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SECTORAL SHIFTS AND CYCLICAL FLUCTUATIONS*

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Abstract:

This paper studies a two sector real business cycle model in which the sectors experience different trend rates of growth and labor mobility is costly. Predictions are derived concerning the correlation between sectoral reallocation of workers and the cycle. This correlation may be positive or negative depending upon whether the growing sector displays larger or smaller fluctuations than the shrinking sector. The post-World War II period has witnessed two major patterns of sectoral change in industrialized countries: movement out of agriculture and movement out of the industrial sector. The model's basic prediction is shown to be consistent with the observed pattern of reallocation.

1. Introduction

Virtually all industrialized countries have experienced substantial secular changes in the sectoral distribution of labor in the past thirty years. The main pattern is a decrease in the share of employment going to agriculture and industry with an increase in the share of employment in the service sector. Although these shifts have continued over a long period, they have not always proceeded at an even pace. In a paper that has stimulated much work, Lilien (1982) argued that a substantial part of cyclical fluctuations in the post WWII US economy can be viewed as the economy responding to sectoral shocks that affect the desired allocation of resources, and labor in particular, across sectors. The underlying factors causing sectoral shifts do not change smoothly over time, but rather evolve stochastically, resulting in a stochastic process for the

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amount of reallocation that occurs over time. Sectoral reallocation is large in some periods because there are shocks which have a large impact on the desired allocation of labor across sectors in those periods.

This paper presents a similar but different view of the relationship between sectoral shifts and cyclical fluctuations. This relationship is studied in a two sector version of a real business cycle model. In a sense to be made precise in the analysis, a model is presented where all cyclical fluctuations are the result of aggregate shocks and sectoral reallocation is the result of constant differences in productivity growth across sectors. Nonetheless, this model predicts a correlation between sectoral reallocation and the cycle, with the sign of the correlation depending upon the relative cyclical sensitivities of the two sectors. Empirically, the model predicts that the shift out of industry should be heavier during downturns whereas the shift out of agriculture should be heavier during upturns. The intuition for this result is straightforward. If cycles are not neutral across sectors then relative productivities vary over the cycle and hence interact with the optimal timing of reallocation. If a downturn makes sector 1 worse off relative to sector 2 then this will encourage workers in sector 1 to move into sector 2 sooner than they might have in the absence of a downturn. Conversely, if an upturn makes sector 1 improve relative to sector 2 then a worker may postpone their decision to move into sector 2 relative to what it would have been in the absence of an upturn.

Having demonstrated this possibility theoretically the paper then uses data from thirteen countries to examine the relationship between sectoral change and the cycle. In almost all countries the evidence is in accord with the prediction of the model: the movement out of industry is concentrated during downturns and the movement out of agriculture is concentrated during upturns. The difference between agriculture and industry is of some significance vis a vis alternative hypotheses. Davis (1987) has argued that if reallocation is more costly during periods when productivity is high then this factor will tend to cause reallocation to be concentrated during downturns.

2. Model

There is a continuum of identical infinitely lived agents, uniformly distributed along the interval [0, 1]. Production takes place in two sectors, but the two outputs are perfect substitutes in consumption. In any period each worker must be in only one of the two sectors. Within both sectors it is assumed that production has the following structure. Each period can be broken down into a large number of identical subperiods. In each subperiod an individual either works a specified amount of time or works none at all, but individuals are free to vary the number of subperiods in which they work. In this way, the labor supply choice for an individual in a given period can be thought of as choosing the fraction of the period in which labor is supplied. One may think of this as an economy in which the workweek (or workday) is fixed and individuals simply choose what fraction of weeks (or days) to work in a given year. With this in mind, each sector has a production function of the form:

$$g_i(n_{it},\ f_{it},\ \theta_t,\ d_{it})$$

where i denotes sector, t indexes time, n denotes number of workers in the sector, f_{it} is the fraction of the period worked by each worker, θ_t is an aggregate shock, and d_{it} is a sector specific productivity shift. In what follows the d_{it} will be deterministic.

The analysis of this paper will focus on a quadratic specification of the technology so that closed form solutions can be obtained. One can either view this as an exact quadratic specification or more generally as a quadratic approximation that is appropriate in specified region. The functions g_i will take on the following form:

$$g_i(n_{it},\ f_{it},\ \theta_t,\ d_{it}) = (a_i\theta_t + d_{it})n_{it} - .5bn_{it}^2 + (a_i\theta_t + d_{it})f_{it} - .5df_{it}^2 + ef_{it}n_{it}$$

where a_i is a sector specific constant, and b, d, e are all positive constants. It would be straightforward to allow b, d, and e, to have sector specific values but this would only add notation without adding anything of substance to the results obtained. A key feature of the production functions is that because a_i is sector specific the aggregate shock has differing effects on the two sectors. Note that if $a_1 > a_2 > 0$ then both are affected positively by the shock but sector one is affected by a greater amount. If $a_1 > 0 > a_2$ then the shock affects the sectors in opposite directions.

