

Industrial shut-downs and medium-run factor intensity reversals

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Abstract. While short-run factor intensity reversals lead to industrial shut-downs when there are two productive factors, this paper shows that an industry can undo an intensity reversal over the medium run and avoid shutting down when there are three or more factors. Medium-run adjustment begins with a capital fixed input and extends until it has become perfectly mobile. Neary (1978) develops a picture of adjustment with two industries and two inputs where an industry must shut down following an intensity reversal. The present study adds a third input – skilled labour or natural resources – to capital and labour.

Fermetures d'usines et renversements de l'intensité d'utilisation des facteurs de production à moyen terme. Le renversement de l'intensité de l'utilisation des facteurs de production à court terme entraîne des fermetures d'usines quand il y a deux facteurs de production. Ce mémoire montre que quand il y a trois facteurs de production ou plus, une industrie peut renverser ce renversement d'intensité d'utilisation des facteurs de production à moyen terme et éviter les fermetures d'usines. L'ajustement à moyen terme commence avec un intrant de capital fixe et se poursuit jusqu'à ce qu'il soit devenu parfaitement mobile. Neary (1978) donne une image de ce processus d'ajustement où une industrie doit fermer suite à un renversement d'intensité d'utilisation des facteurs de production dans le cas où il y a deux industries et deux intrants. Ce mémoire ajoute un troisième intrant – ressource naturelle ou travail spécialisé – aux deux intrants de base, le travail et le capital.

1. INTRODUCTION

Factors of production move freely between sectors of an economy to eliminate payment differences in the long run. In the short run, capital is a fixed input. An industry suffering a fall in its relative price can reduce output right away by laying off inputs other than capital. If there are two inputs and a labour-intensive industry

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lays off enough labour to become capital intensive. Neary (1978) shows that it will eventually shut down.

The present study adds another input, skilled labour or natural resources, which like labour is mobile between sectors in the short run. An industry experiencing a short-run factor intensity reversal can run a double reverse, return to its original factor intensity, and continue production indefinitely. Short-run factor intensity reversals are not necessarily fatal, which is typical in this adjustment process when there is more than a single mobile input.

II. THE TWO-INPUT MODEL

Consider Neary's diagram of a two-factor economy in figure 1. Industry X is capital intensive, as reflected by the contract curve. In terms of factor inputs,

$$a_{KX}/a_{KY} > a_{LX}/a_{LY} \quad (1)$$

for any combination of factor payments. Values of labour's marginal product in either sector are labelled V_X and V_Y . Labour freely migrates between sectors so the wage rate w is uniform. The initial equilibrium is represented by A_0 and B_0 .

Prices are assumed to be exogenous, the small-country assumption in international trade. A one-time, ceteris paribus increase in the price of capital intensive good X , due perhaps to a tariff, causes V_X to shift right. Labour migrates to industry X in response to the induced higher wage. Capital cannot flow between sectors in the short run, so equilibrium is reached at A_1 and B_1 . With B_1 off the contract curve, the ratio of wages to rents is greater in sector Y :

$$w/r_Y > w/r_X. \quad (2)$$

Capital in sector X enjoys increased marginal productivity with the labour inflow, while the opposite is true in sector Y . Payment to capital increases in sector X where price has risen, and falls in the other sector Y .

