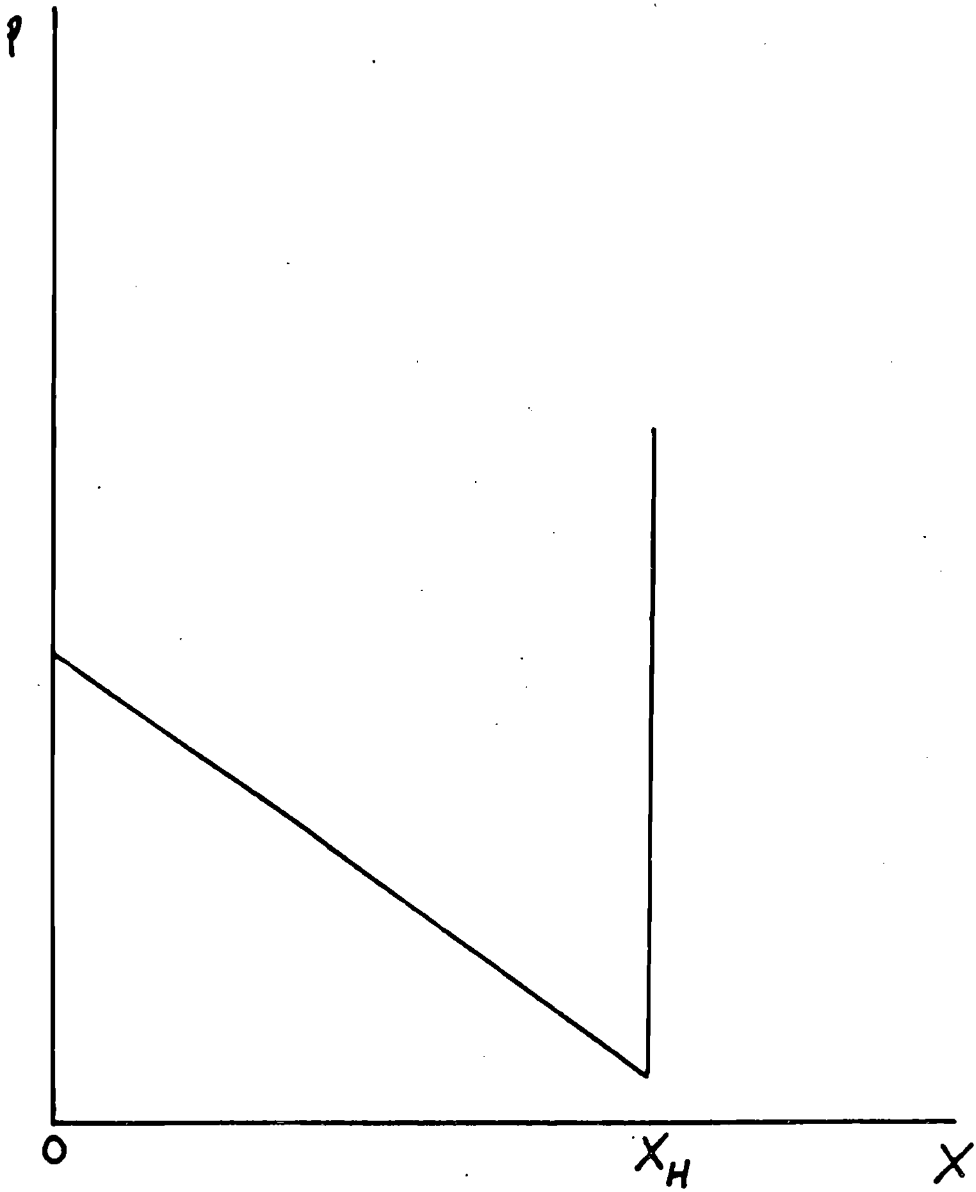

FIGURE 1: SUPPLY

where w/p is the real wage. These conditions give us the industry supply curve, defined as the locus of price quantity pairs that can arise as an industry equilibrium. The supply curve subsumes the equilibrium wage, given by the current and future stocks of durables the consumer owns that firms today take as given. At this equilibrium wage, labor supply is perfectly elastic. Accordingly, industry supply at the real wage w/p is given by:

$$X = f^{-1}(w/p), \tag{9}$$

provided that firms are not at the capacity constraint.

Let X_H solve

$$X_H = l\, f(X_H), \tag{10}$$

so X_H is the industry's capacity output. The goods supply curve is then given in Figure 1: it is decreasing from $p = w/f(0)$ at 0 output to $p = w/f(X_H)$ at capacity output, and then has a vertical spike at capacity output. This industry supply curve can be interpreted as the social average cost curve, since:

$$\mathrm{SAC} = \frac{wl}{lf(X)} = \frac{pf(X)l}{lf(X)} = p. \tag{11}$$

The combination of this industry supply curve with horizontal short run demand is the source of equilibrium fluctuations in this model.

How do we interpret our downward sloping industry supply curve? We stress that we do not literally believe that technological externalities are an important explanation of cyclical fluctuations. However, the Marshallian externality formulation can be thought of as a reduced form for some things that we do believe to be important, and discuss at some length in MSV88. The most plausible form of industry-wide increasing returns probably has to do with "thick markets" externalities or with the closely related economies of scale in distribution. When the output in the industry is high, there are many customers in the market, and so the probability of a fast match between the seller and the buyer is much higher. Because the selling costs are a significant component of the costs of making the final good, and because these costs plausibly fall when the industry rather than the firm's output rises, we find specification (6) appealing. In this respect, the work most closely related to our specification is Diamond (1982) and Howitt and McAfee (1988).

There are several industry structures that can be thought of in this way. For example, our supply curve can describe an industry such as housing in which time to sale falls and therefore productivity rises when there is a lot of construction and many consumers are in the market. Alternatively, our supply curve might be a reduced form description of an industry in which specialized supplies are cheaper when the industry is humming because individual suppliers can take advantage of their increasing returns at the firm level. Our supply curve can also describe an industry in which there are increasing returns in retailing.

An important question is whether our downward sloping supply curve can describe an industry in which markets are perfectly organized, but individual firms face increasing returns in production. Ramey (1987) finds that the industry marginal cost curve for a number of manufacturing industries is declining, suggesting that in fact one can get industry increasing returns purely in production. Ramey also surveys a number of other empirical studies documenting declining industry marginal cost curves. Hall (1988a,c) presents evidence for increasing returns at the industry level, although his evidence pertains to decreasing average rather than marginal cost. As we mentioned in the introduction, the decreasing average cost story typically yields procyclical real wages because of countercyclical markups and not because of procyclical productivity. It is thus a different story from the one we tell.

Despite Ramey's and others' evidence on declining industry marginal cost, there are no good theoretical models of such industries. If an industry where individual firms have increasing returns in production adjusts to declines in demand by shutting down inefficient plants, then even if each plant operates subject to increasing returns industry returns to scale are decreasing. For increasing returns in production at the plant or firm level to translate into industry increasing returns, an industry must contract in a recession by keeping most plants in operation, and reducing the output of each rather than by shutting down inefficient plants. This would be the case if, for example, products of different plants were geographically or otherwise highly differentiated. Contraction of all plants would also result if different firms in the industry could not, for competitive reasons, share the market in a way that enables a few to produce at capacity and to take advantage of increasing returns. Such firms would rather keep their customers and produce at a high marginal cost. However one thinks of these industries, they must have the property that most firms and indeed most plants are marginal and so increasing returns at the plant level translate into increasing returns at the industry level. Since our paper focuses on the *structure* of increasing returns models, we treat (6) as a primitive assumption and do not pursue a specific model of the market structure.

B. Equilibria

An equilibrium in this model is a path of output X(t), durable stock $S(t)$, wage $w(t)$ and price $p(t)$ such that all markets clear. Note that as long as (5) holds, the consumer is on his labor supply curve.

To make the model interesting, we assume that the long run demand curve $D(X)$ cuts the downward sloping segment of the supply curve. If $D(X)$ cuts the supply curve at capacity, the equilibrium is the trivial outcome in which all firms produce at capacity all the time. In MSV88 we show that if building capacity is sufficiently cheap relative to the cost saving from operating at a higher output, firms will always build enough capacity so that long run demand curve cuts the downward sloping segment of the supply curve.

