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Structural and Macroeconomic Determinants of the
Output Decline in Poland: 1990-91

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Abstract

This paper addresses two questions relating to the output decline in Poland since the initiation of market-oriented reforms at the beginning of 1990. First, to what extent is the decline in output a generalized phenomenon, rather than reflecting the short-term effects of resource reallocation in response to the new relative price structure? Second, what have been the main macroeconomic determinants of the output decline? In response to the first question, the paper finds relatively little evidence to favor a "structural change" view of the output decline. As far as the second question is concerned, the paper finds that both supply-side and demand-side factors have played a role, depending on the specific time period being considered.

JEL Classification Numbers:

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I. Introduction

In the two-year period since 1990, the real value of output in Eastern Europe declined by about 23 percent, and output in the former Soviet Union declined by about 19 percent (Chart 1). There were, however, significant cross-country differences in the extent of the output drop, related to many factors including the extent and type of reform measures that were put in place. Clearly, however, the initiation of market-oriented reforms was not a necessary condition for output to decline, as the experience in the economies of the former USSR clearly shows; nor is it the case that the cumulative decline in output was largest for countries that reformed earlier, as is illustrated for example by the Bulgarian case. Although the structure of central planning in many Eastern European countries had already largely been dismantled by the beginning of 1990, the situation of "neither plan nor market" that emerged (in which state enterprises could function as autonomous units but did not face appropriate market incentives) was not exactly conducive to robust output growth. Output was already on a downward path even before the initiation of reforms in much of the region and it is not immediately obvious what the counterfactual to the reforms might look like, that is how much of an output decline would have taken place had the reforms been postponed.

There is no shortage of explanations of the output collapse in Eastern Europe, the extent of which took many observers (and official forecasters) by surprise. Some have argued that the magnitude of the decline has been overstated by official statistics, either because their coverage excludes all or part of the growing private sector (Berg and Sachs (1991)), or simply because, beginning from an initial situation of widespread shortages, standard price and quantity indexes generally overstate the drop in output and the increase in the price level associated with price liberalization (Osband (1992)). Such explanations do not, however, claim that the decline in output is entirely an artifact of the official statistics.

Some observers have viewed the output decline as being related to the price shock that followed economic liberalization. This "demand side" view would argue that the decline in real wages, money and credit associated with the (greater-than-expected) price increase depressed domestic absorption and thereby contributed to the decline in output. Other demand side factors might include high real interest rates and, in 1991, the change in CMEA trading arrangements and the ensuing collapse in trade among the countries of the region (although this latter factor is not of course entirely exogenous). In contrast, a "supply side" view would characterize the output decline as resulting from the increase in domestic energy prices which, because of overly tight credit ceilings imposed on state enterprises, did not allow firms to pay for their inputs, forcing them both to contract supply and to enter into arrears vis-à-vis their suppliers.

For a country that faces a new relative price structure--as was the case for Poland at the beginning of 1990--one would expect that, over a period of time, resources would move toward sectors whose relative output

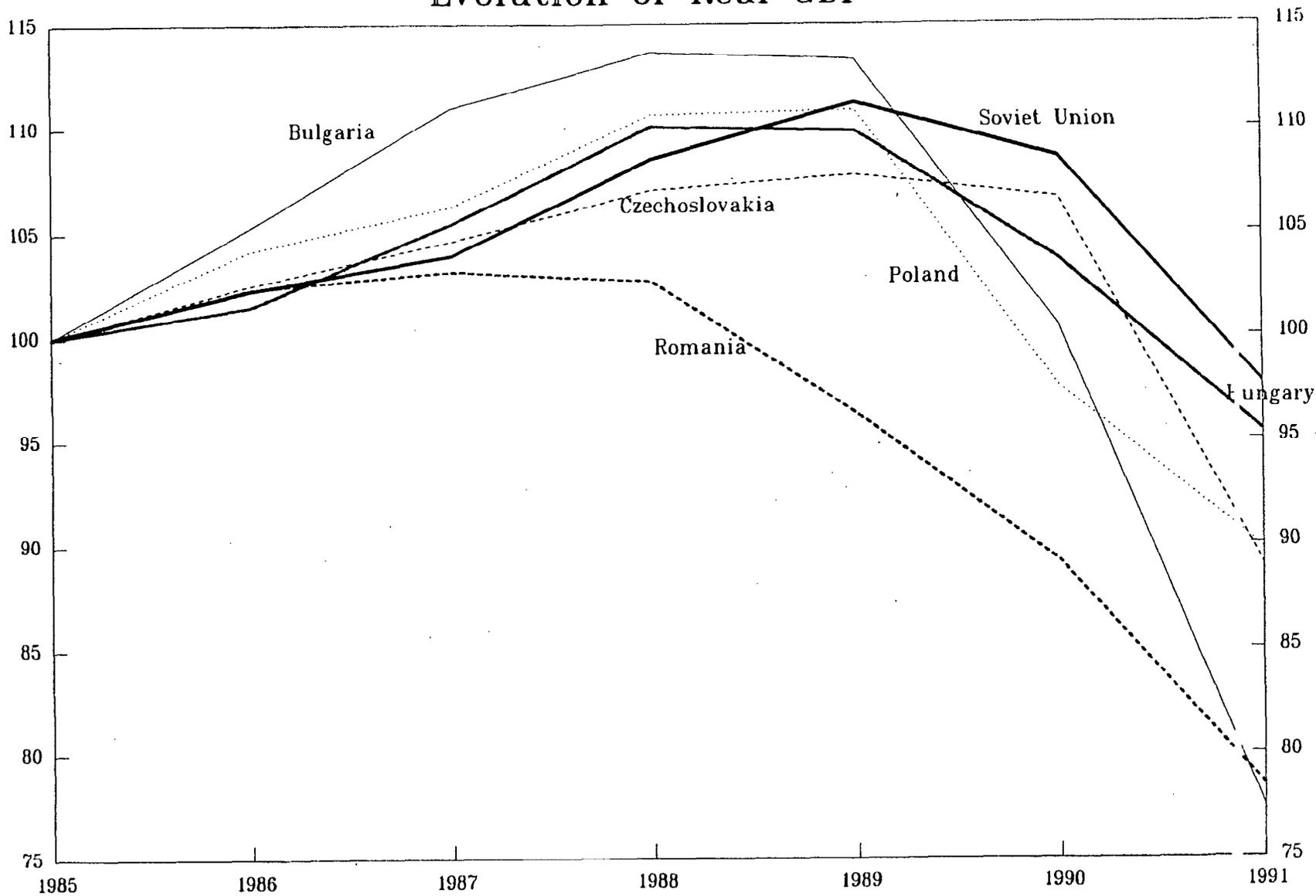
prices had risen and away from the other sectors. Comparative advantage would imply that, if the country faced world market prices for its inputs and outputs, resources would flow towards those sectors where comparative costs were lowest, thereby gradually increasing the value of goods and services produced. A transitional period might, however, be required before factors were allocated to their efficient uses. During this period, the process of structural change might be associated with a decline in aggregate output, especially if, as seems likely, an expansion of activities that were profitable under the new relative price structure was delayed by the presence of significant adjustment costs and uncertainty. To the casual observer, the resulting decline in output would appear very similar to what would occur in a typical recession caused by macroeconomic factors such as fiscal and monetary austerity together with sharp increases in administered energy prices.