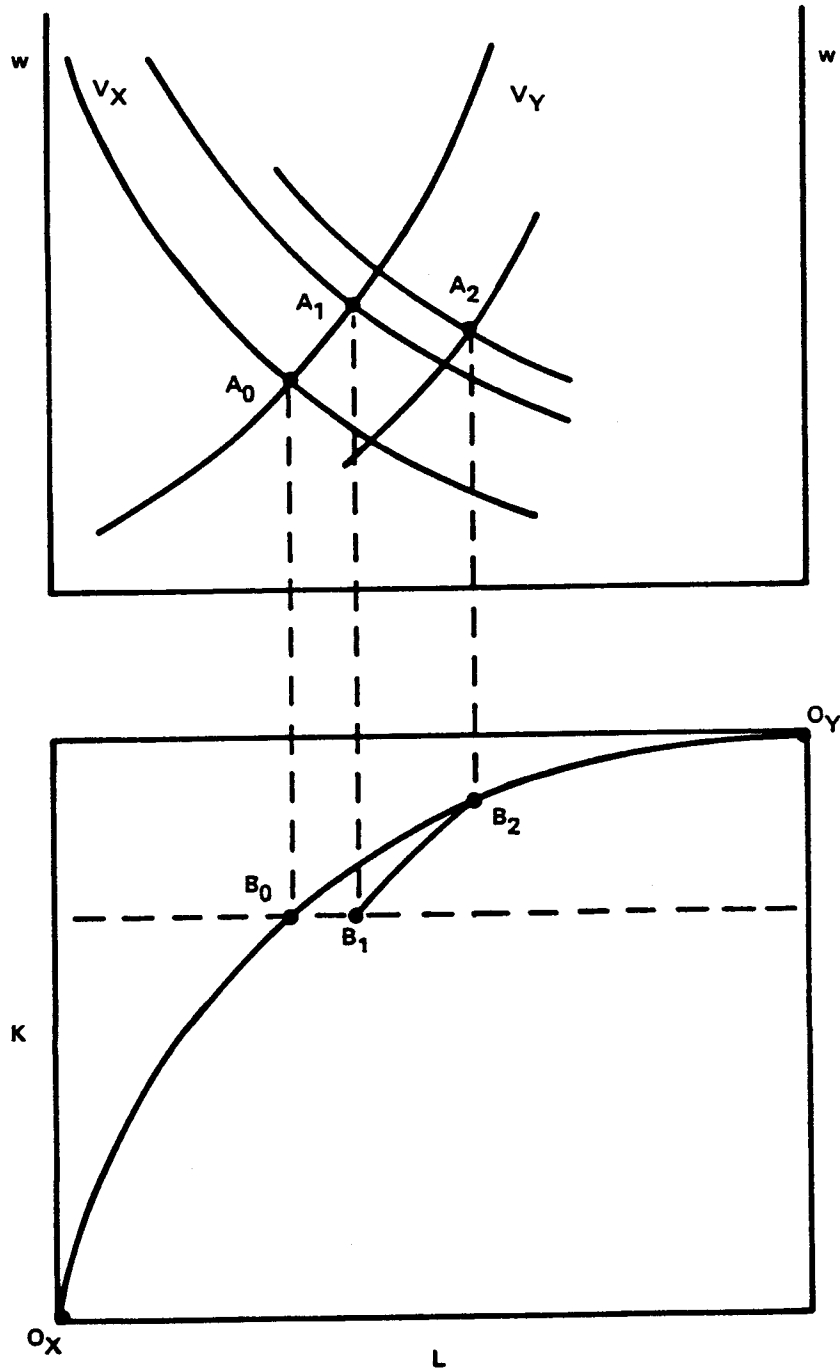
Medium-run adjustment will involve movement of capital to sector X . As a result of this capital movement, marginal productivity of labour rises in sector X and falls in sector Y . Sector X must acquire labour along with capital during the medium run. Since sector Y remains labour intensive, excess supply of labour occurs and wages fall.

Two well-known equations of change reflect this adjustment process, where a hat represents percentage change:

$$\hat{p}_j = \Theta_{Lj}\hat{w} + \Theta_{Kj}\hat{r}_j, \quad j = X, Y. \quad (3)$$

These are derived from conditions of competitive pricing. The p s represent prices of goods and the Θ s distributive factor shares.

During the medium run, prices are constant: $\hat{p}_j = 0$. Since $\hat{w} < 0$, each \hat{r}_j must be positive. The rise in V_X must more than offset the increased supply of capital in



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sector X . Firms switch towards labour as w/r_j falls, with the K/L ratio falling in each sector. This means the new long-run equilibrium must lie along the contract curve to the northeast of the ray from O_X through B_1 .

The medium-run adjustment path runs from B_1 up toward the contract curve, reflecting a falling K/L as it goes. Adjustment moves the economy to a long-run equilibrium illustrated by A_2 and B_2 . The price of capital rises and wages fall in the long run, owing to the higher relative price of the capital-intensive good, Stolper-Samuelson result.

Suppose the lower relative price for good Y causes its production to become capital intensive. With this factor intensity reversal, point B_1 lies across the diagonal. Labour-intensive sector X begins expansion in the medium run. Excess demand for labour occurs and wages rise. Since $\hat{w} > 0$, each \hat{r}_j in (3) must be negative, meaning firms in each sector switch towards capital. The new long-run equilibrium must lie above the ray from O_X through B_1 . If the adjustment path does not cross the diagonal, industry Y shuts down. If it does cross the diagonal, industry X becomes capital intensive, excess supply of labour develops, and K/L falls. The path must then move the economy up the diagonal until industry Y shuts down. In the two-factor model, factor intensity reversals lead to industrial shutdowns.

III. THE THREE-INPUT MODEL

There is ample motivation for expanding the theoretical foundation to include the additional productive input: Griliches (1969) and Hamermesh and Grant (1979) argue that skilled labour is a distinct input; Branson and Monoyios (1977) and others suggest that patterns of international trade involve the input of human capital; numerous studies conclude that energy should be treated as a distinct input. Ruffin (1981), Takayama (1982), Jones and Easton (1983), and Thompson (1985) investigate the theory of production with three factors.