This model has a variety of cyclical equilibria, which take the following form. Over some period of time, the economy produces at capacity X_H, the stock of durables grows, and the rental rate on durables falls. During initial stages of this period, people's willingness to work for goods declines since their consumption rises, and so the price of goods falls while real wages rise. Toward the end of the high production period, the price of goods actually rises in the anticipation of lean times and high rental rates in the future. Eventually the boom ends, and the economy switches to 0 output, again maintained over some period of time. During this period, the stock of durables depreciates and the rental rate rises. As consumption falls over this period, the

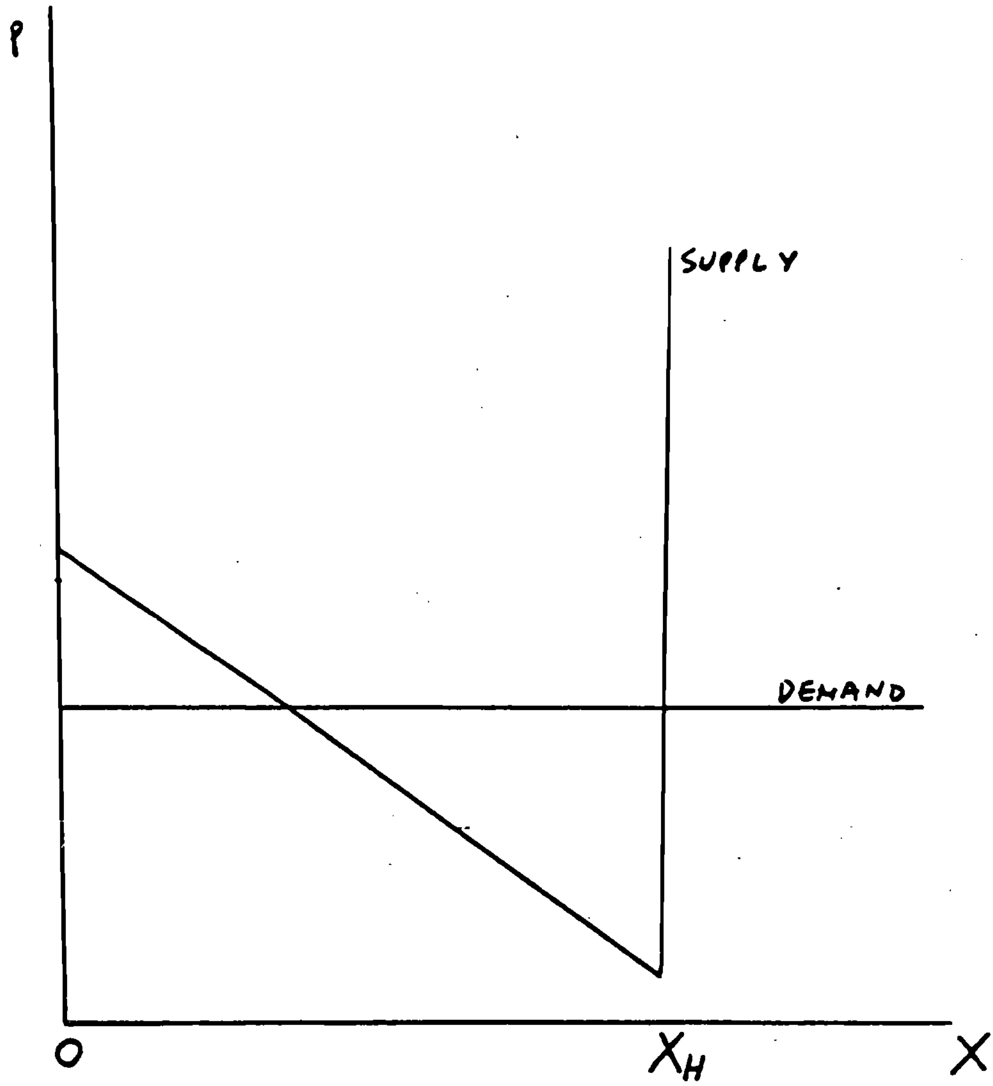

FIGURE 2: EQUILIBRIUM

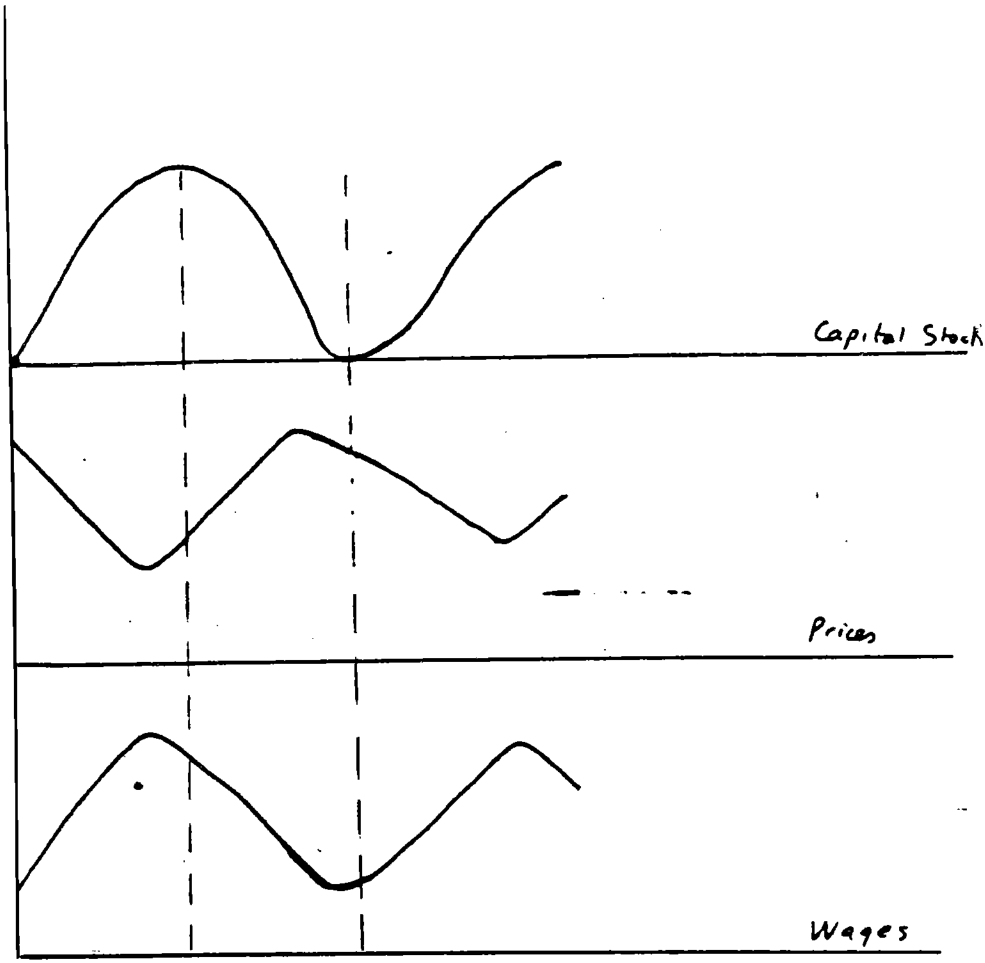

FIGURE 3: CYCLICAL VARIABLES

willingness of people to work for goods rises, and at least at the initial stages of the recession prices rise and real wages fall. Toward the end of the recession, we again get the effect that prices fall because people know that good times are coming and with them low rental rates.

This business cycle can be easily thought of in terms of figure 2. During the boom, the economy operates on the vertical segment of the supply curve. As the boom continues, the demand curve essentially slides down the vertical segment of the supply curve, because the willingness to work diminishes (again, the demand curve moves up shortly before the boom ends). At some point, the economy switches to 0 output, and at the initial stages of the boom the demand curve is moving up. Eventually, the economy goes back to the high production level. Figure 3 describes the behavior of the capital stock, prices, and real wages over the business cycle.

The period of these cycles can be very short, where the economy "chatters" between high and low output, or much longer. In the longer cycles, the sector gets stuck at a high or low output level because a coordinated change in output by many firms is required to change each firm's productivity and prices. The Marshallian externality in the production function is the source of this coordination failure. The coordination failure is crucial to the model, since without it the economy would fluctuate at a very high frequency, and there would be no hope of explaining low frequency business cycle fluctuations. Although many cycles are sustainable, constant output is not sustainable as an equilibrium, since in this case any firm raising its output would bring other firms to do likewise and to destroy the equilibrium.

An interesting property of this model is that it has the cycle of longest possible duration, for reasons detailed by Mitchell (1927). In this cycle, the price of durables reaches its minimum and maximum sustainable values. The longest cycle has the property that both the recession and the boom last as long as they possibly can in a cyclical equilibrium. If the boom were to last any longer, the rental rates would get to be so low that at some point prior to the end of the boom the price of durables would have to fall below production cost even when the sector is operating at maximum efficiency. Because this cannot happen in equilibrium, there is a natural end to the boom, where people get so satiated with durables that they would rather take leisure than work even at a high productivity. In terms of Figure 2, the longest boom can be thought of as the demand curve falling off the cliff at X_H. Similarly, if the recession were to last any longer, at some point prior to its end the prices of durables would get so high that even one firm operating alone at a low productivity can make money by producing. This of course cannot happen in equilibrium. This natural end to the recession means that people eventually want goods so much that they are willing to work at low productivity to get goods rather than consume leisure. The longest cycle is a form of long run stability in this economy, which arises because the long run demand curve for goods is steeper than the long run supply curve.

The welfare properties of the equilibria in this model can be easily summarized. First, at least some output fluctuations are efficient. It is efficient for this sector to take advantage of increasing returns and to produce some of the time and rest the remainder of the time. Second, most equilibrium fluctuations are not efficient. This inefficiency is reflected in the fact that the period of the cycle is too long, which leads to excessive *variability* of consumption. The inefficiency is also reflected in the fact that, for a cycle of a fixed period, recessions last too long relative to booms, leading to too low an *average level* of consumption. The main reason for the latter inefficiency is the Marshallian externality and the resulting coordination problem, that prevents firms from spending more time operating at capacity. The model shows that even in the world where fluctuations of output are efficient, equilibrium business cycles are unlikely to be so.