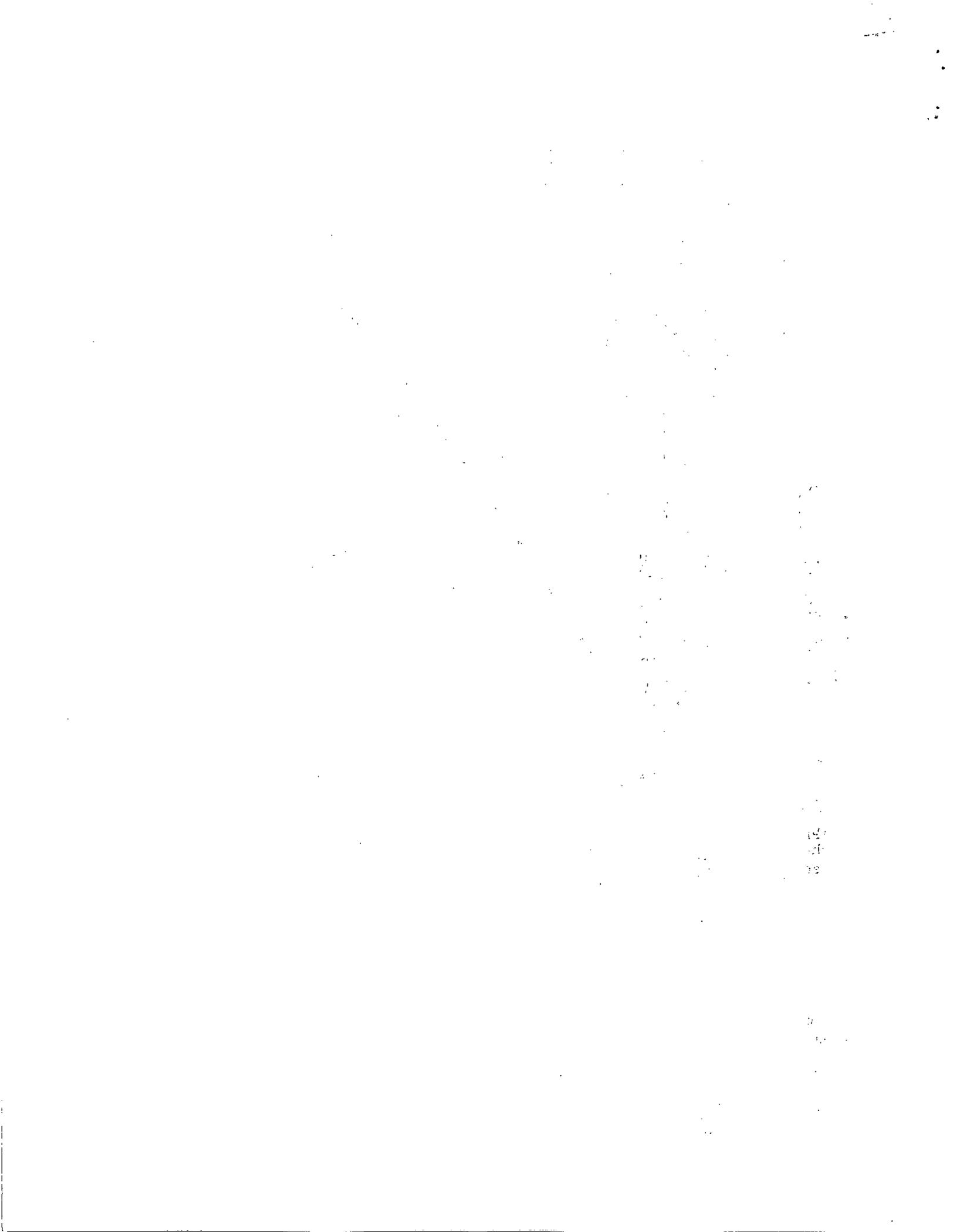
One of the objectives of this paper is to present some evidence on the extent to which the output collapse in Poland may be attributed to the ongoing process of structural change as opposed to more generalized demand- and/or supply-side macroeconomic factors. We do this by examining in detail sub-sectoral price and output developments within the Polish industrial sector. We focus on the industrial sector because, as is discussed in greater detail below, the output decline has been concentrated in this sector (as opposed to others such as agriculture, trade, and services) and because many of the explanations for the output collapse relate to the drop in production of enterprises in the (state) industrial sector.

In particular, we use principal components analysis to investigate what proportion of the variance of industrial output can be accounted for by a small number of common macroeconomic factors. We compare these results with those obtained for a benchmark country, taken for our purposes to be the United States. Our results suggest that the behavior of industrial output across sub-sectors has been more variable in Poland than in our benchmark country, thus tending to lend support to the structural change hypothesis. However, one must be cautious in interpreting this finding for at least three reasons. First, if structural change were really taking place, this should be reflected in employment data as well as output data, with labor moving towards sectors with relatively low comparative costs. Unfortunately, the relevant employment data do not suggest that much structural change has taken place, in the sense that the first few principal components account for a similar fraction of the variance of the employment series in Poland as in the benchmark country. Second, the findings from a multi-country study that attempted to decompose the output decline into country-specific (that is national or macroeconomic) and sector-specific factors, found that the latter played only a very minor role, again suggesting that, as yet, not much structural change has taken place in the industrial sectors of these countries. ^{1/} Third, if structural change is taking place, there should be some evidence that resources are moving

^{1/} See Borensztein, Demekas, and Ostry (1992).

Chart 1
Evolution of Real GDP





towards those sectors where comparative costs are lowest. Unfortunately, in regressions of output and employment changes on two different measures of domestic resource cost (our proxy for comparative advantage), little evidence is found that resource movements can be predicted on the basis of comparative advantage.

A second objective of the paper is to distinguish the roles of supply-side and demand-side factors in the output decline. As implied by a simple supply-demand model, a preponderance of supply-side shocks would result in a predominance of negative correlations between price and output changes; conversely, if demand-side factors were more important, relative prices and outputs would tend to show mostly positive correlations. The calculated correlations suggest that supply-side factors were relatively more important in the second halves of both 1990 and 1991, while demand-side factors played a more prominent role in the first halves of 1990 and 1991.

As a further test of the relative importance of demand and supply factors, we estimate a set of sectoral supply-demand models for each of seven major industrial sectors in Poland. Estimation of sectoral supply and demand functions provides a basis for decomposing the source of output fluctuations between supply and demand factors. In addition, the estimates shed some light on the relative importance of various macroeconomic factors (energy price increases, credit contraction, wage increases) in accounting for the output decline. The results suggest that the importance of various macroeconomic factors varies across sectors, but give some support to the view that both energy price increases and tight credit conditions may have influenced the behavior of industrial output in Poland during the two-year period since the initiation of reforms.

The remainder of this paper is organized as follows. In Section II, we describe the main elements of the economic reform program in Poland and also the principal developments in output, employment, wages, and prices since the initiation of reforms. The results of our empirical work are discussed in Section III. Section IV contains the main conclusions of the paper. An appendix develops a simple example of how the type of energy tax/subsidy changes implemented at the outset of the Polish program might generate a decline in aggregate output.

II. Developments in Poland in 1990-91

1. The first year of the program ^{1/}

In January 1990, the Polish Government initiated a comprehensive program whose goal was both to stabilize a rapidly deteriorating macroeconomic situation and to begin to lay the groundwork for the

^{1/} For a detailed analysis of the first year of the Polish program, see Lane (1992).

establishment of a market economy. As far as stabilization measures were concerned, the budget balance was programmed to shift from a deficit position equivalent to 7 percent of GDP in 1989 to approximate balance in 1990. This was to be achieved through strict control of government expenditure on goods and services, large reductions in subsidies, and improvements in revenue collection. Monetary policy was programmed to be relatively tight in the early part of the year, but allowance was made for an expected remonetization in later months as inflation came down. Interest rates were increased sharply and were targeted to remain positive in real terms, in contrast to the sharply negative real rates in 1989. The exchange rate was devalued and then fixed at a rate of 9,500 zlotys to the dollar, a level that was believed would hold for a period of three months or so. 1/ Another crucial element of the program was the introduction of a tax-based incomes policy, which penalized enterprises strongly for wage increases above a norm that was a specified fraction of the monthly increase in consumer prices. For the year as a whole, the incomes policy was designed to effect a reduction in real wages of about 30 percent.

As far as liberalization measures were concerned, food subsidies had already been eliminated at the end of 1989, while in January 1990 most remaining controls on the prices of goods and services were removed. 2/ As for the prices that continued to be subject to administrative oversight, the most important were those of coal and electricity which, notwithstanding very sharp increases (of between 300 and 600 percent) at the beginning of the program, remained significantly below world levels. Other measures included a significant liberalization of foreign trade, and currency convertibility for transactions in goods and nonfactor services. Finally, the government indicated its intention to develop plans for privatizing state enterprises, and initiated plans for breaking up monopolies; clarifying bankruptcy legislation; and modernizing the banking system.

The program was successful in many areas. Inflation, after a (larger-than-expected) surge in the early months of 1990, was reduced to about 3 percent per month by midyear. The incomes policy was successful in holding down the growth in wages and, in fact, wage growth in the first half of the year was lower than allowed for under the terms of the policy, with the consequent drop in real wages being greater than programmed. The budgetary situation also showed greater improvement than anticipated, aided

1/ Relative to December 1989, the official rate of devaluation was about 81 percent, while the devaluation on the free market was about 25 percent.