Suppose that skilled labour or natural resources labelled S is employed in each sector along with labour and capital. The production box becomes three dimensional. The factor intensity condition

$$a_{KX}/a_{KY} > a_{LX}/a_{LY} > a_{SX}/a_{SY} \quad (4)$$

is postulated for any set of factor payments. The middle factor, labour, lies between capital (the extreme input in sector X) and skilled labour (the extreme input in sector Y). Figure 2 shows the tetrahedral portion of the production box defined by this factor intensity. There are six regions of factor intensity in the production box. Factor payments along the contract curve in figure 2 are determined by supporting isocost planes tangent to isoquant dishes for goods X and Y .

With a *ceteris paribus* increase in the price of good X , short-run adjustment must take place in the slice of figure 2 through K_0 , the original employment of capital. This triangular slice is pictured in figure 3, where B_0 is the point the contract curve intersects. Production of good X rises in the short run as the economy moves to

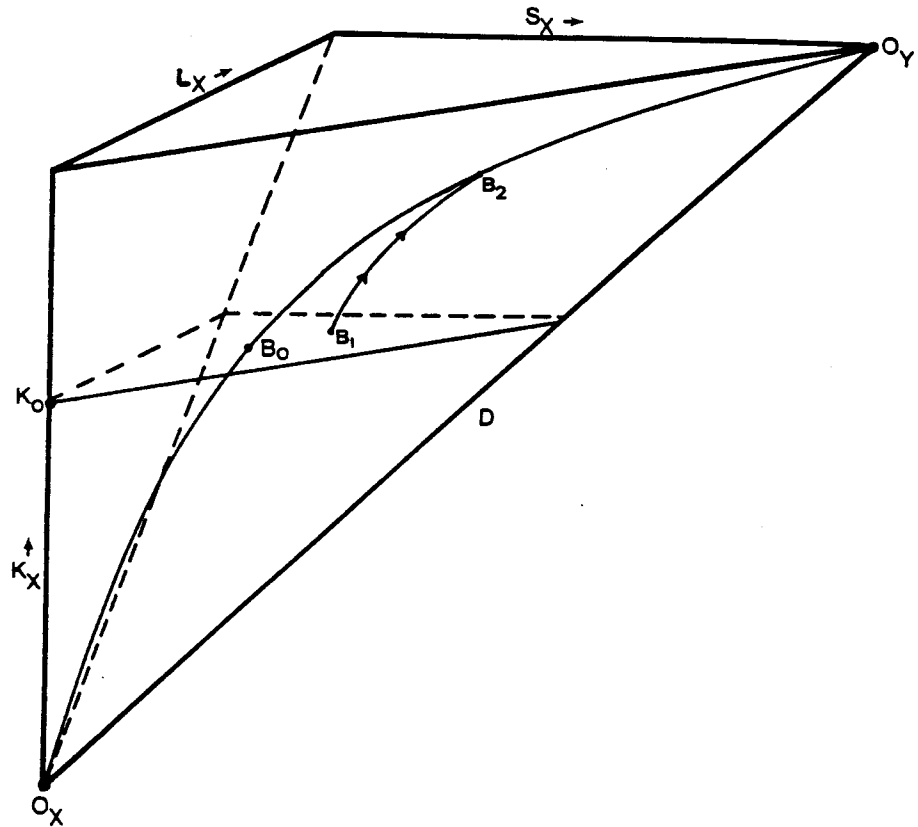


FIGURE 2

a higher isoquant. Adjustment into the shaded area is ruled out, since employment of one of the freely mobile inputs must increase in expanding sector *X*.

If the economy moves into region *A*, excess supplies of both mobile inputs develop, since sector *Y* uses them intensively relative to capital. Expanding on (3), the three-factor model's equations of change are

$$\hat{p}_j = \Theta_{Lj}\hat{w} + \Theta_{Sj}\hat{s} + \Theta_{Kj}\hat{r}_j, \quad j = X, Y. \quad (5)$$

Excess supplies mean $\hat{w} < 0$ and $\hat{s} < 0$. In region *A* with $\hat{p}_X > 0$ and $\hat{p}_Y = 0$, it follows that $\hat{r}_X > 0$ and $\hat{r}_Y > 0$. This is completely analogous with Neary's two-input model. In region *B*, expanding industry *X* sheds unskilled labour but adds skilled labour. An excess supply of labour occurs as in region *A*, but there is excess demand for skilled labour. This could understandably occur if capital and skilled labour were complements. Then $\hat{w} < 0$ and $\hat{s} > 0$, which means \hat{r}_X or \hat{r}_Y could be negative in the short run. By similar reasoning, $\hat{w} > 0$ and $\hat{s} < 0$ in region *C*.