C. A Comparison of the IR Model with the TS model

Similarities

There are a significant number of similarities between the IR model described above and the TS model. Most obviously, fluctuations in both models are driven by productivity movements. In the TS model, such movements result from exogenous technological shocks. In the IR model, they result from endogenous movements along the increasing returns production function. The consequence of either assumption, however, is that business cycles are associated with movements in true, rather than just measured, productivity.

A key feature of our model is durability of the good, that leads to extremely elastic short run demand and instability. As a result, the model generates large output fluctuations even with small increasing returns. TS models have not stressed durable consumption goods, although they do emphasize the durable nature of capital. The large responsiveness of investment to small changes in productivity is an important element of the Kydland/Prescott and Prescott models as well.

An appealing feature of our model, that can be easily worked into a TS model, is the natural limit on the length of booms and recessions. Proponents of the TS view rarely talk about business cycles per se, and so this issue of mean reversion does not arise. However, the effect we are talking about would appear in a TS model also. Even if the economy is subjected to a sequence of fairly persistent adverse technology shocks, eventually it would pay to work and to produce even if opportunities are poor, provided that people are hungry enough for goods. Such long run stability would thus appear in a TS model as well.

Differences

Here we note four differences between 1-sector IR and TS models, other than the source of productivity movements. First, the IR model is an *endogenous* business cycle model, and the TS model is an *exogenous* shocks model. To the extent that we have trouble identifying technology shocks, particularly the bad ones that cause recessions, an endogenous business cycle model seems more attractive. Moreover, we find the importance of self-fulfilling expectations an attractive feature of the IR models.

Second, most technology shocks are likely to be persistent, whereas periods of production at high capacity in IR models are temporary. Because Prescott (1986) assumes highly persistent shocks, the ability of agents to engage in intertemporal substitution is limited. Hence, intertemporal substitution must be very high to rationalize the observed movements as an equilibrium response to permanent shocks. In contrast, since in our endogenous model good times are very temporary, we need much less intertemporal substitution to induce agents to respond to periods of high productivity with increased labor supply. Since intertemporal substitutability needed to calibrate TS models is extremely large, the fact that IR models need much less of such substitutability is attractive.

Third, IR and TS models have different implications about the response of labor productivity to demand shocks. Kydland/Prescott predict that, holding technology constant, labor productivity should fall and certainly not rise in response to a demand shock because of diminishing returns. In contrast, our model predicts that a demand shock could switch the economy to a high output level, and so raise productivity because of increasing returns.

Consistent with the last prediction, Hall (1988*c*), using instruments for demand disturbances, finds that demand shocks positively affect the Solow residual. The appropriateness of Hall's instruments, which include most notably the price of oil, has been questioned. His results can also be explained by unobserved procyclical work effort. If Hall's results stand up to scrutiny, however, they provide strong evidence against TS models. In an observation similar to Hall's, Mankiw (1989) points out that measured labor productivity rose in World War II, at the time of a sharp increase in the government's purchases of durables. One explanation of Mankiw's result is increasing returns, although there are others, including the increased war effort.

A final distinction between the simple IR and the simple TS models is in the treatment of welfare consequences of fluctuations. Our IR model suggests that the efficiency cost of most business cycles is small, since consumption of durables varies a lot less than do purchases. Empirically, we may not be too far from Prescott's (1986) conclusion that business cycles are efficient. Nonetheless, it seems obvious that neither TS nor IR models have yet dealt with important costs of business fluctuations, such as unequal distribution of the burden of the recessions or their excessive duration because of more fundamental problems, such as financial collapse. It is fair to say that neither approach has seriously dealt with policy.

We can summarize this section by stressing that both models are similar in that fluctuations are driven by movements in labor productivity. Both models are significantly more plausible when they stress durability of goods as a way to generate large output responses to small productivity changes. The increasing returns model has the additional advantage of being supported by independent evidence (Ramey 1987, Hall 1988a,c). In the next few sections, we describe in more detail some of the ways to augment both the standard TS model and our IR model to make them match the evidence better.

3. Comovement of Outputs and Labor Inputs Between Sectors

A. The Evidence and the Problem

The previous section has presented a 1-sector IR model of the business cycle and compared it to a 1-sector TS model. One sector models do not, however, address the question of comovement of outputs and labor inputs across sectors during the business cycle. In this section, we first discuss the fact that such comovement is extremely pronounced, and is clearly one of the crucial stylized facts that a business cycle model should explain. We then suggest that the Prescott (1986) and Long/Plosser (1983) models do not adequately explain why outputs and labor inputs in different sectors move together. Finally, we present an alternative approach to comovement, based on immobile (specialized) labor and imperfect credit.

Table 1 presents the evidence on annual correlation of growth rates of different sectors of the economy during 1947-87. Panel A focuses on annual growth rates of real output, and panel B presents data on annual growth rates of employment. Table 1 also includes correlations with changes in detrended employment rate—described in more detail in Section 5—which is our preferred business cycle indicator.

Table 1 shows extremely high correlations of output growth across sectors, as well as high correlations of sectoral growth rates with the business cycle indicator. Most strikingly, the correlation of growth rate of durables with the growth rate of GDP is .95, and with the change in the detrended employment rate it is .92. Growth rates of output in construction, nondurables, and even trade are also extremely highly correlated with the GDP growth rate, the cyclical indicator, and each other. Mining comoves somewhat less, in part because there is a sharp change in the trend growth rate of mining over this period. Even government and finance seem to move in step with other sectors. In fact, there is not a single negative coefficient in panel A of table 1. It is very much the case in these data that outputs in broadly defined sectors move together and procyclically.

A similar picture emerges for labor inputs in panel B of table 1. Growth rates of labor inputs are highly correlated across sectors, and with the cyclical indicator. Durables again lead the pack, showing a .95 correlation with the growth rate of total employment, and a .93

Table 1

Correlations of Growth Rates Across Sectors
Annual 1947-1987

	All	Mining	Construction	Durables	Nondurables	Trade	Transportation	Service	Gov't	Finance	Detrended Employment Rate
Panel A: Correlations of Output Growth Rates											
All	1.00										
Mining	.32	1.00									
Construction	.76	.05	1.00								
Durables	.95	.27	.69	1.00							
Nondurables	.89	.13	.72	.91	1.00						
Trade	.89	.30	.75	.76	.75	1.00					
Transportation	.92	.51	.67	.83	.73	.84	1.00				
Services	.72	.34	.42	.54	.53	.74	.74	1.00			
Government	.34	.05	.20	.30	.24	.23	.25	.15	1.00		
Finance	.54	.05	.67	.40	.44	.58	.58	.54	.03	1.00	
Detrended Employment Rate	.93	.15	.81	.92	.89	.83	.81	.64	.22	.47	1.00
Panel B: Correlations of Employment Growth Rates											
All	1.00										
Mining	.63	1.00									
Construction	.67	.36	1.00								
Durables	.95	.58	.62	1.00							
Nondurables	.76	.45	.59	.73	1.00						
Trade	.71	.32	.52	.76	.71	1.00					
Transportation	.77	.63	.32	.78	.63	.54	1.00				
Services	.54	.33	.33	.61	.52	.56	.68	1.00			
Government	.48	.28	.20	.28	.08	-.09	.28	-.13	1.00		
Finance	.60	.37	.61	.53	.47	.48	.43	.29	.22	1.00	
Detrended Employment Rate	.89	.59	.58	.93	.64	.65	.81	.68	.33	.52	1.00

correlation with the changes in the cyclical variable. There are a few negative correlations of employment growth rates, such as between government and trade and government and services, but by and large employment growth rates behave like output growth rates. In fact, the extent of comovement in labor inputs between durables, nondurables, construction, and trade is quite remarkable—and those are the sectors across which labor is potentially mobile.

One question table 1 does not address is whether comovement between sectors is just a reflection of trend growth rates in the economy, or whether it reflects shorter-run cyclical fluctuation of sectors. To address this issue, table 2 presents partial correlations of output and employment growth rates controlling for business cycle movements. In these partial correlations, the business cycle control is our detrended employment growth rate. Large residual correlations would be evidence of strong noncyclical comovement, which can just reflect the growth rate of the economy.

The partial correlation coefficients in table 2 are obviously much smaller than those in table 1, and many of them are negative. For example, the residual correlation of growth rates of durables and nondurables is .50, compared to the correlation of .91 in table 1, and the residual correlation of durables and construction is .26 compared to the correlation of .69 in table 1. Similarly, the residual correlation of growth rates of durable and nondurable employment is .53, compared to the raw correlation of .59, and the residual correlation of growth rates of employment in durables and construction is -.20, compared to the raw correlation of .62. In fact, the average difference between the total correlation of sectoral output growth rates with GDP growth and the residual correlation of these two variables is .28. Similarly, the average difference between the total correlation of sectoral employment growth rates with GDP growth rate and the residual correlation is .24. These results demonstrate quite convincingly that cyclical comovement of growth rates of output and employment across sectors qualifies as a bona fide stylized fact of business cycle analysis.

Theoretically, generating such strong positive comovements of outputs and labor inputs from sectoral productivity changes is not easy. To see the problem, suppose that sector A is operating at a high level with an increasing returns technology, or has a good technology shock.

