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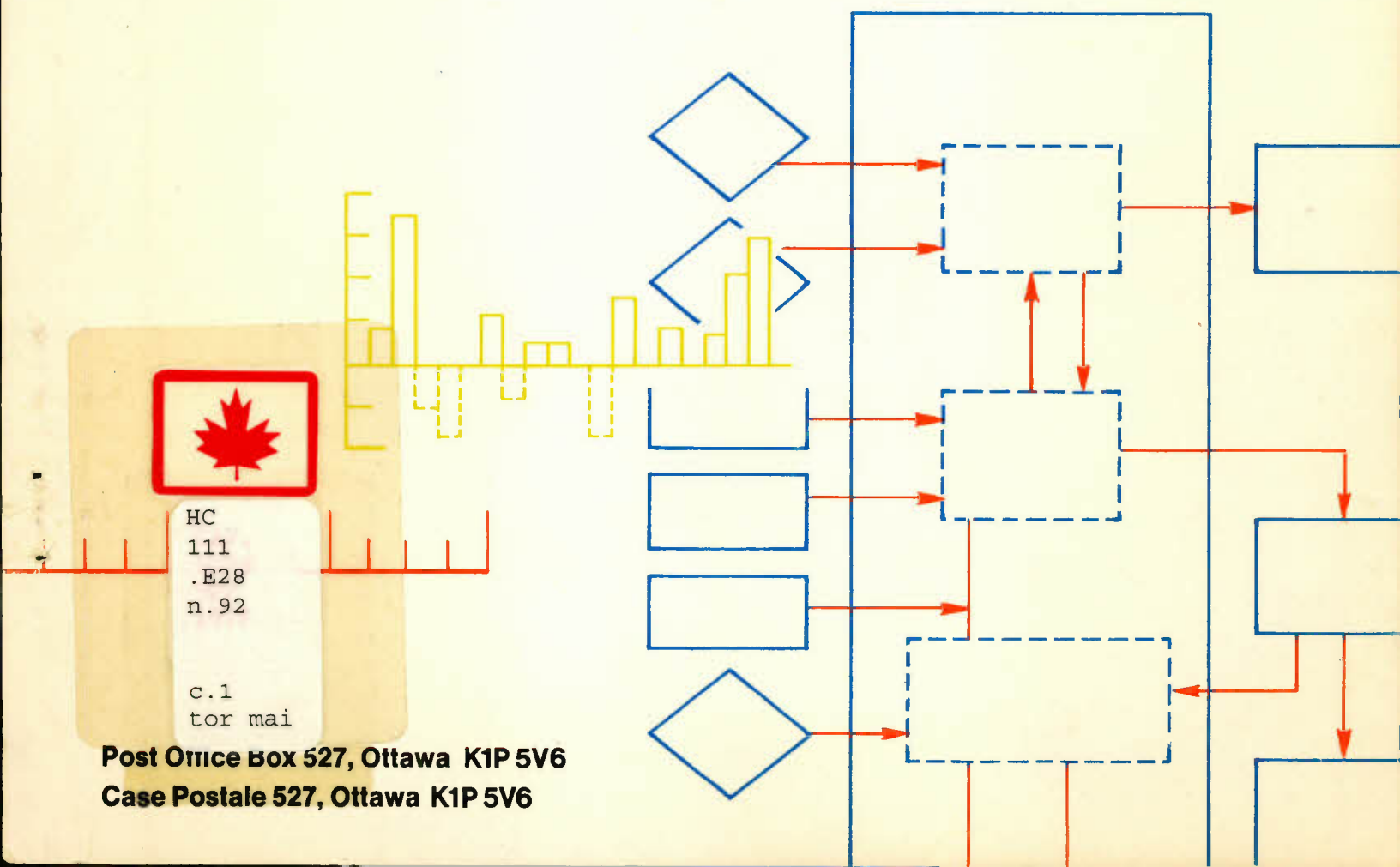

DISCUSSION PAPER NO. 92

A Neoclassical Perspective on Natural Resource-Led Regional Economic Growth

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Summary

This paper presents a neoclassical theory of the role of natural resources in regional economic disparities. While the traditional "staple theory" emphasizes the role of natural resources in generating economic growth and raising the standard of living, multi-sectoral neoclassical models of inter-regional trade demonstrate that in the absence of in-migration, and given very conservative fiscal policies, a new natural resource discovered and appropriated by a foreigner could be exploited without causing any economic growth or any increase in per capita incomes. The amount of economic growth that the new natural resource is allowed to create depends crucially on the amount of in-migration that occurs and on government's fiscal response to financing the new infrastructure needed to exploit the natural resource and in releasing labour and capital from elsewhere in the regional economy to exploit it. The level of wages in the region is determined in the non-primary tradeable goods sector, if there is one. The basic level of wages cannot be permanently altered by a natural resource discovery unless the region becomes (or already is) specialized in the production of non-tradeable home goods and natural resource goods for export. A region that need not be specialized in home goods and export staples could become so if government passively allows its natural resource rents to partly be captured by unionized labour in the form of wages that exceed the marginal value product of natural resource labour, and if these high wages (which contain an element of natural resource rent) are emulated by other unionized sectors, thereby pricing the import-competing sector out of existence, and causing unemployment while attracting still more labour from other regions where wages are lower.