Although each worker must work in only one of the two sectors in any given period, it is possible for a worker to switch sectors between adjacent periods. There is a cost of doing so however, and the cost is assumed to take the form:

$$c + m\theta_t.$$

The first term, $c > 0$, is a fixed resource cost associated with movement, whereas the second term $m\theta_t$, with $m > 0$, represents a cost which is dependent upon the state of aggregate technology. Because $m > 0$, moving is relatively more costly when productivity is high, a feature that is included in order to facilitate comparison with the results obtained in Davis (1987).

As mentioned above, individuals are assumed to have identical preferences. In order to obtain closed form solutions preferences will be assumed to be of the form:

$$\sum_{t=1}^{\infty} \beta^t(c_t - f_t)$$

where $0 < \beta < 1$ is a discount factor, c_t is period t consumption, and f_t is the fraction of period t spent working. It is assumed that the initial distribution of workers across sectors is that half of the workers are in each sector.

3. Solution to the Model

Because individuals are risk neutral, the equilibrium allocation for this economy is one that maximizes total expected discounted output net of disutility of labor supply and moving costs. Hence, equilibrium allocations are given by the solution to the following problem:

$$\text{Max } E_0 \sum_{t=1}^{\infty} \beta^t \left\{\sum_j [f_j(n_{jt},\ f_{jt},\ \theta_t,\ d_{jt}) - n_{jt}f_{jt}] - |n_{1t} - n_{1t-1}|(c + m\theta_t)\right.$$

where f_1 and f_2 are as before. Note that in the above problem $n_{1t} + n_{2t}$ must always sum to one, the total mass of workers, and the total moving costs are given by taking the absolute value of the change in the mass of workers in sector one, since this minimizes moving costs subject to the given allocation of workers. In this economy with identical workers it follows that in any period there will never be movement in both directions in any period.

The goal here is not to provide a general characterization of the solution to the above problem, but rather to illustrate some of the outcomes that can occur as solutions to this model. Hence, several conditions will be imposed that allow a closed form solution to be obtained. A condition on the d_{jt} and θ_t will permit this. There are two aspects to the conditions, both related to the moving cost term. One is to specify the productivity processes so that movement between sectors will only be in one direction over time, which without loss of generality can always be assumed to be from sector one to sector two. With this done the absolute value sign in the above programming problem can be dispensed with. Having done so, a second issue is that with a linear moving cost function it is possible for a corner solution to arise in which no workers are moved from sector one into sector two even though there has been a change in relative productivities across sectors. If the change in the relative productivities is sufficiently large then there will be a positive flow of workers from sector one into sector two, and hence it is possible to assure that this is so with joint conditions on the d_{jt} and θ_t.

In addition to assuming that the productivity processes are such that there is positive movement between sectors in every period it will be assumed that $d_{1t} = -d_{2t}$. The reason for this choice of specification is that it means there is no trend in aggregate technology. With preferences linear in consumption this implies that in equilibrium there will also be no trend in total employment.

The aggregate shock θ_t is assumed to follow a process with the following properties:

$$E_t\theta_{t+1} = \rho\theta_t,\ \theta_t \in [-\bar\theta, \bar\theta] \text{ for all } t, \text{ and unconditional mean equal to } 0$$

where $0 < \rho < 1$ and $\bar\theta > 0$. By choosing $\bar\theta$ to be sufficiently small this specification will imply that setting $d_{jt} = 0$ for all t results in no movement of workers between sectors. When this is true it can be claimed that the reason for sectoral movement is the deterministic productivity change and not the aggregate shocks. However, even though the aggregate shocks do not induce sectoral reallocation on their own, they will affect the pattern of sectoral reallocation in the presence of d_{jt}'s that do result in movement of workers. This feature arises in the model because of the linear moving cost. With a linear cost it may be that a small shock is not sufficient to generate movement. Conditional upon there being positive movement, however, small shocks will affect the amount of movement.