Table 2

Partial Correlations of Output and Employment Growth Rates across Industries after Controlling for Business Cycle Variation*

	All	Mining	Construc-tion	Durables	Non-durables	Trade	tation	Service	Transpor-Gov't	Finance
Panel A: Partial Correlations of Output Growth										
All	1.00									
Mining	.28	1.00								
Construction	.42	.03	1.00							
Durables	.69	.10	.26	1.00						
Nondurables	.55	.12	.35	.50	1.00					
Trade	.17	.32	-.32	.10	.26	1.00				
Transportation	.38	-.10	.23	.54	.50	.03	1.00			
Services	-.19	-.11	-.11	-.08	.15	.30	.22	1.00		
Government	.42	.11	.01	-.09	-.19	.01	-.43	-.52	1.00	
Finance	.35	.09	.44	.16	.21	.02	.22	-.10	.06	1.00
Panel B: Partial Correlations of Employment Growth										
All	1.00									
Mining	.49	1.00								
Construction	.05	-.13	1.00							
Durables	.63	.33	-.20	1.00						
Nondurables	.35	.00	.01	.53	1.00					
Trade	.80	.66	.06	.39	.07	1.00				
Transportation	.60	.31	.24	-.01	.06	.51	1.00			
Services	.45	.32	-.21	-.15	-.10	.49	.49	1.00		
Government	.39	.02	.04	.24	.11	.13	.09	.02	1.00	
Finance	.34	-.02	.57	-.07	.08	.40	.38	.35	-.09	1.00

*Partial correlations are conditional on detrended unemployment rate changes as defined in the text.

Either way, productivity and wages in sector A are high, and so, with a positively sloped labor supply curve, labor input in sector A rises. If other sectors do not also experience a productivity improvement, and if the output of sector A is not complementary in consumption or production with the outputs of these other sectors, labor should move out of these sectors and into sector A, resulting in a negative comovement of labor inputs across sectors. Unless the good productivity shock is pervasive, so that the only sector that shrinks is leisure, this model has trouble explaining comovement of labor inputs.

This problem is troubling for both Prescott's (1986) and Long and Plosser's (1983) approaches. As has been pointed out independently by Benhabib, Rogerson and Wright (1988), Prescott's (1986) model predicts a negative comovement of labor inputs between consumption and investment sectors. Prescott does not distinguish between consumption and investment sectors, but we in fact can think of the two sectors as separate but having identical production functions. Prescott calibrates his model by noting that, in the long run, labor input does not rise and maybe even declines with increases in productivity. This means that, within the consumption sector, the income effect is at least as strong as the substitution effect. The implication of this assumption is that employment in the consumption sector does not rise, and possibly shrinks, in response to a good productivity shock to that sector. From the point of view of employment in the consumption sector, we can therefore think of shocks in this model as being only to the investment good sector.

Suppose that there is a good productivity shock to the investment sector. In response to this attractive temporary opportunity, labor input in the investment sector rises, raising the marginal utility of leisure. Calibration says that holding the labor input in the investment sector constant, labor input in the consumption sector is independent of productivity in the consumption sector. Hence, since labor input in the investment sector rises, we should get a fall in the labor input in the consumption sector. The Prescott (1986) model thus predicts, counterfactually, countercyclical labor input in the consumption sector. This result is much more general than Prescott's (1986) specific model; details are available from us upon request.

A similar problem would arise in Long and Plosser's model, except they assume unit elastic demand for leisure. As a result of this assumption, labor inputs do not change over the cycle in their model: their model generates comovement in outputs at constant labor inputs. If LP instead assumed a more conventional positively sloped labor supply, they would get a *negative* comovement of labor inputs between sectors at the time productivity shocks hit. An increase in productivity in one sector raises the real wage and draws labor into that sector out of other sectors as well as out of leisure. Long and Plosser can still get a positive comovement of final outputs by the time shocks propagate through the input-output matrix. As we show in section 5, however, this story is inconsistent with relative price evidence.

In the rest of this section, we offer a solution to this problem, based on the idea that, first, labor is specialized and immobile between sectors, and, second, there are borrowing constraints. In practical terms, immobile labor means that people have a strong comparative advantage at working in only one, or a few, sectors, and therefore cannot easily move into whatever sector is productive at the moment. This assumption is perfectly consistent with large gross labor flows in the economy, and with a high level of mobility of some segments of the labor force. It only says that, for many workers, it is better to work in their own sector and to exchange the output for other goods than always to move into the most productive sector. Immobile labor creates a need for people to trade the goods they produce, rather than working in each sector to produce the good for their own consumption.

This need to trade when labor is immobile is an important component of the story explaining comovement. Consider first the case of mobile labor. When sector A is productive, and labor is mobile, it pays all workers to come work in sector A to buy sector A's good, which is now particularly cheap. Unless some other goods are complements to A—which we assume they are not—the tradeoff between leisure and work in other sectors has not changed. In this case, workers should both consume less leisure and work less in other sectors.

Suppose, in contrast, that outside workers are not trained to work in sector A, so that the increase in sector A's labor input comes entirely from the reduction in leisure of its own workers. Good A is still cheap, and so outside workers want to spend more on it if demand for A is elastic. To do that, they must work more in their own sectors, and then spend more on good A.

This leads to increased labor input in other sectors, and a positive comovement of labor inputs across sectors. Alternatively, workers from outside sector A can borrow and buy more of good A now, working slightly more today and in all the future periods to repay their debts. If workers can easily borrow, there would be some but not much comovement. Generating significant comovement between sectors requires both immobile labor and restricted borrowing opportunities.

In the next subsection, we present the immobile labor argument formally using a 1-period TS model. Subsection C summarizes the arguments in MSV88 that use these ideas in an IR model. Our theory of comovement illustrates the importance of trade, as opposed to Robinson Crusoe, for understanding fluctuations. We show at the end of this section that several earlier papers have made assumptions amounting essentially to immobile labor.

B. A Formal TS model

This section presents a one-period competitive RBC model with technological shocks. There is a unit interval of small sectors, each producing its own good, s. There is also a unit measure of consumers. The utility function of each consumer is given by

$$\int_0^1 \frac{C(s)^\theta}{\theta} ds - \frac{L^\beta}{\beta}, \tag{12}$$

where $c(s)$ is consumption of good s and L is labor. We assume that $\beta \geq 1$ and $\theta \leq 1$. For consistency of the model, we also assume that $\beta - \theta^2 > 0$. In this model, the case of $\theta > 1$ corresponds to elastic demand for goods and upward sloping labor supply. The substitution effect in the demand for goods is stronger than the income effect. In contrast, when $\theta < 0$, the income effect is stronger, the demand for goods is inelastic, and labor supply is backward bending. Naturally, the case of $\theta > 0$ is more plausible for durables. Also note that $\beta = 1$ corresponds to no diminishing marginal utility of leisure and $\theta = 0$ to the Long/Plosser case of unit elastic demand for goods and therefore for leisure.

The production function of good s is given by

$$y(s) = \gamma(s)L(s), \tag{13}$$

where $\gamma(s)$ is technological shock and $L(s)$ is labor input in sector s. Each good is produced competitively in its own sector.

Consider first this model with mobile labor, so there is actually a representative consumer we can talk about. This consumer's budget constraint is given by

$$\int c(s)p(s)ds = Lw. \tag{14}$$

Market clearing requires that $c(s) = y(s)$ for all s, and competition says that $\gamma(s)p(s) = w$. We can let the wage be numeraire: $w = 1$.

This model can be solved for consumption of each good s and labor input in each sector s as a function of technological shocks in all sectors:

$$c(s) = \gamma(s)^{\frac{1}{1-\theta}} [\int \gamma(s')^{\frac{\theta}{1-\theta}} ds']^{\frac{1-\beta}{\beta-\theta}} \tag{15}$$

$$L(s) = \gamma(s)^{\frac{\theta}{1-\theta}} [\int \gamma(s')^{\frac{\theta}{1-\theta}} ds']^{\frac{1-\beta}{\beta-\theta}} \tag{16}$$

Several observations can be made about these solutions.

First, consumption of good s always increases in $\gamma(s)$. This is because a good productivity shock always reduces the relative price of good s, and since s is normal, its consumption rises. Second, when $\theta > 0$, labor input in sector s rises with the technology shock, and when $\theta < 0$, labor input declines with the shock. The former case corresponds to the elastic demand for good s, so when the price of good s falls, demand for s rises more than the increase in output due to the productivity increase, and so employment rises. Conversely, when $\theta < 0$, the demand for good s is inelastic, and so a rise in productivity leads to a less than proportional increase in the quantity consumed, and so a reduction in the labor input. The case of $\theta > 0$ corresponds to durable goods, and so both labor and output should probably rise when a sector experiences a positive productivity shock.