2/ Prices that were not freed included those of: housing (rents); public utilities; passenger transportation; hard coal; coke; and electricity. In total, only 10 percent of all prices remained subject to administrative oversight at the beginning of 1990, compared to 50 percent in the latter part of 1989.

by a much improved financial position of enterprises and banks. 1/ The budget swung into sharp surplus in the first half of 1990 (equivalent to about 4 percent of annual GDP), compared to an anticipated position of small deficit. Again contrary to expectations, convertible-currency exports surged and imports fell sharply, with both the current account surplus and increase in reserves being much larger than programmed. 2/ Consistent with the balance of payments performance, monetary policy proved to be somewhat tighter than envisaged at the outset of the program, with both money and credit to nongovernment falling sharply in real terms. Finally, in addition to the program's unexpected financial performance, significant progress was also made on the microeconomic side, particularly as regards the elimination of shortages, privatization of small firms, and to some extent demonopolization.

While the financial performance of the program--as measured by the turnaround in the budget and the balance of payments--exceeded expectations, developments in the real economy--particularly the behavior of output--were cause for serious concern. In January 1990, sold production of socialized industry fell by about 30 percent, and remained relatively flat until the middle of the year. 3/ Although the decline in real GDP is likely to have been much smaller, owing to a relatively better performance of other sectors of the economy such as services, construction, agriculture, and private industry, developments in these sectors would have been insufficient to alter the conclusion that at the beginning of 1990, Poland entered a depression of historical proportions. The unemployment rate, which had been effectively zero at the end of 1989, rose to 3 percent by midyear.

In part as a result of these developments, fiscal, monetary, and incomes policies were all eased in the second part of the year. 4/ To some extent, developments in the second half of the year reflected these changes, with the monthly inflation rate rising from a low of 1.8 percent in August to an average 5.5 percent monthly in the last quarter, 5/ and

1/ Enterprise profitability was boosted by a number of factors including: the very sharp drop in real wages; and large capital gains on holdings of inventories and of foreign currency deposits (a sizable portion of which were liquidated in the early months of 1990). The financial position of banks was aided by the very large interest rate spreads that emerged in the early part of 1990.

2/ Despite an exchange rate that was appreciating in real terms from January onwards.

3/ This figure is adjusted for the larger number of working days in January than December.

4/ This was in addition to the planned easing of financial and incomes policies that was already embedded in the program.

5/ The increase in inflation can be attributed not only to the easing of policies, but also to seasonal factors and to the effect of moving domestic petroleum prices to world levels (which were boosted by the Gulf crisis) in October.

output of socialized industry recovering 4 percent from its level in the first half. 1/, 2/ Despite the recovery in the second half of 1990, production of socialized industry (for the year as a whole) was down 25 percent on the level of 1989, and real GDP was down by about 12 percent. Finally, as far as the program of systemic change was concerned, especially privatization of the large state enterprises, development of competitive labor and housing markets, banking system reform, and reform of the tax system, the bulk of the work remained to be carried out in subsequent years.

2. The second year of the program

Reflecting both the easing of financial policies in the latter part of 1990 and large administered price increases at the beginning of 1991, inflation rose to nearly 13 percent in January, with the "underlying" rate estimated to have been in excess of 4 percent. To get inflation back under control, monetary policy was tightened at the beginning of 1991 by increasing the NBP's refinance rate; incomes policy was firmly targeted to reduce the level of real wages which had risen sharply in the latter part of 1990; and calls for a devaluation of the zloty were resisted despite the very sharp real appreciation that had taken place in the latter part of 1990. 3/ The discretionary elements of fiscal policy were programmed to remain tight in 1991, although a significant worsening of the budget (to a position of small deficit) was envisaged. This reflected mainly a reduction in corporate income tax revenues, itself the result of many factors, including: (i) the nonrecurrence of capital gains on inventories and enterprise foreign currency deposits, which would contribute to a reduction in state enterprise profits; and (ii) the narrowing of interest rate spreads which would reduce bank profits. On the expenditure side, significant increases in appropriations for unemployment compensation and other safety nets would also serve to increase the deficit.

On the microeconomic side, the program for 1991 embodied a commitment to reduce state ownership in the economy by about 15 percent. This was to be achieved both through a program of mass privatization involving the free

1/ Real wages were also up on the first half, by about 12 percent.

2/ Industrial output in the second half of 1990 was down about 20 percent on the second half of 1989, while output in the first half of 1990 was down about 30 percent on the first half of 1989. Clearly, therefore, even on a seasonally-adjusted basis, there was some recovery in the second half of 1990.

3/ Incomes policy was targeted to reduce real wages from the high levels recorded in the latter part of 1990; however, in year-average terms, the policy was for a small increase in real wages, in line with a programmed increase in labor productivity. Another change between 1990 and 1991 as far as incomes policy is concerned is that excess wage tax was now to be assessed against the average wage rather than the total wage bill, in order to eliminate any anti-employment bias in the previous legislation.

issue of vouchers to the public, 1/ and by traditional methods (public offerings, private placements, and joint ventures). There was also a renewed commitment to make bankruptcy a reality for nonviable enterprises in the state sector. Systemic change was to continue on other fronts as well, including strengthening competition policy, liberalizing foreign investment legislation, financial sector reform, and further liberalization of those prices remaining under administrative control (energy, transportation, and alcohol). Based on this program, the authorities believed that output would begin to recover in the second half of the year and that, relative to 1990, GDP would rise by 3-4 percent in real terms, reflecting a continued strong expansion of an increasingly important private sector. This estimate was consistent with a substantial decline (about 60 percent in volume terms) in exports to the CMEA area, and with the shift of CMEA trade to world market pricing which represented a considerable deterioration in Poland's terms of trade (on the order of 15-20 percent).

In the event, performance in 1991 was much worse than foreseen. While industrial output was expected to be flat in the first half of the year, followed by a recovery in the second half, in fact, sold production of industry (which from 1991 includes the larger private enterprises), actually fell by over 20 percent over the first six months of 1991, and displayed virtually no recovery in the second half. 2/ For the year as a whole, industrial production is estimated to have been about 12 percent below the 1990 level (which itself was 25 percent below the 1989 level), while GDP in 1991 is believed to have declined by about 7 percent relative to 1990, reflecting the resilience of some other sectors-- notably agriculture, private trade, and construction--in the face of the continuing deep depression in industry.

The decline in activity in 1991, and particularly its extent, came as a much greater surprise than the decline in 1990, which many believe to have been a necessary accompaniment to the stabilization-cum-reform measures that were enacted in that year. While a full explanation of the decline is still lacking and is considered in more detail below, among its main proximate causes were clearly a greater-than-foreseen decline in exports to the CMEA area in the wake of disarray in the U.S.S.R., 3/ and the loss of much of the former GDR market following German unification; and a largely unanticipated shift in domestic demand toward imports. Several factors may have contributed to the latter, including: (i) the continued erosion of Poland's competitiveness, and a substantial increase in the purchasing power

1/ Under the Polish scheme, however, vouchers would not be convertible directly into shares in the enterprises; instead, recipients would lodge them with investment funds which would use them to bid for shares through a competitive auction.

2/ In fact, on a seasonally adjusted basis, industrial output in the second half of 1991 was below that in the first half of the year.

3/ See Rodrik (1992) for an attempt at quantification of the effect of the CMEA trade shock on Polish output.

of wages measured in foreign currency terms, consequent on the maintenance of a fixed exchange rate; (ii) an increase in demand for foreign inventory goods (following the considerable destocking of 1990), particularly for new private firms; and (iii) a lagged response to the liberalization of the trade and payments system that had taken place in 1990.

Weaker-than-expected activity had other ramifications. Enterprise profitability fell sharply at the beginning of the year (by about 50 percent) and continued to fall for much of the year. Apart from the decline in sales and the reversal of transitory accounting profits referred to above, the decline in profitability during 1991 may also have been related to a significant increase in unit labor costs--to which both the decline in productivity and a sharp increase in real product wages would have contributed--and to an increase in energy costs associated with the reform of CMEA trading arrangements. ^{1/}

The declines in output and enterprise profitability had a profound impact on the budget, where revenues were nearly 5 percent of GDP lower than originally envisaged and 11 percent of GDP lower than in 1990. ^{2/} Despite some very sharp expenditure cuts, the budget deficit for 1991 reached about 6 1/2 percent of GDP, or 6 percent more than projected under the program. To finance the deficit, credit to government increased sharply and, despite a much smaller than envisaged expansion in credit to nongovernment, the result was considerable overshooting of the program's inflation target--the

^{1/} Of course, the increase in energy costs makes the decision of Workers' Councils to grant substantial wage increases all the more inappropriate, and offers some insight not only into the decline in enterprise profitability, but also into the decline in investment in much of this sector, even while private consumption was buoyant.