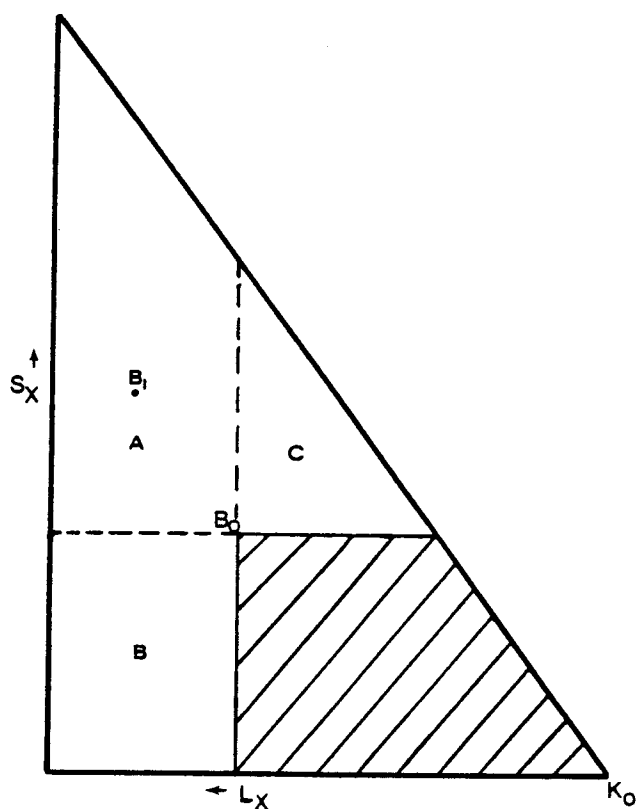


FIGURE 3

It may seem surprising that a higher price can lead to a falling price for the capital specific to that sector. To illustrate, picture the triangular unit isocost surface with three inputs. An increase in p_X causes its unit value isoquant to all towards the origin, so the isocost triangle must fall with at least one factor payment (w , s , or r_X) rising. Clearly, r_X could fall as the isocost surface flattens. This result is developed more formally in Thompson (1988).

Assume the short-run movement to B_1 in region A of figures 2 and 3. Medium-run adjustment can take the economy back to the contract curve and a point analogous to B_2 in figure 2. Capital then moves into sector X, raising the marginal productivity of the other inputs and attracting them to the capital intensive sector. Excess supplies of labour and skilled labour develop with w and s falling as the r_j s rise. With lower payment ratios w/r_j and s/r_j , input ratios K/L and K/S fall. The medium-run adjustment path lies below the K/L and K/S planes through B_1 in figure 2. The K/L plane intersects the S axis and B_1 , capturing all points with

the same K/L ratio as B_1 . The K/S plane intersects the L axis and B_1 , capturing all points with the same K/S ratio as B_1 .

If the initial increase in p_X is large enough to cause a factor intensity reversal, the point corresponding to B_1 lies outside the triangle of figure 3. With input ratios K/L and K/S falling, the economy sees sector Y shut down as in the two factor case. The falling K/L ratio pushes the economy west of figure 3, while the falling K/S ratio pushes it north. The economy does not return to the region of figure 2 or the contract curve. This result is again completely analogous with the two-input model.

Medium-run adjustment may, however, involve rising w/r or s/r ratios. Suppose that capital and skilled labour are complementary and short-run adjustment takes the economy into region B of figure 3. The expanding sector X uses a lower ratio of skilled to unskilled labour than the contracting sector Y , creating an excess supply of skilled labour and a falling factor price s in the short run. Marginal productivity of capital in sector X falls as skilled labour is released. Sector X substitutes labour for the complementary pair, capital and skilled labour. Marginal productivity of capital in sector Y falls as labour departs, so $\hat{r}_X > \hat{r}_Y$. Medium-run movement of capital into sector X occurs. Skilled labour is attracted to sector X as well by a rising price s . Firms in the expanding sector X substitute capital and skilled labour for labour, with the wage w falling from its high level back in the short run. The input ratio K/L rises as K/S falls, which means the adjustment path must lie above the K/L plane through the short-run point in region B .

Suppose the increase in p_X is drastic enough to create a factor intensity reversal, industry Y laying off so much labour that it becomes capital intensive:

$$a_{LX}/a_{LY} > a_{KX}/a_{KY} > a_{SX}/a_{SY}. \quad (6)$$

The economy moves to the west of figure 3 or behind figure 2. Medium-run adjustment brings the economy back into figure 2 if K/L rises enough. The economy can return to a point along the contract curve, undoing the factor intensity reversal. When there is more than a single mobile input in the short run, factor intensity reversals do not necessarily lead to industrial shut-downs.

IV. CONCLUSION

The basic lesson of this three-factor model is that short-run factor intensity reversals need not lead to complete specialization. Such intensity reversals must regularly occur, especially at high levels of disaggregation. A relevant historical exercise would be to determine how frequently industries that experience factor intensity reversals actually shut down in the long run. The more shut-downs are avoided, the stronger would be the evidence that there must be various inputs that are mobile in the short run.

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