More interesting results concern comovement of outputs and labor inputs across sectors. When $\beta = 1$, (15) and (16) show that all sectors move by themselves, without any influence from other sectors, as one would expect in the case of separability of goods and no increasing disutility of work. The same result obtains in the Long/Plosser case of $\theta = 0$, where labor inputs in different sectors are fixed, and outputs move proportionately with productivity because of unit elastic demand. Except for these two cases, however, labor always negatively comoves between sectors. When $\theta > 0$, a good productivity shock in sector s' raises demand for labor in s', and so, since the tradeoff between employment in sector s and leisure has not changed, there will be a reduction both in leisure and in employment in s. When $\theta < 0$, a good productivity shock to s' reduces labor input in s' because of inelastic demand for this good, and so labor moves both into leisure and into sector s. This case, of course, is blatantly inconsistent with the evidence. In either case, labor inputs in s and in s' move in opposite directions, contrary to what happens over a business cycle.

Furthermore, output negatively comoves in the plausible case of $\theta > 0$, and positively comoves with $\theta < 0$. When $\theta > 0$, a good shock in s' raises employment and output in s' but cuts employment in s, as we mentioned earlier. Because productivity in sector s is unchanged, output of good s must also fall. Output in s and s' thus move in opposite directions. When $\theta < 0$, a good shock in s' raises output but reduces employment in s'. Because labor moves into sector s, both employment and output in sector s rise. This leads to comovement of outputs. In the case of mobile labor, we thus get two unrealistic results: employment comoves negatively, and output comoves negatively in the plausible case of upward sloping labor supply. Long and Plosser do not get the latter result because, in their model, shocks are to common intermediate inputs and so are correlated.

Consider next the more interesting case of immobile labor, where a worker can only work in one sector or consume leisure. We assume the same preferences as before, and the same number of workers per sector. Let $c(s,s')$ be consumption of good s by a worker in sector s'. The budget constraint of worker s' now takes the form:

$$\int c(s,s')p(s)ds = L(s')w(s') \tag{17}$$

for all s'. Competition now does not restrict wages to be the same in all sectors:

$$\gamma(s)p(s) = w(s) \tag{18}$$

for all s. Finally, market clearing takes the form

$$\int c(s,s')ds' = \gamma(s)L(s) \tag{19}$$

for all s. For our purposes, we do not need to choose a numeraire.

A considerable amount of grinding leads to the following closed form solution to this model:

$$w(s) = \gamma(s)^{\frac{\theta(\beta-\theta)}{\beta-\theta^2}} \tag{20}$$

$$p(s) = \gamma(s)^{\frac{\beta(\theta-1)}{\beta-\theta^2}} \tag{21}$$

$$c(s,s') = \gamma(s')^{\frac{\theta\beta}{\beta-\theta^2}} \cdot \gamma(s)^{\frac{\beta}{\beta-\theta^2}} \left[\int \gamma(s^*)^{\frac{\beta\theta}{\beta-\theta^2}} ds^* \right]^{\frac{\beta-1}{\theta-\beta}} \tag{22}$$

$$L(s') = \gamma(s')^{\frac{\theta^2}{\beta-\theta^2}} \left[\int \gamma(s^*)^{\frac{\beta\theta}{\beta-\theta^2}} ds^* \right]^{\frac{1-\theta}{\beta-\theta}} \tag{23}$$

Using (22)-(23), we can ask the same questions as we did with mobile labor.

Similarly to the case with mobile labor, consumption of good s by a worker in sector s' increases both in the shock to sector s and in the shock to sector s'. But there are some crucial differences. First, due to the symmetry assumption, labor input in sector s always rises with productivity in that sector, whether or not θ is positive. When $\theta > 0$, demand for good s is elastic.

At the same labor input as before the shock, the price of good s declines less than productivity rises, so that the real wage in sector s rises. Since labor supply is upward sloping for $\theta > 0$, labor input rises in response to the increase in the real wage. In contrast, when $\theta < 0$, demand for good s is inelastic. When $\gamma(s)$ rises, $p(s)$ falls more than the productivity increase, and so the real wage in sector s falls. But labor supply slopes down for $\theta < 0$, and so labor input rises in response to the fall in the real wage. Independent of the value of θ, labor input in sector s always moves in the same direction as productivity in that sector.

The most interesting results again concern comovement of labor inputs and of consumption. In this model, we get comovement of labor inputs as long as $\theta > 0$. When productivity $\gamma(s')$ in sector s' rises, $p(s')$ falls, which raises the real wages of workers in all other sectors. With $\theta > 0$, labor supply in these sectors slopes up and so workers there all work more. Conversely, with $\theta < 0$, labor supply slopes down and labor input in sector s falls in response to a rise in $\gamma(s')$. As long as workers want to work more when their real wage rises, they respond to a lower price in another sector by producing more of their own good, and trading it for the productive sector's output.

Comovement of consumption, like comovement of labor, depends on the sign of θ. When sector s experiences a good productivity shock, $p(s)$ falls and real wages in all sectors rise. When $\theta > 0$, workers in all sectors want to work more and to buy more of all goods, so consumption of all goods rises. In contrast, when $\theta < 0$, the response to a rise in real wages from a fall in $p(s)$ is to work less, so hours and consumption of all goods other than good s fall. Consumption of different goods comoves, therefore, as long as labor supply slopes up.

The results for mobile and immobile labor are very different. With mobile labor, employment always comoves negatively across sectors, and consumption comoves only if $\theta < 0$. With immobile labor, employment and consumption both comove for $\theta > 0$ and not otherwise. The reason for the difference is that with mobile labor, one can get more of another good by working in the sector it is produced, whereas with immobile labor one has to work in one's own sector and trade. For durables, the case of elastic demand (and therefore positively sloped labor supply) is the empirically correct one. Since in this case the model clearly generates empirically correct predictions about comovement of labor inputs and consumption over the business cycle, the case for assuming specialization and immobile labor seems to be compelling.

Because our model assumes identical demand elasticities for different goods, it does not deal with Prescott's case. We have looked at a model where $\theta = 0$ for one good, and $\theta > 0$ for another. In such a model, one indeed gets a negative comovement of labor inputs with mobile labor, and a positive comovement with immobile labor.

So far we have presented a one period model, and have not addressed the issue of credit. If we think of some of the goods in our model as future consumption goods, the credit point is apparent. Even if labor is immobile, an increase in productivity and the resulting decline in the price of good s are likely to lead to only a small increase in today's labor input in other sectors. Instead of working much harder today, a worker in a sector s' would borrow to take advantage of the low price of good s, and repay the loan by raising his labor supply today and in all the future periods by a small amount. To generate a significant amount of comovement between sectors, both immobile labor and imperfect credit are required.

The role we have assigned to imperfect credit here is different from—and complementary to—that in other recent models (Bernanke and Gertler 1989, Greenwald and Stiglitz 1987). In those models, a bad shock reduces the internal availability of funds to a firm, which then has to reduce its investment because of the credit constraint. The reduction in investment in turn leads to lower output and therefore a persistently lower availability of funds in the future. Importantly, this is basically a 1-sector (or one-firm) story of the role of credit. In contrast, here and in MSV88 credit serves to facilitate intertemporal trade between sectors. When credit markets are imperfect, such trade is less attractive, leading agents in different sectors of the economy to synchronize their production periods so they can trade instantaneously and economize on credit. In this sense, imperfect credit in our model serves to concentrate the effects of shock at a point in time rather than to spread them over time. We believe that both consequences of imperfect credit are important in practice. In fact, it may be possible to combine the Greenwald-Stiglitz-Bernanke-Gertler view of countercyclical costs of credit with some features of our model, such as immobile labor, durables and elastic labor supply, to generate self-fulfilling fluctuations even in the absence of increasing returns at the sectoral level.

C. Comovement in a Model with Increasing Returns

So far, we have considered the comovement issue in a TS model, where it is simpler to see. Identical arguments apply also in a variant of an IR model of section 2, and are developed in MSV88. The question in the IR model is: why wouldn't different sectors of the economy cycle out of synch with each other, especially if there is an aggregate resource constraint? If they do cycle out of synch, aggregate output would be smooth, and we would not observe aggregate fluctuations.

In MSV88, we show that aggregate fluctuations obtain when labor is immobile and borrowing is constrained. In this case, when a sector is productive and its output is cheap, the only way workers in other sectors can take advantage of low prices is by working themselves and trading their output for the productive sector's output. In equilibrium, all sectors fluctuate together. As in a TS model, aggregate fluctuations obtain with immobile labor and restricted borrowing in an IR model.

The notion of immobile labor has appeared in a number of recent models in somewhat different ways. Diamond (1982), Weitzman (1982) and Roberts (1987) assume either that workers are specialists in production and generalists in consumption, or that they cannot consume the good that they produce. The power of this assumption is always to make trade necessary for consumption and to preclude the possibility that people, Robinson Crusoe like, simply toil to produce their own consumption good. The point that MSV88 and the current paper emphasize is that these assumptions can be used to explain the observed comovement of outputs and of labor inputs across sectors in a wide range of models. Specialization does not just generate "Keynesian" results, but also yields empirically correct predictions about comovement—even in a TS model. There is nothing intrinsically Keynesian about specialization.[1]

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[1]Scheinkman and Weiss (1986) assume immobile labor and imperfect credit to generate a role for money as a store of value. They do not consider the role of immobile labor in generating comovement of outputs and of labor inputs across sectors.

4. Elastic Labor Supply

A. The need for assuming elastic labor supply

Recent empirical research (Bils 1985, Kydland and Prescott 1987, Solon and Barsky 1988) finds that real wages move procyclically over the business cycle, but only mildly so. At the same time, to generate large labor supply movements from small changes in real wages, one needs to assume that the intertemporal or lifetime elasticity of labor supply is much higher. For example, Prescott (1986) takes this elasticity to be 2, and still predicts too low fluctuations in hours.