^{2/} The decline in profitability also had implications for the solvency of the banking system. According to audits of seven state-owned banks conducted in mid-1991, 62 percent of outstanding loans were classified as substandard or worse. By mid-1991, provisioning needs had increased to 35 percent of the gross risk portfolio; fulfilling these provisioning needs would result in the seven commercial banks being insolvent in the aggregate.

through-the-year rate was 60 percent instead of 36 percent as originally envisaged--and a marked deterioration in the external accounts. 1/

Finally, as concerns the structural reforms, there was a significant scaling back of the mass privatization program, in part because of the recognition that the viability of many firms originally included in the list had been overestimated, but also because of a genuine shift in the direction of policy, towards more active involvement of the state in restructuring the large enterprises (industrial policy), and a reduced priority accorded to transferring ownership to the private sector. With the program of ownership change being pushed back, the anticipated supply response to improved market incentives would be delayed further.

3. The anatomy of the recession

This section looks in detail at the main features of the depression that Polish industry entered at the beginning of 1990. The reasons for focusing on industry, rather than on GDP as a whole, are first that the depression was really concentrated in the industrial sector, so that if we want to explain why GDP declined so much, we should direct our attention to industry, rather than agriculture--which was not much affected by the changes initiated in 1990--or private trade, which was booming for most of the period since 1990. Second, most of the explanations that have been advanced for the decline in output--such as the credit-crunch view, the deficient-demand view, and others--seem mostly relevant for the industrial sector, rather than at the whole of aggregate supply. Finally, one of the issues that we will wish to investigate below is whether, looking at a disaggregated level, there is any significant difference in the behavior of the various subsectors of industry, as would be the case in an economy undergoing structural change, or whether all sectors were similarly affected, as might be the case if a single common shock were driving output.

Chart 2 plots monthly data on output, employment, productivity, and real product wages for the industrial sector for the two-year period beginning in December 1989, i.e., the month prior to the initiation of the Polish stabilization program.

1/ The associated reserve loss contributed to a decision to devalue the zloty by 14 percent in mid-May. A decision was also taken at that time to peg the zloty to a basket rather than to the dollar. In mid-October, the authorities abandoned the fixed exchange rate altogether (which, apart from the May devaluation, had been in place for 19 some months), and moved to a crawling peg arrangement according to which the zloty is depreciated against the basket at a preannounced rate of 1.8 percent per month, or somewhat less than the underlying inflation rate. It is noteworthy that the move to a crawling peg in October was not preceded by a maxi-devaluation of the zloty, and hence did nothing to mitigate the effect on the real exchange rate of the three-to-fourfold increase in the Polish price level that had taken place since the beginning of 1990.

a. Output

As far as output is concerned, there is a very steep fall in January 1990, stagnation until midyear, followed by a recovery in the second half of 1990. ^{1/} At the beginning of 1991, there is another steep fall, a continuing downward trend until midyear, followed by a largely seasonal pickup in the closing months of 1991.

Within the industrial sector, and particularly within manufacturing (which makes up the bulk of industry), there are some interesting subsectoral differences. For example, the change in output in January 1990 ranged from minus 32 percent in electro-engineering to plus six percent in the metallurgical sector, with the average for manufacturing as a whole being minus 19 percent. Similarly, after 12 months, the average decline in manufacturing was 17 percent, and the range was from minus 34 percent in the chemicals sector to plus 4 percent in the food sector. After two years, the cumulative decline in manufacturing was about 33 percent, with the largest decline (52 percent) being recorded in the electro-engineering sector (which is heavily dependent on trade with the former-CMEA area) and with the food sector actually recording a small increase relative to its end-1989 level.^{2/}

b. Employment

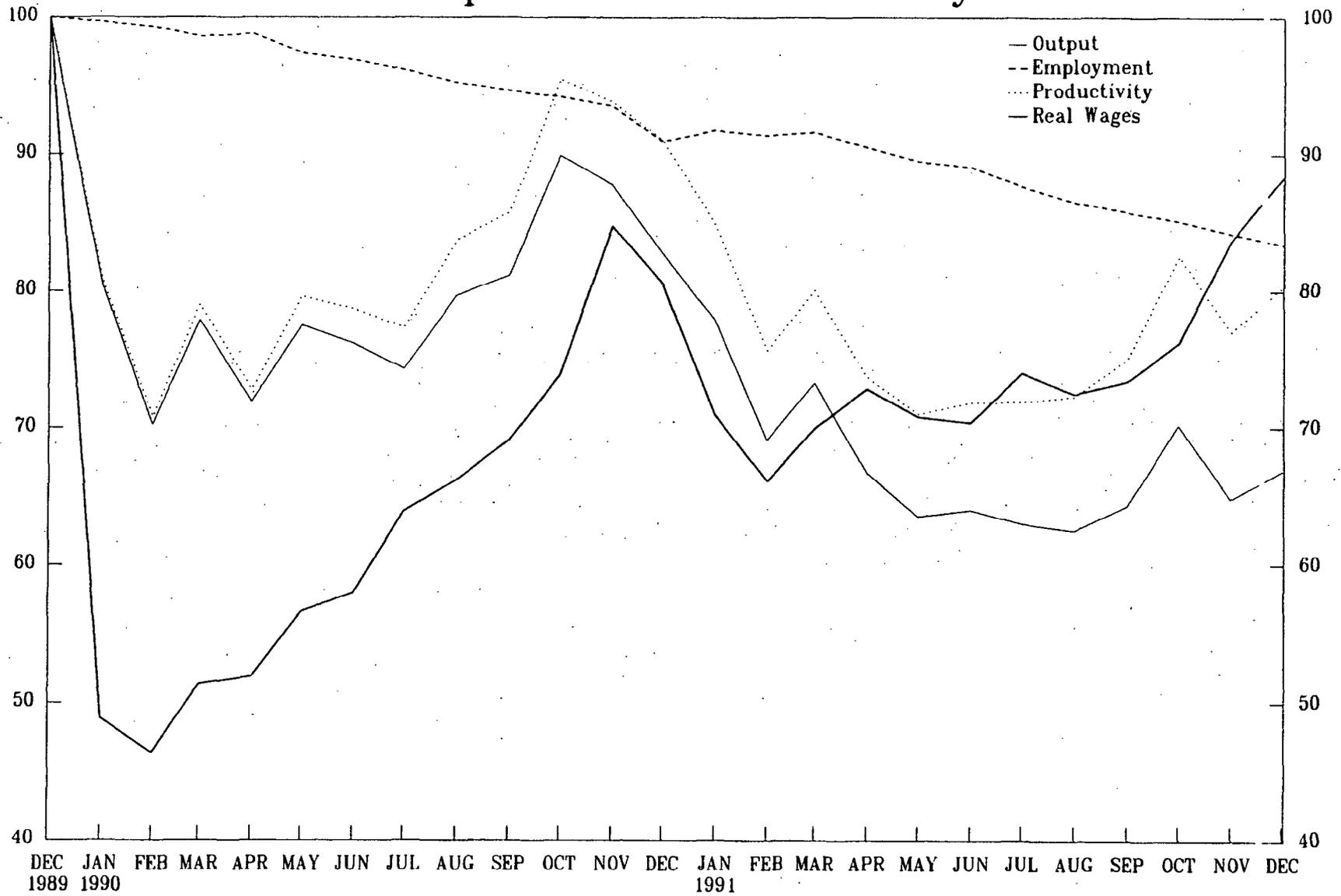
Given the extent of the decline in output, the very slow adjustment in employment is perhaps remarkable. While one would generally expect employment reduction to follow output reduction with some lag, the Polish data suggest that even after a period as long as two years, industrial employment has declined by only half as much as output. Moreover, the employment reduction has been very smooth, and there is little evidence for example that, following a large negative output shock, there is an accelerated effort to adjust the level of employment. Nevertheless, there is some correlation between the magnitudes of output and employment changes, with two of the three sectors recording the largest declines in output (electro-engineering and light industry) also recording the largest reductions in employment. There is also evidence that pressures to adjust the labor force are increased in enterprises with below-average profitability. ^{3/} Finally, the relatively slow adjustment of employment

^{1/} As mentioned earlier, the recovery was partly policy-induced. However, the seasonality of the Polish economy also is such that the second half of the year is generally up on the first half.