When seeking a solution in which n_{1t} is monotone decreasing over time the programming problem written above is a relatively straightforward quadratic optimization problem. Imbedded in this problem are two distinct problems: a static problem (solving for the f_{jt}), and a dynamic problem (solving for the n_{jt}). For any value of the n_{jt} it is straightforward to determine the optimal values of the f_{jt} by differentiating the objective function. Some manipulation yields:

$$f_{jt} = (1/d)\ [a_j\theta_t + d_{jt} + (e-1)n_{jt}].$$

Not surprisingly, holding the number of workers fixed, increasing productivity increases the fraction of the period worked by each individual, whereas holding productivity

constant, increasing the number of workers in a sector decreases the fraction of a period worked by all workers in the sector.

These solutions for the f_{jt} can then be substituted into the previous planning problem, leaving a problem in which n_{1t} can be viewed as the only choice variable (recalling that $n_{2t} = 1 - n_{1t}$). This is a straightforward problem to solve, and the solution is given by:

$$(1)\quad n_{1t} = .5 + B[A(a_1 - a_2)\theta_t + m(\theta_t - \beta E_t\theta_{t+1}) - A(d_{2t} - d_{1t})] + B(1-\beta)c$$

where $A = 1 + (e-1)/d$, $B = .5[b - (e-1)^2/d]^{-1}$.

If we interpret each individual not working at any point in time to be unemployed, then the average unemployment rate in a sector in period t will be given by $(1 - f_{jt})$. The aggregate unemployment rate will be given by:

$$U_t = n_{1t}(1 - f_{1t}) + (1 - n_{1t})(1 - f_{2t}).$$

4. Results

In analysing the implications of equation (1) for the dynamics of sectoral reallocation it will be useful to consider a sequence of cases.

Case 1: $\theta_t = 0$, all t.

This case, in which there are no aggregate shocks, serves as a useful benchmark. In this case equation (1) reduces to:

$$n_{1t} = .5 + B(\beta - 1)c - A(d_{2t} - d_{1t}).$$

Hence, n_{1t} is a constant plus a trend term. In the special case where the change in $d_{2t} - d_{1t}$ is constant over some interval, say

$$(2)\quad d_{2t} - d_{1t} = \alpha + (\gamma/A)t,$$

where α, γ are positive, then over this interval n_{1t} follows the path:

$$(3)\quad n^1_{1t} = K - \gamma t,$$

where the superscript simply indexes that this is the solution in case 1.

Note that this can only hold over some interval, since n_{1t} is bounded below by 0. It turns out that focussing on the interval where this relationship holds is a very useful device for analysing some of the model's implications.

Case 2: θ_t non-degenerate, $a_1 = a_2$.

Assuming (2), substitution into (1) yields:

$$n^2_{1t} = K - \gamma t + Bm(1 - \beta\rho)\theta_t.$$

The simplest way to understand the different implications of cases one and two for the path of sectoral employment is to compute the difference between sample paths, which is:

$$n^2_{1t} - n^1_{2t} = Bm(1 - \beta\rho)\theta_t.$$

Note that whenever θ_t equals zero, the two solutions coincide, when θ_t is negative, n^2_{1t} will always lie below n^1_{1t}, and that whenever θ_t is positive, n^2_{1t} lies above n^1_{1t}. Loosely speaking then, given that the unconditional mean of the θ_t process is zero, sectoral reallocation will take place at the same pace on average, but it will tend to be concentrated during aggregate downturns as long as m is positive. This result is fairly intuitive. A positive value for m indicates that reallocation is less costly during aggregate downturns, and hence the economy responds by carrying out more reallocation during bad times. If m is equal to zero, then case two has exactly the same path for sectoral employments as does case 1, i.e. the presence of neutral aggregate shocks has no affect on the path of sectoral reallocation. Note however, that aggregate shocks do affect the solutions for the f_{jt}, and hence both output and employment are affected by neutral aggregate shocks. The implications of a positive m for sectoral reallocation patterns have been previously studied by Davis (1987).

Case 3: non-degenerate θ_t, $a_1 > a_2 > 0$, $m = 0$.

Proceeding as above, one easily obtains:

$$n^3_{1t} - n^1_{1t} = AB(a_1 - a_2)\theta_t.$$

Note that a similar result to that obtained above holds in this case as well. Whenever $\theta_t = 0$ the two solutions will be identical, independently of what came before. Furthermore, whenever θ_t is positive (negative), n^3_{1t} will always lie above (below) n^1_{1t}. The implication is once again that sectoral reallocation will proceed at the same pace "on average", but that it will intensify during bad times. The intuition for this is again fairly straightforward. With $a_1 > a_2$, sector one is affected to a greater extent by aggregate shocks. Hence, during good times, sector one improves relative to sector two, and during bad times sector one deteriorates relative to sector two. Because reallocation is driven by relative productivity differences, it follows that the pace of reallocation slows down during good times and speeds up during bad times. Obviously if we assumed $a_1 < a_2$ then the opposite pattern would emerge: reallocation would speed up during good times and slow down during bad times.