Even if one believes that real wages are installment payments that do not reflect underlying productivity, and do not really serve to allocate labor over the business cycle, one still needs fairly elastic labor supply. The effects of both technology shocks and increasing returns over the business cycle are probably small quantitatively. To get large efficient movements in the labor input in response to such small changes in technology requires easy substitutability of labor over time. That is, for workers and firms to agree to a contract that requires large changes in their labor input in response to small changes in productive opportunities, leisure must be easily substitutable over time. Otherwise, one needs to explain why the worker and the firm do not eliminate inefficient fluctuations in hours that are not justified by fluctuations in productivity.

We have pointed out earlier that TS models with reasonably persistent technology shocks require a greater labor supply elasticity than do IR models to generate the same fluctuations. This is because in an IR model, periods of high productivity are by definition temporary, since it is not an equilibrium to produce high output all the time. In contrast, in a TS model driven by reasonably permanent shocks, good opportunities to work are equally permanent, and so the instantaneous labor supply response to a shock is small. Because productivity changes are less permanent in an IR model, the labor supply elasticity required by such a model is smaller.

At the same time, whereas a TS model depends on elastic labor supply only quantitatively, an IR model fails to generate fluctuations altogether if labor supply is sufficiently inelastic. In a TS model, less elastic labor supply dampens the effects of technological shocks on output, and consequently reduces output volatility. In our model, in contrast, sufficiently inelastic labor supply can eliminate the possibility of fluctuations altogether. The reason is that when labor supply is sufficiently inelastic, increases in industry output raise costs even if labor productivity rises, and so make the supply curve slope up rather than down. If the supply curve slopes up, the unique stable equilibrium is constant output. In this way, inelastic labor supply completely eliminates the possibility that our model can explain business cycle fluctuations.

As this subsection suggests, even though TS and IR models rely in different ways on the elastic labor supply assumption, they both rely on it strongly. More generally, any model that fits the observed fluctuations of labor input must rely on this assumption. For example, it is needed for countercyclical markup models, since the decline in markups must more than compensate for the rise in costs in a boom. Keynesian rigid wage models also rely on elastic labor supply to the extent that the cost of setting wages flexibly must be large to explain the costly fluctuations in hours. Below we offer a few comments on plausibility of elastic labor supply.

B. The plausibility of elastic labor supply

Although the macroeconomic models described above require an elasticity of labor supply of at least 1 or 2, the elasticity estimated from micro data is extremely low, perhaps around .3. The reason for this low estimate is that wages and hours for a given individual are both highly variable, and are basically uncorrelated. Put differently, the coefficient of the regression of the change in hours on the change in wages, just as that of the regression of the change in wages on the change in hours, is close to 0. The fact that there are many reasons why measured hours and wages change, unrelated to the labor supply elasticity, is undoubtedly responsible for the low estimate of this elasticity in micro data. This observation has led a number of researchers to try to reconcile the low labor supply elasticity obtained from micro studies with a high elasticity needed to explain the macro evidence.

One recent approach, begun by Rogerson (1988), starts with the observation that there may be important non-convexities in the labor supply decision, such as transportation costs. This model then says that people take leisure in the recession because it is not efficient for everyone to incur these fixed costs of going to work when productivity is low.

We have two reservations about this approach. First, it relies on the assumption that all individuals are identical. If there is heterogeneity of individuals' cost of going to work, then changes in the wage would get a few marginal people to discretely change their labor supply decision, but would not affect hours for inframarginal workers. It is by no means clear that the resulting aggregate labor supply curve is more elastic than it is when fixed costs are absent. For a similar reason, the fact that the decision to eat Chinese food on a particular day is discrete does not mean that the intertemporal elasticity of substitution for Chinese food is infinite. Second, fixed costs of going to work should equally affect both the micro and macro estimates of labor supply elasticity. It is not correct to say that micro evidence yields true preference parameters, since micro estimates are also affected by fixed costs. This approach cannot then explain the inconsistency between micro and macro evidence. Although non-convexities might be part of the explanation of elastic labor supply, they do not reconcile micro and macro evidence.

There seem to be some more plausible ways to explain why hours change a lot over the business cycle when wages change only a little. One obvious possibility in the later period is unemployment insurance with high replacement rates and imperfect experience rating, which should significantly raise the effective elasticity of labor supply. The second possibility is that people with a high intertemporal elasticity of substitution should sort themselves into cyclically sensitive industries. That is, people who like to work hard some of the time and rest other times have a strong comparative advantage at working in durable sectors, where employment volatility is expected. Third, the reason that hours respond strongly to small changes in wages may be that wages are simply installment payments in a long-term relationship and do not serve to allocate labor over the short run. Finally, it may be the case that the employer gets to choose employment at some fixed wage and so effectively faces an elastic labor supply even though leisure is not easily substitutable over time. On the surface, such a rigid Keynesian wage model looks very similar to a model with perfectly elastic labor supply (Hall, 1988*b*) except with distinctly different welfare implications.

To summarize, market clearing models of economic fluctuations require an intertemporal labor supply elasticity of at least 1 or 2, but micro estimates are much smaller.

However, micro evidence is not informative on the intertemporal elasticity of labor supply because it is hard to identify temporary wage changes at the individual level. Trying to reconcile micro and macro evidence may not, therefore, be necessary. A more fruitful approach might be to understand why the true elasticity is high or, alternatively, why wages are rigid.

5. The Behavior of Relative Prices

A. Overview

In this section, we present evidence on the behavior of relative prices of different commodity groups over the business cycle. We then interpret this evidence in light of IR, TS as well as countercyclical markup models of economic fluctuations.

IR and TS models make very strong predictions about the behavior of relative prices. Both models say that goods produced with low productivity are expensive relative to goods produced with high productivity. Since low productivity is associated with recessions, the models say that in the recession the relative price of goods experiencing a productivity decline should rise. This implication leads to a natural question: what are the goods that become relatively more expensive in the recession? By isolating these goods, we can find the nexus of technology shocks or increasing returns.

We consider several commodity groups and ask three questions: (1) What is the cyclical behavior of the prices of finished goods, intermediate goods and raw materials relative to the GNP deflator and to the private sector wage? (2) What is the difference in the cyclical behavior of the prices of durable and nondurable goods relative to the GNP deflator and to the private sector wage? (3) How do the relative prices of outputs and inputs move over the cycle? Answers to these questions can give us some information about then nexus of increasing returns, technology shocks, and countercyclical markups.

B. The Evidence

This section presents the evidence on the cyclical behavior of relative prices. All the data for this study are annual for 1947-1987, taken from the 1988 Economic Report of the

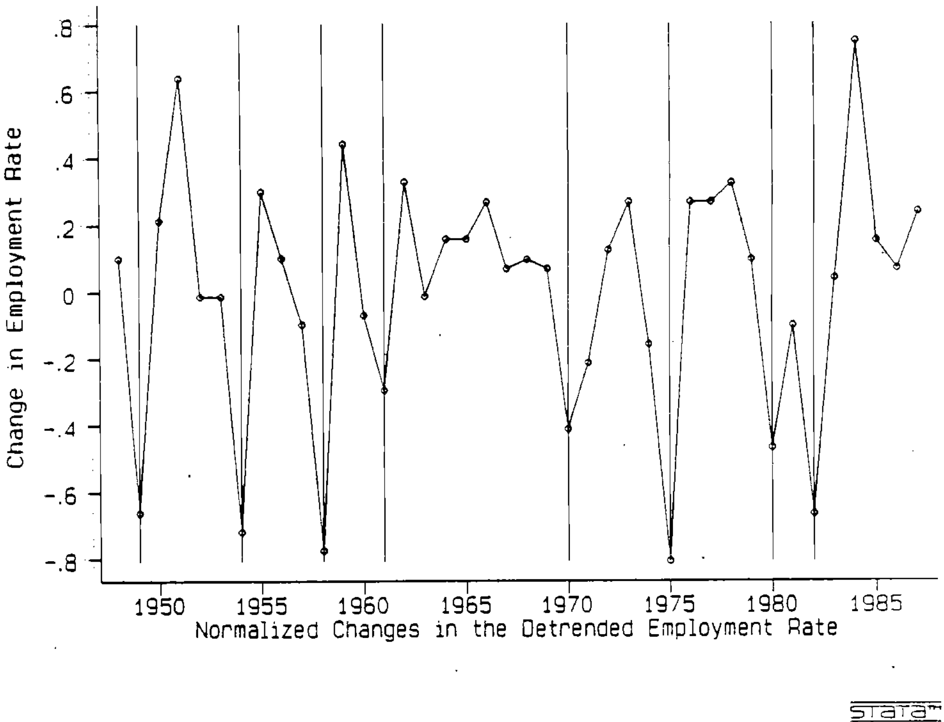
.8
.6
.4
.2
0
-.2
-.4
-.6
-.8
Change in Employment Rate
1950
1955
1960
1965
1970
1975
1980
1985
Normalized Changes in the Detrended Employment Rate
STATA™