^{2/} While these differences may indicate the onset of a reallocation of resources across sectors, they may also simply reflect different sensitivities to business-cycle factors.

^{3/} Theoretically, of course, the correlation could go either way since low profitability might reflect lack of adjustment on the employment front. The data, however, seem to suggest that firms with subnormal profits have undertaken relatively more labor force adjustment.

Chart 2
 Developments in Total Industry



5.10a3-



to output changes may be taken as evidence of perceptions, on the part of enterprise managers, that the output decline is temporary. With adjustment costs, if managers feel that the output fall will be short-lived, they would reduce employment by only some fraction of the decline in sales. Obviously, if the output decline is viewed as temporary, it cannot at the same time be the result of structural change, which would presumably be viewed by managers as permanent.

c. Productivity

The counterpart to the relatively slow adjustment in employment has been a pronounced decline in productivity (output per worker) throughout manufacturing. While an initial decline might have been expected, it is interesting to note that labor productivity is actually lower after two years than it was at the end of the first year of the program. In the electro-engineering, wood and paper, and light industry sectors, which recorded the sharpest declines, productivity at the end of 1991 stood at about 60 percent of its end-1989 level, while the average decline in productivity for total industry over the past two years is nearly 20 percent.

d. Real product wages

As noted previously, real wage developments for 1990 as a whole were broadly in line with program targets. In order to compensate for (i) excessive (in light of productivity developments) real wage increases in the three years leading up to the program, and (ii) the removal of the subsidy implicit in sharply negative real interest rates at the end of 1989, a downward adjustment in real wages of about one third was thought necessary to maintain the viability of many state enterprises. 1/ In 1991, however, both real wage and productivity behavior have not been consistent with the maintenance of enterprise profitability, as is attested to by the latter's continuing decline through the year. 2/ Real product wages (excluding premia from profits) in industry have increased on average by about 18 percent in 1991 relative to their average level in 1990. 3/ Within manufacturing, the change in real product wages ranges from minus 5 percent

1/ It should be noted, however, that the decline in productivity in 1990 was considerably larger than originally envisaged so that unit labor costs in 1990 would, other things equal, have been higher than foreseen under the program. One might therefore wish to think of the actual real wage in 1990 as being an upper bound on the market clearing real wage.

2/ As discussed previously, the sharp decline in profitability at the beginning of 1991 had other causes as well.

3/ We focus on product wages here since the discussion is related to employment and enterprise profitability. The different behavior of real product wages and real consumption wages is due to the fact that, largely as a result of administered price changes, consumer prices rose much more quickly than industrial prices in 1991 (the opposite was true in 1990).

in the fuel and power sector to over 20 percent in the electro-engineering, wood and paper, and mineral sectors, and over 30 percent in the light industry and metallurgical sectors. 1/ In addition to the increase in real wages, productivity in industry has declined by an average of nearly 8 percent between 1991 and 1990, implying an increase in unit labor costs on the order of 25 percent over the same period. It would seem to follow therefore that, in addition to the shocks coming from the demand side (including the collapse in CMEA exports and the increase in import demand), and other supply-side factors (such as tight credit and energy price increases), an increase in wage costs may have played some role in accounting for the continuing decline in output in 1991. This is in sharp contrast to developments in 1990 when producers were able to increase prices much more quickly than wages, thereby offsetting the impact of cost pressures coming, inter alia, from higher input prices and the move to positive real interest rates. In 1991, both the change in CMEA trading arrangements, and the increase in labor costs, are consistent with a view of the output decline being partially related to the emergence of a significant price/cost squeeze for firms operating in the tradable goods sector. 2/

III. Empirical Findings

In this section we perform statistical analysis on monthly industrial production data disaggregated by branches, for the period since the initiation of reforms in Poland, in an attempt to shed some light on the relative importance of different exogenous factors in accounting for the decline in output. Because the initiation of market reforms is a relatively recent phenomenon, the amount of data at our disposal is relatively modest, essentially covering two years in the case of Poland. 3/ In the cross-sectional dimension, the sample covers about 20 industrial sectors.

1/ In sectors that benefited from trade under the "old" CMEA arrangements (for example, electro-engineering), a case could be made that the "equilibrium" product wage fell substantially between 1990 and 1991, owing to the negative terms of trade shocks experienced by such sectors. In this case, the increase in real product wages provides a (perhaps gross) lower bound of the magnitude by which real wage costs are currently out of line.

2/ An interesting parallel emerges here between Poland and Eastern Germany following unification. East German producer prices rose much more slowly than consumer prices (indeed they fell in some instances) in the period following unification, implying a much larger increase in product wages than in consumption wages, and the emergence of significant pressures in both labor and product markets. While Polish producer prices rose more quickly than consumer prices in 1990, alleviating pressures in labor and product markets, this trend was reversed in 1991, at which point significant parallels between the Polish and East German experience began to emerge. On the East German case, see Akerlof, Rose, and Yellen (1991).

3/ A change of methodology adopted by the Polish Statistical Office (GUS) at the beginning of 1992 also limited the sample size at our disposal.

Nonetheless, the variance of estimators will tend to be high, and the sample may be too short to capture the proper lag structure of the adjustment to the economic shocks. Subject to these caveats, however, there is still important information that can be extracted from the data, particularly if the shocks that have affected the Polish economy are relatively large, as they appear to have been.

Our empirical work deals with two questions that may contribute to the explanation of the output decline. First, we try to differentiate between structural change on the one hand (as evidenced by changes in the structure of the industrial sector over time), and macroeconomic or aggregate factors on the other, which arguably would tend to affect the various sectors in a similar fashion. Second, we try to assess the relative importance of demand-side and supply-side factors, by examining price-output correlations and by developing and estimating simple sectoral supply-demand models.

1. Structural versus macroeconomic factors

There is no doubt that the process of economic reform in the PCPEs must generate a reallocation of productive resources on a massive scale, and that such a process must already have begun as price and trade liberalization have exposed enterprises to domestic and foreign competition, and enterprise budget constraints have been "hardened" as automatic bank financing has dried up. But the true extent of structural change in the productive core of the Polish economy remains a matter of debate. Although public enterprises are no longer mere executors of the central plan in this transitional period, it is safe to say that they have not yet become fully profit-maximizing entities in the same way that their private counterparts are in a market economy. 1/

But why would structural change cause a fall in output rather than merely a shift in the composition of output? One reason is that an asymmetric response may be expected between those sectors that become unprofitable and must contract, and those that find increased opportunities for profitable expansion. On the one hand, enterprises might be forced to immediately stop loss-making production by limitations on their financial resources or by a complete disappearance of demand; on the other hand, a sizable expansion of production might require more time, particularly if it required significant increases in specialized factors of production. Moreover, public enterprises are unlikely to engage in substantial fixed investments in the highly uncertain environment of the transition phase, in

1/ For example, it is hard to reconcile the fact that enterprises paid wages above established norms and were penalized by excess wage taxes of several hundred percent--especially in view of the "softness" of the labor market--with purely profit-maximizing behavior. In 1991, excess wage taxes amounted to Zl 39 trillion (nearly 5 percent of GDP), with actual collections equal to Zl 27 trillion.

which ownership changes are contemplated and the potential new owners may wish to significantly alter business strategy.

In order to gauge the extent to which output developments have reflected a process of structural change rather than a response to some common macroeconomic disturbances, we apply the technique of principal components to sectoral industrial production and employment data. Principal components is a technique that finds (mutually orthogonal) linear combinations of a set of variables accounting for the largest proportion of the variability (sum of the variances) of those series. The first principal component accounts for the highest fraction of the variability of the series, the second for the second highest, and so forth. 1/ Naturally, there are as many principal components as there are series.