Combining cases 2 and 3 it is easy to see that if the a_i are not equal and m is positive then the two effects may reinforce or offset each other. The effect of a positive m is to encourage reallocation to occur during downturns, whereas the effect of differing cyclical sensitivities may either speed up or slow down reallocation during downturns. The next section looks at some international evidence on sectoral reallocation to observe the timing between sectoral movements and the cycle.

5. Empirical Evidence

There are two conclusions that the preceding theoretical analysis has highlighted. The first is that sectoral flows may be correlated with the business cycle even though the

flows are caused by differences in trend rates of growth and these rates are constant. The second conclusion concerns the factors which influence the sign of this correlation. Differences in cyclical sensitivity may cause the correlation to be of either sign, whereas if moving is more costly during good times then the correlation will be biased toward negative values. The purpose of this section is to present some descriptive evidence of major sectoral changes that have taken place over the last thirty years in several countries, and to assess these patterns from the perspective of the models discussed above.

Industrialized countries have witnessed two major patterns of sectoral shifts over this period. One is a shift out of manufacturing (or more generally industry), and the other is a (continued) shift out of agriculture. The service sector has been increasing at the expense of these two sectors. With respect to the above discussion these shifts are interesting because among the three sectors, industry is most cyclically sensitive and agriculture is least sensitive, hence these two shifts provide a natural test of the implications of the model which stresses cyclical sensitivity.

These flows are studied for a sample of thirteen countries: Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Luxembourg, Netherlands, Sweden, United Kingdom, and the United States. The following procedure is used. The raw data consists of time series data for the fraction of total employment accounted for by industry, services and agriculture, and the aggregate unemployment rate. The data used are from the OECD Labor Force Statistics. The unemployment rate each country is regressed against a constant, and four powers of time. The residuals from this regression are used to identify turning points in the cycle and hence whether a given year is counted as an upturn or a downturn. Table 1 shows the years identified as downturns for each of the countries. It should be noted that several variations of this were also tried, since in some cases the classification of particular years is not entirely clear. The results reported below were robust with respect to all variations tried, so only one set of results is reported. Having identified pairs of years (e.g. 1981-82) as corresponding to upturns or downturns, the sectoral shares are first differenced, and the first differences are summed over the two categories of upturn years and downturn years. This determines the amount of sectoral change that takes place in upturns and downturns respectively. There are two additional details about this procedure. The first concerns the starting date for measuring the flow out of manufacturing. Some countries experienced an increase in the share of employment in industry during the early part of the period. In these cases the initial year is chosen to be the year in which industry's share reaches a peak. The spirit of the models that were analysed concerned sectoral shifts which were permanent. In the data there a few cases where for example, industry's share decreases in a downturn and then increases in the ensuing upturn. To eliminate this consideration, the first differencing of the sectoral share series involved the following correction. If there was a decrease in an industry's share that was subsequently reversed, then that entry was decreased by the amount of the subsequent increase, or zero if the entire decrease was later reversed. This alteration turns out to be relatively unimportant qualitatively, although the results are somewhat stronger if the corrections are not made. From these calculations the following statistics are computed for both industry and agriculture: the average decrease in share during upturns and the average decrease in share during downturns. The results of this exercise are shown in Tables 5 and 6. There is one additional entry in Table 6, corresponding to the shift out of agriculture for the US during the period 1900-1914, a period of large shifts out of agriculture. For this period the sectoral share data come from Lebergott (1958) and the unemployment data are taken from Romer (1986).