Figure 4

Table 3

Cyclical Behavior of Prices Relative to GNP Deflator

Variable	Cyclical Indicator	1974-1975 Dummy
Panel A: Broad Groups by Stage of Processing		
Finished goods	.79 (.92)	4.54 (3.20)
Consumer durables	-.77 (-1.00)	.78 (.61)
Consumer nondurables	.37 (.23)	7.38 (2.76)
Capital equipment	-.81 (-1.00)	4.37 (3.26)
Total intermediate	2.69 (2.09)	8.87 (4.16)
Manufacturing materials	3.32 (2.54)	10.47 (4.83)
Construction materials	3.05 (3.41)	5.69 (3.84)
Fuels	1.31 (.36)	21.4 (3.52)
Crude Materials	9.91 (2.44)	4.59 (.68)
Panel B: Commodities		
Power	.59 (.15)	22.04 (3.34)
Chemicals	1.78 (1.18)	18.94 (7.58)
Lumber	10.58 (4.11)	-3.69 (-.87)
Paper	3.53 (2.62)	10.07 (4.52)
Metals	3.65 (2.39)	9.70 (3.83)

Table 3 (cont'd):

Variable	Cyclical Indicator	1974-1975 Dummy
Machinery	-.67 (-.70)	4.81 (3.05)
Household durables	-.20 (-.29)	2.08 (1.79)
Vehicles	-2.08 (-2.03)	.11 (.07)
Rubber	4.05 (1.67)	8.89 (2.22)

Note.--*t*-statistics in parentheses.

Table 4

Cyclical Behavior of Prices Relative to Average Hourly Earnings of Private-Sector Employees

Variable	Cyclical Indicator	1974-1975 Dummy
Panel A: Broad Groups by Stage of Processing		
Finished goods	.29 (.30)	6.35 (3.98)
Consumer durables	-1.27 (-1.72)	2.59 (2.12)
Consumer nondurables	-.13 (-.08)	9.19 (3.29)
Capital equipment	-1.31 (-1.65)	6.18 (4.69)
Total intermediate	2.19 (1.63)	10.68 (4.80)
Manufacturing materials	2.82 (2.08)	12.28 (5.47)
Construction materials	2.55 (2.99)	7.50 (5.30)
Fuels	.82 (.22)	23.2 (3.76)
Crude Materials	9.41 (2.29)	6.40 (.94)
Panel B: Commodities		
Power	.09 (.02)	23.85 (3.59)
Chemicals	1.28 (.79)	20.75 (7.73)
Lumber	10.08 (4.01)	-1.88 (-.45)
Paper	3.03 (2.13)	11.88 (5.05)
Metals	3.15 (2.07)	11.52 (4.57)

Table 4 (cont'd)

Variable	Cyclical Indicator	1974-1975 Dummy
Machinery	-1.17 (-1.24)	6.62 (4.23)
Household durables	-.70 (-1.06)	3.90 (3.54)
Vehicles	-2.58 (-2.55)	1.92 (1.15)
Rubber	3.55 (1.42)	10.71 (2.59)

Note.--*t*-statistics in parentheses.

Table 5
Cyclical Behavior of Relative Prices

Variable	Cyclical Indicator	1974-1975 Dummy
Panel A: Broad Groups by Stage of Processing		
Finished goods/Total intermediate	-1.90 (-2.96)	-4.33 (-4.07)
Finished goods/Fuels	-.53 (-.17)	-16.85 (-3.25)
Finished goods/Crude materials	-9.12 (-2.61)	-.052 (-.009)
Consumer durables/Total intermediate	-3.46 (-2.77)	-8.09 (-3.91)
Consumer durables/Manufacturing materials	-4.09 (-3.32)	-9.69 (-4.74)
Consumer nondurables/Total intermediate	-2.32 (-2.57)	-1.49 (-.995)
Consumer nondurables/Manufacturing materials	-2.96 (-2.57)	-3.09 (-1.62)
Capital equipment/Total intermediate	-3.50 (-2.72)	-4.50 (-2.11)
Capital equipment/Manufacturing materials	-4.13 (-3.24)	-6.10 (-2.89)
Total intermediate/Crude materials	-7.22 (-2.37)	4.28 (.850)
Manufacturing materials/Crude materials	-6.59 (-2.08)	5.88 (1.12)
Construction materials/Crude materials	-6.86 (-1.87)	1.10 (.181)
Panel B: Broad Groups and Commodities		
Total intermediate/Metals	-.96 (-.92)	-.83 (-.48)
Manufacturing materials/Metals	-.33 (-.37)	.77 (.52)
Construction materials/Metals	-.60 (-.58)	-4.01 (-2.33)
Construction materials/Lumber	-7.53 (-3.46)	9.38 (2.61)

Table 5 (cont'd)

Variable	Cyclical Indicator	1974-1975 Dummy
Vehicles/Manufacturing materials	-5.40 (-3.14)	-10.36 (-3.63)
Household durables/Manufacturing materials	-3.52 (-3.26)	-8.39 (-4.68)
Machinery/Manufacturing materials	-3.99 (-3.31)	-5.66 (-2.83)
Vehicles/Metals	-5.73 (-3.37)	-9.59 (-3.41)
Machinery/Metals	-4.32 (-3.17)	-4.89 (-2.17)
Household durables/Metals	-3.85 (-2.92)	-7.62 (-3.49)
Capital equipment/Metals	-4.46 (-3.27)	-5.33 (-2.36)
Household durables/Lumber	-10.78 (-4.01)	5.77 (1.30)

Note.--*t*-statistics in parentheses.

President. Our cyclical indicator is constructed from the civilian unemployment rate. To make the regression coefficients interpretable, we rescale this variable before using it in the regression. First, we pass a spline in time through the unemployment rate starting in 1965 to control for changes in the natural rate of unemployment, and then take the residuals. Second, we first difference the resulting series and take the *negative* of so obtained changes. This gives us a *procyclical* measure, equal to detrended changes in the employment rate. In each business cycle, we define *a boom* as the year of the fastest growth rate of (detrended) employment, and *a recession* as the year of the smallest growth rate of (detrended) employment. Finally, we scale these detrended growth rates of employment so that the average over all cycles of the difference of growth rates of employment between boom and recession is equal to .01. That is, in an average cycle, our detrended and normalized employment grows 1% faster in the year defined as boom than in the year defined as a recession. This cyclical indicator is presented in Figure 4, where vertical lines denote recessions. Importantly, the peaks and troughs of this indicator coincide with peaks and troughs in the growth rate of output.

In addition to using the Normalized Detrended Growth Rate of Employment in the analysis, we also use a dummy equal to 1 in 1974 and 1975, and 0 in all the other years. We do so because the 1974-75 recession has been accompanied by a large and very unusual change in relative prices. In particular, the relative price of oil and derivative products has increased significantly. The 1980 recession also exhibits this pattern of relative prices, but it is not as pronounced. Because the 1974-75 recession looks so different from all the others but one, we did not want to contaminate our inference by this episode. All the regressions we run take the form

$$\text{Change in relative price} = A + B \times (\text{Cyclical Indicator}) + C \times (\text{1974-1975 dummy}).$$

Tables 3-5 present the results. Table 3 presents the evidence on prices relative to the GNP deflator. Table 4 presents the results on prices relative to the average private sector hourly earnings. Table 5 presents the evidence on relative prices. In all tables, panel A deals with broad groups of goods by stage of processing, and panel B deals with individual commodities. Based on the scaling of the cyclical indicator, all the coefficients in the tables are easy to interpret. For example, the coefficient in the finished goods regression in panel A of Table 3 is .79. This means that, relative to the GNP deflator, prices of finished goods on average change .79% more in a boom (the year of the fastest increase in the employment rate for each cycle) than in the recession (the year of the lowest change in the employment rate for each cycle). The coefficient of 4.54 on the 1974-1975 dummy in this regression means that the price of finished goods rose 4.54% per year faster relative to GNP deflator in 1974-75 than in other periods.

In interpreting the results of Tables 3-5, we refer to relative prices that yield a positive coefficient on the cyclical indicator as procyclical, and relative prices that yield a negative coefficient as countercyclical. The regression coefficient measures the difference in the growth rate of relative prices between the boom (defined as the year of fastest growth rate of detrended employment in each cycle) and the recession (defined as the year of the lowest growth rate of detrended employment in each cycle). The reason we need such a relative measure is that some prices follow strong trends, and so may, for example, fall relative to the GNP deflator in both booms and recessions. If the relative price does not have a trend, a positive regression coefficient would say that, the relative price rises in a boom and falls in a recession. If, in contrast, the relative price is always falling, a positive coefficient would say that it falls less in the boom than it does in a recession. Either way, the relative price is procyclical in the sense that *relative to how they do in a recession relative prices rise in a boom*. The same logic explains why negative regression coefficients correspond to countercyclical relative prices.

Two kinds of results emerge from Table 3. First, finished goods do not show much cyclical behavior relative to the GNP deflator, except for slightly countercyclical relative price changes of finished durables. In contrast, prices of intermediate goods other than fuels are highly procyclical. For example, in an average cycle manufacturing materials grow 3.32% faster relative to the GNP deflator in a boom than in a recession. One exception to this is capital equipment, which may be thought of as an intermediate good, and which shows mildly countercyclical prices. By far the most procyclical are the prices of crude materials. In an average cycle, crude materials prices rise 9.91% more relative to the GNP deflator in a boom than they do in a recession. The procyclicality of prices clearly declines as one gets further in the production chain.