As far as the data on industrial production are concerned, the results in Table 1 show that the first few principal components account for a smaller proportion of the variability of the series in the Polish case than in the case of the benchmark country (the United States). The results are based on a sample of industrial production data from about twenty subsectors of industry in the case of Poland. The interpretation of the figures is that the higher is the fraction of the variability of the change in industrial production that is accounted for by each principal component, the smaller is the extent of structural change that has taken place within the industrial sector. In the limit, if one hundred percent of the variability of the change in output were explained by a single factor, output of all sectors would be proportional, and this would be interpreted as indicating that a single macroeconomic variable were responsible for most of the output decline and that virtually no structural change had taken place. 2/ To have a benchmark for comparison, we use data on production of subsectors of industry in the United States over the same period (1990-91), with a roughly similar level of disaggregation. 3/

1/ See, for example, Dhrymes (1978).

2/ Note that there are some ambiguities in the interpretation of the results. For example, if there were two or more independent macroeconomic factors that explained most of the variability of output, we would tend to interpret the results as indicative of structural change instead.

3/ In the computations leading to the results reported in Table 1, we use a sample of only two years for the United States, in order to make it more directly comparable to the Polish case. Changes in the sample do have a bearing on the results, however. When principal components are computed for US industrial production for the 1970-91 period, the fraction of variability explained by the first few principal components decreases by some 5-6 percentage points. This suggests that, at high frequencies, business cycle developments may exert a stronger influence and impose more uniformity across sectors, while at lower frequencies a somewhat higher degree of structural change is present.

Table 1. Poland: Cumulative Fraction of Variance Explained by Principal Components

Principal component	Log Differences of Output	
	Poland	U.S.A.
1	0.51135	0.74052
2	0.65373	0.84525
3	0.72740	0.90481
4	0.77971	0.93052
5	0.82843	0.95339
6	0.87247	0.96773
7	0.90860	0.97680
8	0.92673	0.98337

Principal component	Log Differences of Employment	
	Poland	U.S.A.
1	0.36421	0.30797
2	0.48550	0.47682
3	0.58305	0.58091
4	0.65851	0.67464
5	0.72038	0.74665
6	0.77353	0.80331
7	0.82040	0.85184
8	0.86051	0.89047

Thus, the results of the first panel of Table 1 indicate that the most important common macroeconomic factors are less capable of accounting for the behavior of output across the different industrial subsectors in Poland than in the United States. 1/ In isolation, this result would suggest that within the industrial sector, more structural change has taken place in Poland than takes place in the course of a (hopefully) standard business cycle in the benchmark country. Given the very large relative price changes that the Polish economy was subjected to, this result is at one level perhaps not very surprising. However, if one looks for additional supporting evidence for the structural change hypothesis, the case for structural change becomes harder to make. For example, if resources were really being shifted towards sectors with lower comparative costs, one would expect this to be reflected in the employment data. Unfortunately, as the second panel in Table 1 shows, these data do not suggest that employment across the various subsectors has been particularly variable, as one would expect if structural change were really taking place. 2/ Moreover, results of a multi-country study that attempted to decompose output developments into country-specific (that is, macroeconomic) and sector-specific factors found that the former was capable of explaining virtually all of the variability of output in all of the PCPEs considered (including Poland), thereby again casting some doubt on the structural change hypothesis. 3/ Finally, our attempts to correlate output changes with available measures of comparative costs do not suggest that the direction of resource shifts has been towards activities in which Poland has some comparative advantage.

This last finding is reported in Table 2, which examines the extent to which output changes can be predicted on the basis of estimates of comparative advantage. For this purpose we make use of two studies that compute domestic resource costs (DRCs) for Poland prior to price and trade liberalization. 4/ Domestic resource costs are defined as the ratio of value added at domestic prices to value added at international prices (that is, valuing products and inputs at their estimated domestic-currency equivalent to the world price). The lower the DRC, the more competitive a sector will be after price and trade liberalization because the price of its output will rise more than the cost of its inputs.

It should be noted at the outset that the estimates of DRCs are highly tentative because of the large number of judgmental assumptions necessary to value products at world prices, including problems arising from the existence of nontraded goods, substantial quality differences, and peculiar

1/ The data cover 21 industrial sectors for Poland and 16 for the United States.

2/ Specifically, the first few principal components account for a similar proportion of the variance of the employment series in Poland and in the United States.

3/ See Borensztein, Demekas, and Ostry (1992).

4/ See de la Calle (1990) and Hughes and Hare (1992).

Table 2. Poland: Output and Employment Changes and Comparative Advantage 1/

	DRC (1)	DRC (2)
Output changes	-0.17 (1.50)	-0.19 (0.77)
R ²	0.13	0.04
DW	2.35	1.95
Employment changes	-0.11 (1.43)	-0.22 (0.16)
R ²	0.12	0.11
DW	2.04	1.71

1/ Cross section regressions of overall change in output and prices on a constant and: (1) Inverse of domestic resource cost as calculated by de la Calle (1990) and (2) inverse of domestic resource cost as computed by Hughes and Hare (1992) Table 2. Figures in parenthesis correspond to t-statistics (in absolute value).

exchange rate arrangements in the CMEA area. 1/ At a more fundamental level, DRCs are based on the assumption of a fixed coefficient technology and do not consider the possibility of different elasticities of substitution across sectors. As is well known, energy was generally the most underpriced input in many of the PCPEs. This implies that, according to the DRC methodology, sectors with high energy intensity will appear to be the most uncompetitive. However, it might be that these sectors employed highly energy-intensive technologies because they had the highest elasticities of substitution between energy and other inputs (labor and capital). If this were the case, the DRCs would be misleading as far as providing a ranking of comparative advantage. Notwithstanding all these caveats, the DRC estimates are the only available measures of comparative advantage, and for this reason they cannot be overlooked.

To determine the extent to which output changes are correlated with this measure of comparative advantage, we ran regressions of the cumulative output change since the beginning of the reform program on (transformed) measures of DRC. The transformation is necessary because DRCs are not a monotonic measure: They are negative for those sectors that produce negative value added at world prices; when the DRC is positive, a higher DRC indicates a less competitive sector. To overcome this non-monotonicity, we applied the transformation suggested by Hare and Hughes (1992): for positive DRCs, we use the inverse of the DRC while for negative DRCs we use the ratio of value added at international prices to the domestic price.

The results presented in Table 2 do not provide much support for the structural change hypothesis since there is little evidence on the basis of the regressions that output is moving in the direction dictated by the available estimates of comparative advantage. 2/ As explained above, however, the construction of the DRC measures is subject to numerous pitfalls and the results may partly reflect the imperfections associated with this measure of competitiveness.

2. Supply and demand shifts

The issue of whether demand shocks or supply shocks have been predominant in accounting for the output decline is an important element in our understanding of developments in the early stages of reform in Poland. While it seems obvious that both types of shock have been present, it is not clear which has exerted the largest influence. The tight financial policies pursued in order to ensure domestic stabilization and a satisfactory balance of payments position on the one hand, and the exogenous component of the drop in export demand from other former CMEA countries on the other,

1/ It should be mentioned that, for some sectors, the coverage in the Hughes and Hare study is more disaggregated. For comparability, in those cases (3 out of 17), a simple average was used to aggregate the data.

2/ Our transformation of the DRC is such that the higher is the measure, the more competitive is the sector.

certainly had a restraining effect on aggregate demand. But the increase in a number of administered prices--notably for energy--and liquidity restrictions affecting enterprises is also likely to have had a negative impact on aggregate supply. 1/

It is important to note that the demand-shock versus supply-shock question is not entirely the same as the structural-change versus macroeconomic-recession question. Although business cycle fluctuations have traditionally been associated with aggregate demand shocks, and supply shocks have frequently been taken to indicate a reallocation of resources, this interpretation may not always be valid, particularly in the circumstances of Poland. For example, a drop in demand may be the result of increased import competition, which reflects only structural change. Or a contraction in supply may be caused by a credit squeeze on enterprises, clearly a macroeconomic shock.

a. Price-output correlations

The correlation between price and output changes is, in principle, a good summary indicator of the predominance of supply or demand shifts. In any given market, a positive correlation between price and output changes would indicate that demand shifts were relatively more important than supply shifts. Similarly, the sign of the correlation between price and output changes in a cross-section of industrial sectors would indicate whether demand or supply shifts have been predominant in the economy.