The results are quite striking. In the case of manufacturing there is a clear tendency

TABLE 1

IDENTIFICATION OF DOWNTURN YEARS

Year	Aus.	Bel.	Can.	Den.	Fran.	Ger.	It.	Jap.	Lux.	Ne.	Swe.	UK.	US.
61/62												X	
62/63	X		X	X								X	X
63/64							X	X					
64/65		X		X	X		X	X	X				
65/66		X		X		X	X	X	X	X	X		
66/67	X	X	X		X	X			X	X	X	X	
67/68	X	X	X		X		X		X		X	X	
68/69													
69/70			X		X							X	X
70/71			X		X			X	X	X	X	X	X
71/72		X					X	X	X	X	X	X	
72/73													
73/74	X			X		X		X					X
74/75	X	X	X	X	X	X	X	X	X	X		X	X
75/76		X		X			X		X			X	
76/77			X				X				X		
77/78								X			X		
78/79							X						
79/80									X			X	X
80/81	X	X	X	X	X	X		X	X	X	X	X	X
81/82	X	X	X	X	X	X	X	X	X	X	X	X	X
82/83	X	X		X		X	X	X			X	X	X
83/84					X		X	X					
84/85													
85/86							X	X					
86/87		X					X			X			

for the shift out of manufacturing to intensify during downturns, whereas in the case of agriculture the opposite is observed. It is important to contrast the findings for industry and agriculture. As stated earlier, one factor which predicts heavier reallocation during bad times is that time is less valuable in production during these times and hence individuals intertemporally substitute into reallocation during downturns. However, if this factor were dominant then one would also expect movement out of agriculture to exhibit the same pattern, but in fact it displays the reverse pattern.

Evidence in Loungani and Rogerson (1988) concerning patterns of sectoral reallocation in the PSID for the years 1974-1984 is also of interest with respect to this issue. Over the course of this period there are many individuals who moved from manufacturing into services (and remained there) as well many who moved from services into manufacturing (and remained there). They also found that the flow of individuals from services to manufacturing was procyclical whereas the reverse flow was countercyclical.

6. Conclusion

This paper has studied the relationship between sectoral reallocation of workers in the context of a real business cycle model. Predictions were derived for the correlation

between the change in sectoral employment shares and the cycle. These predictions were in agreement with properties of the actual reallocation process in a sample of thirteen industrialized countries. One message that emerges from the analysis is that one should not necessarily interpret the observation that resources flow one sector to another during a downturn that there was a contemporaneous shock to one of the sectors.

TABLE 2

RESULTS FOR INDUSTRY

Country	Total Loss in Industry Share	Average Loss in Downturn	Average Loss in Upturn
Austria	7.2	.86	.32
Belgium	17.2	.82	.68
Canada	8.4	.88	.11
Denmark	9.6	.38	.61
France	8.7	.70	.58
Germany	8.0	.88	.30
Italy	7.1	.54	.30
Japan	3.4	.33	.14
Luxembourg	15.3	.90	.62
Netherlands	14.0	.78	.56
Sweden	13.0	.76	.45
United Kingdom	17.8	.95	.42
United States	8.9	.97	.15

TABLE 3

RESULTS FOR AGRICULTURE

Country	Total Loss in Agriculture Share	Average Loss in Downturn	Average Loss in Upturn
Austria	14.1	.34	.60
Belgium	5.6	.18	.07
Canada	7.9	.23	.34
Denmark	11.8	.34	.51
France	14.5	.53	.58
Germany	7.9	.11	.37
Italy	20.3	.66	.93
Japan	20.7	.63	.96
Luxembourg	12.0	.53	.41
Netherlands	4.7	.11	.21
Sweden	10.8	.32	.51
United Kingdom	2.2	.04	.12
United States	5.1	.14	.22
US 1900-1914	10.0	.29	1.14

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LAS REGULARIDADES EMPIRICAS DEL TIPO DE CAMBIO REAL EN CHILE: UN ENFOQUE DE CICLO DE NEGOCIOS REALES

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Abstract:

The paper formulates, solves, and calibrates a nonlinear stochastic dynamic competitive equilibrium model for Chile for the period ranging between the first quarter of 1977 and the fourth quarter of 1990. The framework used here incorporates both, elements from standard open economy models, and elements coming from the more recent literature on real business cycle models. It is found that within the competitive setting adopted here, a number of important empirical regularities exhibited by the real exchange rate can be closely replicated by the model. Among others, these include, the volatility of the real exchange rate, the correlation with the main export price, the correlation with real wages, and the correlation with foreign capital inflows. An important assumption needed to produce these results is that the country has, in general, been unable to fully smooth consumption by relying on the international credit market. On the other hand, the high serial autocorrelation exhibited by the real exchange rate, remains unexplained by the theoretical framework here adopted.

1. Introducción

¿Cuántas (y cuáles) regularidades empíricas exhibidas por el tipo de cambio real en un país menos desarrollado pueden ser explicadas por un modelo de equilibrio general perfectamente competitivo? El presente trabajo se centra en esta pregunta, la cual resulta de interés, tanto desde un punto de vista teórico como de política.

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