Similar results come from the more narrowly defined commodities. As is well known, prices of lumber, metals, paper and rubber are extremely procyclical. In contrast, prices of finished durable goods, including household durables, machinery, and vehicles are countercyclical. Commodities such as power and, surprisingly, chemicals do not show much action over the cycle.

Table 4 confirms the results of Table 3, except that the evidence is a little stronger. Relative to the private sector average hourly earnings, prices of finished goods do not show any cyclical behavior except that durables and capital equipment are more clearly countercyclical. Relative prices of raw materials and intermediate goods are, in contrast, strongly procyclical, except for capital equipment. Durable goods, such as household durables and vehicles, show the opposite pattern. Tables 3 and 4 show very clearly that the place to look for productivity declines in the recession is finished durable goods. Table 4 also suggests that procyclical real wages are most pronounced in terms of durables—a finding common to real wage studies.

Table 5 presents some more novel results, namely those on relative prices. The conclusion of Table 5 is that, in the production chain, the relative price of outputs to inputs is countercyclical. For example, relative to intermediate materials, finished goods grow 1.9% less in the boom than in the recession. Relative to crude materials, this number is 9.1%. Throughout this table, the result is that prices of finished goods are countercyclical relative to intermediate goods and crude materials, and prices of intermediate goods are countercyclical relative to crude materials.

Similar results emerge from Panel B of Table 5. Relative to the price of lumber, those of construction materials and household durables move countercyclically. Relative to the price of manufacturing materials, those of vehicles, household durables, and machinery also move countercyclically. Relative to the price of metals, those of vehicles, machinery, household durables are again countercyclical. It is very clear from this table that the price of outputs relative to that of inputs is countercyclical.

We draw three conclusions from Tables 3-5. First, the more finished are the goods, the less procyclical are their relative prices. Second, the goods that exhibit the most countercyclical relative prices are durables. Third, outputs appreciate relative to inputs in the recession. Importantly, these results are very similar to those found for the Great Depression period by Mills (1936) and Means et al. (1939) for a broader range of commodities. However, in the Great Depression, real wages actually increased, and so these findings can be rationalized by the observation that the relative price of goods with a greater labor content should be higher. Our starting point, in contrast, is that in the postwar period real wages have been if anything procyclical. Our next task is to interpret our findings for the postwar period.

C. Interpretation

The evidence in Tables 3-5 allows us to discriminate at least partially between various business cycle stories. One story—which we associate with Long and Plosser (1983)—is that technology shocks occur in the production of widely used raw materials or intermediate inputs, and then spread across the economy through the input output matrix. These shocks need not even be technology shocks; they can simply be price shocks to inputs supplied from outside the economy, like oil. An IR version of this theory says that increasing returns are in the production of raw materials or intermediate goods. As a result, these are the activities experiencing major productivity declines in the recession. Both TS and IR versions of this story predict that the relative price of raw materials and/or intermediate goods is countercyclical.

This story is inconsistent with the evidence in Tables 3-5. The tables confirm the standard finding that the relative prices of raw materials are extremely procyclical. An exception might be the case of oil in 1974-74 and 1979-80. However, except in these episodes, it is clear that recessions are not driven by adverse shocks or endogenous productivity declines in raw materials or in intermediate goods. This fact also poses a problem for the Long/Plosser theory of comovement, which works through shocks to common inputs.

The evidence in Tables 3-5 is much more favorable to the view that productivity changes occur at the later stages of the production process, particularly in durable goods. The IR version of the story says that increasing returns occur in the final stages of production or distribution of durables or possibly at the stage of producing capital equipment. The productivity of these stages declines in the recessions, and therefore the relative price of durables rises. The reason that relative price movements are so pronounced for wide categories of goods is that the comovement mechanism outlined in the previous section leads to synchronization of output and productivity movements across sectors.

The TS version of this story is somewhat different, and harder to reconcile with the evidence. In the TS world, the goods that get expensive in the recession are only the goods experiencing adverse technology shocks, and not the goods whose output declines simply because of comovement. This is an important difference between IR and TS models: even though both generate comovement with immobile labor and imperfect borrowing, the TS model exhibits countercyclical price movements only in the sectors with bad shocks. In contrast, the IR model yields relative price increases in all increasing returns sectors in response to output declines. To reconcile the TS model with the evidence, to bring on a recession one needs fairly widespread adverse technology shocks in either the finished durable goods sectors or in the capital equipment sector. We leave to the reader to evaluate the plausibility of pervasive adverse technology shocks in durable goods sectors as a cause of recessions.

Before concluding this section, we stress that the evidence in Tables 3-5 is also broadly consistent with countercyclical markups at the later production stages, especially in durables. None of the evidence we have presented bears on the behavior of true productivity; all the action might well be in markups. Hall's (1988a) earlier evidence can be interpreted in terms of countercyclical markups, although his later (1988c) work points to true increasing returns. As we mentioned before, however, Hall finds evidence of declining average costs and firms earning close to zero profits. This finding points to countercyclical markups as a way to generate procyclical real wages. Domowitz, Hubbard and Petersen (1988) present some evidence bearing on this issue, and conclude that markups are countercyclical. At this point, we are not sure which theory is right and leave this issue to a further investigation.

In summary, the evidence presented in this section enables us to at least partially narrow down the range of theories consistent with the data. If economic fluctuations are driven by technology shocks, these must be pervasive shocks across durable good industries, and not in intermediate input industries. If fluctuations are driven by increasing returns, these must be in the production and distribution of durable goods. Finally, fluctuations could be explained by countercyclical markups in durable good industries, without productivity movements.

6. Conclusion

In this paper we have discussed models of business cycles driven by movements of productivity. In particular, we have compared models in which these productivity movements result from exogenous technology shocks with models in which they result from endogenous movements along an increasing returns production function. We asked what kinds of assumptions these models require to at least roughly fit the data. We have found that although these models have very different sources of productivity changes, the assumptions required to fit the data are very similar. First, to generate large movements in output in response to small changes in productivity, these models rely on durability of goods. Second, to produce comovement of outputs and labor inputs across various sectors of the economy, these models need to assume specialized (immobile) labor and restricted borrowing. Third, to obtain large movements in labor inputs in response to small changes in real wages or productivity, these models require very elastic labor supply. Although none of these results is completely new, we hope that our emphasis on identifying the critical building blocks of a market clearing model proves useful.

Our paper has also documented the countercyclical behavior of prices of outputs relative to inputs, and of finished durables relative to wages and to the GNP deflator. This evidence suggests that the place to look for technology shocks or increasing returns is at the final stages of production, or in the distribution of durable goods. In the increasing returns framework, this evidence supports illiquid markets models of recessions. In these models, time to sale is long and therefore the marginal cost is high in the recession. The fact that such variable liquidity costs are most plausible for durable goods is evidence favorable to this approach.

There are three topics that are closely related to the issues we have discussed, but that we have not dealt with for lack of space. The first is downward rigid real wages as an alternative to elastic labor supply. Even if one assumes downward rigid real wages, one still needs a source of productivity changes—such as increasing returns or technology shocks—to generate shifts in labor demand. Downward rigid real wages would probably exacerbate the recession is a model of the sort we described, because firms might shut down even when they would not with a flexible real wage. Downward rigid real wages also make the comovement story look more like an aggregate demand story: instead of changes in relative prices we get changes in income and in demand for individual goods. It remains to be explored what are some of the other consequences of this assumption.

We have also ignored what is perhaps the most natural explanation of our evidence on cyclical behavior of relative prices: countercyclical markups without productivity changes. There are a number of reasons why producers of durables in a recession might not want to cut prices even if marginal costs fall when input prices decline. Most plausibly, we think that the customer mix shifts in the recession away from buyers with elastic demand, and so the profit maximizing markup rises. This change of customer base might occur because most people would require enormous price concessions to buy durables in a recession. The only remaining customers are those who need to replace durables that have fallen apart and so have inelastic demand. The change in the customer base might also occur if people who shop around and therefore have elastic demand are precisely the ones who have very low reservation prices in the recession—they may be individuals who face the risk of unemployment or firms fearing bankruptcy. Such theories of countercyclical markups, developed in particular by Phelps/Winter (1970), Okun (1981), Stiglitz (1984), Bils (1986), Weitzman (1982), and Solow (1984), can probably explain most of our evidence. Not surprisingly, one can build an endogenous business cycle model driven by countercyclical markups without productivity changes.

Finally, all of our discussion has assumed a fixed capital stock in production. In contrast, technology shocks models incorporate capital in the production function. Capital in these models serves in part as a propagation device, whereby today's technology improvements lead to an increase in the capital stock and therefore labor productivity tomorrow. There are also increasing returns models in which a business cycle is generated by movements in the capital stock (Shleifer 1986, Kiyotaki 1988). In these models, waves of investment raise productivity and income, and so lead to increased demand for goods. The higher demand for goods in turn justifies the initial investment outlay. Unifying the increasing returns models discussed in this paper with increasing returns investment models remains a topic for future work.

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