The (cross-sectional) quarterly price-output correlations suggest that demand shocks were relatively more important in the first halves of both 1990 and 1991 (when the correlations are positive), while supply shocks predominated in the second halves of these two years (Table 3). One interpretation may be that fiscal, monetary, and incomes policies were all very tight in the first half of 1990, but were eased later in that year, and, to some extent, this pattern was repeated again in 1991. An alternative interpretation, and one that receives some support from the regression results reported in the next subsection, is that although supply shocks (in the form of large administered energy price increases) were indeed prevalent at the beginning of both 1990 and 1991 (and would, other things being equal, result in a negative correlation between price and output, contrary to what is actually observed in the data), the relative inelasticity of demand for various industrial goods implies that the impact

1/ It is far from obvious that an increase in administered energy prices would contribute to an aggregate output decline in the case of perfect markets and costless substitution among factors. However, as shown in the appendix, it is straightforward to develop an example of an economy with irreversible investment, in which such price increases can indeed lead to short-run declines in output.

Table 3. Poland: Correlation Between Quarterly Price and Output Changes

	Industrial Output Growth	Industrial Price Increase	Y-P Correlation
1990:1	-0.27137	0.80140	0.08567
1990:2	-0.01364	0.05810	0.20954
1990:3	0.04082	0.07252	-0.56320
1990:4	0.10263	0.10966	-0.29421
1991:1	-0.16723	0.16657	0.30667
1991:2	-0.12610	0.03838	0.08451
1991:3	-0.02291	0.06366	-0.08214
1991:4	0.06180	0.05220	-0.15669

of such supply shocks on the correlation between price and output will be relatively small. 1/

b. A simple supply and demand model

Price-output correlations are an imperfect indicator of the extent of supply and demand shifts. For example, as mentioned previously, the sign and magnitude of such correlations are influenced not only by the size of the shocks affecting demand and supply, but also by the price elasticities of the underlying supply and demand functions. To better assess the relative importance of supply and demand shocks, estimation of a simple structural supply-demand model for each of the industrial subsectors would seem to be advisable.

In the contemplated framework, demand in sector i is given by

$$(1) \log D_t^i = \alpha_0^i + \alpha_1^i \log P_t^i + \alpha_2^i \log Y_t$$

where P^i denotes a (relative) price index for sector i and Y is a scale variable that proxies aggregate spending (on a monthly basis). 2/ Supply in sector i is given by

$$(2) \log S_t^i = \beta_0^i + \beta_1^i \log P_t^i + \beta_2^i \log w_t^i + \beta_3^i \log P_t^E + \beta_4^i \log C_{t-1}$$

where w^i is the real wage, P^E is an index of the price of energy input and C is the real stock of bank credit to enterprises. That is, supply is a function of the price of the product and of the cost of the relevant inputs (labor and energy). All of these prices and the stock of credit are deflated by the overall industrial price index. We also incorporate the stock of bank credits to enterprises in real terms in order to proxy for the possible effect of an overall liquidity constraint that might have been relevant during this period (as argued by Calvo and Corricelli (1992)). 3/

Equations (1) and (2) were estimated using three stage least squares--with the price of the product treated as an endogenous variable--for seven industrial subsectors. As can be seen from Table 4, the results are encouraging, since the vast majority of the coefficients have their

1/ Of course, for the correlation to be positive as observed, demand curve shifts would have to be relatively large in the case of a highly inelastic demand curve.

2/ We use aggregate industrial production for all sectors except food (the demand for which is likely to come from final consumers rather than firms) where total household consumption spending is used. It should be noted that, from the point of view of each of the individual subsectors, aggregate industrial production is effectively exogenous.

3/ In their model, credit may be viewed as an input, like labor and energy, into the production process.

Table 4. Poland: Demand and Supply Estimation Results 1/

	Metallurgy	Electro- Engineering	Chemical	Wood & Paper	Light Industry	Food	Mineral Industry
DEMAND							
Constant	-1.42 (1.42)	-3.82 (4.87)	-1.15 (4.54)	0.13 (0.23)	-3.49 (6.06)	5.94 (36.41)	-0.45 (0.38)
Relative price	0.04 (0.29)	-0.09 (0.57)	-0.09 (2.23)	-0.42 (3.39)	-0.34 (1.88)	-0.07 (0.69)	-0.16 (1.01)
Aggregate spending	1.29 (5.83)	1.74 (9.95)	1.15 (20.48)	0.90 (7.06)	1.66 (13.37)	0.52 (7.96)	0.91 (4.07)
R-squared	0.60	0.81	0.95	0.74	0.88	0.78	0.43
Durbin-Watson	0.63	0.87	1.54	0.74	1.43	1.66	0.73
SUPPLY							
Constant	1.28 (1.08)	3.74 (2.58)	-5.74 (1.13)	-3.36 (0.54)	2.60 (3.85)	3.94 (12.34)	-28.67 (0.16)
Relative price	1.84 (4.00)	4.53 (2.41)	9.51 (1.91)	7.53 (1.21)	4.25 (4.45)	1.75 (3.70)	24.90 (0.19)
Real credit (-1)	0.78 (2.50)	1.70 (1.31)	4.56 (1.85)	4.14 (1.16)	1.12 (2.30)	0.03 (0.17)	9.90 (0.18)
Coal price	-1.10 (4.78)	-2.37 (2.49)	-5.37 (1.98)	-3.61 (1.29)	-1.37 (4.75)	-0.51 (2.68)	-12.90 (0.19)
Real wage (-1)	-0.16 (1.10)	-1.85 (1.36)	3.23 (1.71)	-3.02 (1.07)	-0.61 (1.04)	0.26 (1.19)	-3.51 (0.18)
R-squared	0.61	0.48	0.12	0.06	0.41	0.57	0.20
Durbin-Watson	0.83	0.49	0.77	1.26	0.66	1.11	0.57

1/ Estimation is by Three Stage Least Squares; sample period is 1989:12-1991:12; numbers in parenthesis below estimated coefficients are t-statistics (in absolute value).

theoretically-predicted signs. ^{1/} However, the relative price variable in the demand function and the (lagged) product wage variable in the supply function do not perform very well. As far as the former is concerned, the price elasticity of demand is usually estimated to be fairly small, with most of the estimated elasticities falling between 0.1 and 0.3. There are two possible interpretations of this result. One is that the demand functions are in fact highly inelastic. The other interpretation is that the demand equation is not well identified by the set of instrumental variables used in the estimation. As far as the finding that product wages do not seem to have played a substantial role over the estimation period is concerned, this may partly reflect the fact that firms did not believe that the very low real wages at the beginning of the program would be sustained. In this case, real product wages would underestimate the effective cost of labor over the relevant time horizon of firms and, therefore, firms would have been less likely to expand output on the basis of the very low wages at the beginning of the program, particularly if employment changes carried significant costs of adjustment.

As mentioned previously, and notwithstanding these two shortcomings of the estimation, the model produces on the whole reasonable parameter estimates. As far as the supply regression is concerned, the results suggest that energy price increases were a significant determinant of output developments in five of the seven sectors, while the real credit variable turns out to be significant in three of seven cases.

Using the above estimates, it is possible to decompose the total decline in output into a fraction caused by shifts in variables that affect the supply function and a fraction caused by shifts in variables that affect the demand function. Since the fit of the regressions is not perfect, there is a remainder, which is explained by the random disturbances, and which cannot in general be allocated because the disturbances to the demand and supply equations are not independent. The output change in sector i caused by changes in the exogenous demand-side variables can be computed as

$$(3) \quad \Delta \log Q_{DS}^i = [\beta_1^i / (\beta_1^i - \alpha_1^i)] (\alpha_2^i \Delta \log Y),$$

where the operator Δ indicates the cumulative change in the variable. Similarly, the change due to supply-side shifts is

$$(4) \quad \Delta \log Q_{SS}^i = [\alpha_1^i / (\alpha_1^i - \beta_1^i)] [\beta_2^i \Delta \log w^i + \beta_3^i \Delta \log P^E + \beta_4^i \Delta \log C].$$

Both the horizontal shifts in supply and demand functions (that is, evaluated at a constant price) as well as the equilibrium change in output due to those shifts (as given in equations (3) and (4)) were computed. We used the median value of the estimated coefficients and we estimated the shifts for the first quarter of the reform program in Poland (first quarter

^{1/} In roughly 40 percent of the cases, however, the standard errors are large relative to the estimated coefficients.

of 1990), for the first half of 1990, and for the full years 1990 and 1991 (relative to levels at the end of 1989 and 1990, respectively). ^{1/} The results indicate very large supply shifts in the first quarter of 1990, but more moderate supply shifts over the rest of the period. Because our median estimate of the demand function is essentially completely inelastic, shifts in supply generate increases in price but little decline in output, as can be seen from the column identifying the change in output due to supply-side shifts in Table 5. However, as mentioned above, the inelasticity of demand functions may not be a robust finding.

It should be noted that, since the demand and supply shifts are not independent, there is no clear way of fully decomposing their effects. This is because, for example, an exogenous change in the price of energy may have some effect on aggregate demand, and thus would show up as both a demand-side and supply-side shock. However, to the extent that the dependence between demand and supply shocks is characterized by a longer lag structure, the decomposition that we perform would still give reasonable results for short periods.

IV. Conclusions

This paper has sought to address two fundamental questions relating to the output decline in Poland in the two-year period since the initiation of market-oriented reforms at the beginning of 1990. First, to what extent was the decline in output simply a reflection of the short-run response to the new relative price structure which called for a reallocation of resources across sectors? Second, to the extent that macroeconomic forces played a role, were demand-side shocks or supply-side disturbances relatively more important?

After characterizing the salient features of output developments in Poland as well as the main elements of the economic program undertaken by the Polish Government, the paper turned to an analysis of the first question, namely the relative importance of structural versus macroeconomic factors in the output decline. We applied principal components analysis to output and employment data from Poland's industrial sector. As concerns the output data, we found that, relative to the benchmark country (the United States), the first few principal components of the output series accounted for a somewhat lower fraction of the variability of these series, thus tending to lend some support to the view that structural change had at least begun to take place within Poland's industrial sector. We were skeptical, however, about pushing this conclusion too hard, because other data, notably on employment, failed to support the structural change hypothesis. In addition, attempts to correlate the sectoral output changes with available

^{1/} In interpreting the results, it should be borne in mind that Poland experienced a relative recovery in the second half of 1990.

Table 5. Poland: Decomposition of Output Decline

	Total change	Supply shift	Supply-side change	Demand shift	Demand-side change	Error terms
1990Q1	-0.247	-0.846	-0.039	-0.251	-0.246	0.040
1990H1	-0.263	-0.736	-0.028	-0.269	-0.264	0.030
1990	-0.199	-0.771	-0.031	-0.197	-0.193	0.024
1991	-0.185	-0.303	-0.008	-0.217	-0.213	0.044

estimates of comparative advantage for Poland failed to produce significant results. These findings suggested, therefore, that there is little tendency for resources to be shifting towards sectors with lower comparative costs, as the structural change hypothesis would seem to imply. Moreover, the finding of relatively little structural change is consistent with that of a multi-country study of PCPEs that attempted to decompose output changes in the region into macroeconomic and sector-specific factors (Borensztein, Demekas, and Ostry (1992)). The finding of that study indicated that virtually all of the explained variance in output was related to macroeconomic rather than to sector-specific factors, and was thus consistent with the view that not much structural change had as yet taken place within the industrial sectors of these countries, including Poland.

As far as our supply-side question is concerned, the price-output correlations undertaken above revealed that the prevalence of demand and supply shocks seemed to vary considerably over time. This might reflect the relative tightness of macroeconomic policies in the different periods, since periods of relative tightness were also found to be periods in which demand disturbances seemed to predominate. In addition, our estimates of a simple supply-demand model for seven industrial sub-sectors was able to shed some light on the relative importance of various macroeconomic factors in accounting for the output decline, including energy price increases associated with subsidy reductions, and credit and wage developments. The estimates suggested that supply-side factors (including increases in energy prices and credit conditions) were prominent in reducing aggregate supply, although their ultimate effect on output was not as large as one might have thought, owing mainly to the fact that demand for industrial products in Poland appears to be relatively price-inelastic.

Response of Output to Energy Price Increases under
Investment Irreversibility

The purpose of this appendix is to examine the response of output to increases in energy prices when investment decisions may be irreversible. Accordingly, let us assume that production requires two inputs: energy and fixed capital. The profit function of a representative firm can be written as

$$(A1) \quad \Pi(\bar{K}, P, P^E) = P f(\bar{K}, E) - P^E E,$$

where \bar{K} is the initially existing stock of capital, P is the price of output, P^E is the price of the energy input, and E is the quantity of energy used in production. The production function $f(\cdot)$ has the standard properties so that, using the first order condition

$$(A2) \quad f_E = \frac{P^E}{P} = p^E,$$

one can write production as $f(\bar{K}, p^E)$. Let p_L^E be the existing price of energy, where the subscript L stands for "low". Now, let us assume that another technology is available to the firm which can completely substitute capital for energy by undertaking an investment in the amount I :

$$(A3) \quad F(\bar{K}+I) = f(\bar{K}, p_L^E).$$

Firms do not undertake this investment project at $p^E = p_L^E$ because it is not profitable to do so, namely:

$$(A4) \quad -I + PV(\Pi(\bar{K}+I)) < PV(\Pi(\bar{K}, p_L^E)),$$

where the notation $PV(X)$ denotes the present value of a variable that is permanently fixed at a value of X .

Now suppose that the (relative) price of energy were to increase to a level p_H^E , and suppose further that the investment project would be profitable if the price of energy were to remain fixed at this higher level:

$$(A5) \quad (-I + PV\{\Pi(\bar{K}+I)\}) > PV\{\Pi(\bar{K}, p_H^E)\}.$$

In this (perfect-certainty) case, firms "restructure" at once, capital substitutes for energy, and output remains fixed.

Now suppose that the authorities increase the price of energy to p_H^E in period 1, but that there is some uncertainty regarding future policy. Specifically, assume that with probability q the higher energy price will be maintained forever, and with probability $1-q$ the price increase will be

reversed (so that p_L^E will prevail in period 2 and thereafter). It turns out that this near-term resolution of uncertainty greatly increases the option value of waiting to invest.

Will firms restructure in this case? Let us assume that the application of a simple expected present value rule would say yes, so that:

$$(A6) \quad -I + PV\{\Pi(\bar{K}+I)\} > \Pi(\bar{K}, p_H^E) + \frac{1}{1+r} \left(qPV\{\Pi(\bar{K}, p_H^E)\} + (1-q) PV\{\Pi(\bar{K}, p_L^E)\} \right),$$

which is possible given inequalities (A4) and (A5). However, this criterion is not the relevant one in this case because it neglects the option value of waiting. That is, the strategy of investing in period 1 also has to be compared with the strategy of waiting and investing in period 2. The latter strategy yields the following return: 1/

$$(A7) \quad \Pi(\bar{K}, p_H^E) + \frac{1}{1+r} \left(q(-I + PV\{\Pi(\bar{K}+I)\}) + (1-q) PV\{\Pi(\bar{K}, p_L^E)\} \right).$$

It is clear that the waiting strategy has a higher expected payoff from period 2 onwards. It has the same payoff if higher energy prices are not reversed (with probability $1-q$), and also a higher payoff if policy is reversed (with probability q). The waiting strategy, however, uses the "wrong" technology in period 1, when energy prices are high. Nevertheless, the waiting strategy is likely to have a higher payoff overall because it is superior in all but one period if policy is reversed.

A numerical example can establish at least this possibility. Let

$$(A8) \quad \begin{aligned} -I + PV\{\Pi(\bar{K}+I)\} &= 100; \quad PV\{\Pi(\bar{K}, p_L^E)\} = 150; \\ PV\{\Pi(\bar{K}, p_H^E)\} &= 50; \quad q = 0.8; \quad \text{and } r = 0.1. \end{aligned}$$

Then, the returns to each strategy are:

$$\text{Don't Restructure} = 5 + \frac{1}{1.1} \left[\frac{4}{5} 50 + \frac{1}{5} 150 \right] = 68.5;$$

Restructure = 100; and

$$\begin{aligned} \text{Wait and Restructure} \\ \text{if policy is not reversed} &= 5 + \frac{1}{1.1} \left[\frac{4}{5} 100 + \frac{1}{5} 150 \right] = 105. \end{aligned}$$

Clearly, under this example, firms will wait until period 2 to restructure (if policy is not reversed) and output in period 1 will fall because $f(K, p_H^E) < f(K, p_L^E)$.

1/ Because of the resolution of uncertainty, this is the only relevant alternative.

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