Since no Canadian regions are large enough to materially affect the prices of most inter-regionally traded goods, or to affect the international price of capital, and since import-competing sectors exist in all provinces, it is reasonable to obtain a crude measure of natural resource rents as the windfall left after valuing the capital and labour in each province's natural resource sector at their opportunity cost interest rate and wage rate in the local non-primary sector. Since the neoclassical model can be approximated by a linear program (and indeed is developed as a linear program in this paper), it is reasonable to use a more disaggregated linear program of certain natural resource industries to measure economic rents in more detail, to evaluate the impacts of transportation costs and technological developments in individual resource sectors.

Résumé

Le présent document décrit comment l'approche néoclassique explique le rôle des ressources naturelles dans les disparités économiques interrégionales. Alors que la traditionnelle théorie des produits de base (staple theory) met l'accent sur l'apport des ressources naturelles à la croissance économique et à la hausse du niveau de vie, les modèles multisectoriels néoclassiques du commerce interrégional montrent qu'en l'absence d'immigration, et étant donné des politiques budgétaires prudentes, une nouvelle ressource naturelle qui serait découverte et accaparée par une entreprise étrangère pourrait être exploitée sans amener aucune croissance économique ni aucun accroissement du revenu par habitant. La part de la croissance économique pouvant être imputée à la nouvelle ressource naturelle dépend essentiellement de l'importance de l'immigration et des mesures budgétaires prises par le gouvernement pour financer les nouvelles infrastructures nécessaires à l'exploitation de la nouvelle ressource naturelle et pour déplacer des travailleurs et des capitaux, employés ailleurs dans l'économie régionale, afin qu'ils servent à sa mise en valeur. Les salaires dans la région sont déterminés par le secteur non primaire des biens échangeables, s'il y en a un. Leur niveau de base ne peut être modifié d'une façon permanente par la découverte d'une ressource naturelle, à moins que la région ne devienne (ou ne soit déjà) spécialisée dans la production de produits intérieurs non échangeables et de matières premières pour l'exportation. Une région qui n'a pas besoin d'être spécialisée dans les produits du commerce intérieur et les produits de base exportables pourrait le devenir, si le gouvernement permettait passivement que les rentes de ses ressources naturelles passent en partie dans les salaires des travailleurs syndiqués, qui excéderaient ainsi la valeur du produit marginal du travail pour le secteur des ressources naturelles, et si ces salaires élevés (comprenant une partie de la rente des ressources naturelles) étaient recherchés par les syndicats des autres secteurs. Le cas échéant, le secteur des produits qui font concurrence aux importations ne pourrait rivaliser sur le plan des prix et disparaîtrait. De plus, l'attraction exercée sur les travailleurs des autres régions où les salaires sont moins élevés serait plus grande, provoquant ainsi encore plus de chômage.

Comme aucune région canadienne n'est assez grande pour influencer sensiblement les prix de la plupart des biens qui sont échangés entre les régions, ou encore influer sur le prix international du capital, et comme il existe dans chaque province des secteurs qui font concurrence aux importations, il est raisonnable de prendre, comme mesure grossière de la rente des ressources naturelles, la marge excédentaire obtenue après avoir évalué le capital et le travail du secteur des ressources naturelles de chaque province au coût d'option pour le taux d'intérêt du capital et le taux salarial dans le secteur local non primaire. Pour mesurer la rente économique plus en détail, pour évaluer l'effet des coûts de transport et du développement technologique de

secteurs particuliers des ressources, et puisque le modèle néoclassique peut être approché par un programme linéaire (dans cette étude, il est en effet décrit comme un programme linéaire), il est raisonnable de se servir d'un programme linéaire plus désagrégé pour certaines industries exploitant des ressources naturelles.

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Introduction

For a long time Canadians have thought of themselves as hewers of wood and drawers of water. Generations of Canadian students, either directly or indirectly, have been exposed to the writings of Harold Innis and W. A. MacIntosh, who explained the economic evolution of Canada as a series of natural resource exploitations to produce a succession of export staples -- fish, fur, timber, wheat -- which presumably caused much of Canada's economic growth, both in the absolute size of gross national product and in income per capita. Given this historical and educational legacy, Canadians have a natural tendency to believe that natural resources must be the source of their current economic wealth and that regional differences in incomes, wages and rates of economic growth must be founded on differences in the regional distribution of natural resources. In particular, British Columbians popularly attribute their more rapid rate of economic growth and very high wage rates to their believed superior endowment of forests and minerals compared to other regions in Canada.

On the other hand, some people argue that a good natural resource endowment is a detriment to economic development. They argue that British Columbia's passive system of collecting stumpage as a residual (after other factors of production have been paid, including a normal return on capital) gives forest companies no incentive to prevent some of the province's economic rents from being passed on to other factors of

production in the form of wages that exceed the marginal product of labour. Those high wage rates, emulated in other unionized sectors of the province, they argue, drive secondary industry away, creating unemployment while at the same time luring in-migration from lower income regions.

This paper sets out to use neoclassical economic theory to shed light upon these apparently conflicting claims.

The traditional view holds that the discovery of new natural resources in a particular region has the effect of raising the wage level of that region because of the increase in the demand for labour needed to exploit that resource and because an increase in natural resources per worker will raise the productivity of labour. This point of view is consistent with a one-sector growth model in which natural resources are a necessary input into every unit of product produced in the region.[1] In a multi-sector model, however, that wage increase could be temporary, lasting only until the economy adjusts by drawing more workers into the natural resource industry from the non-primary sectors. The traditional view also holds that the discovery of the new natural resource will cause aggregate economic growth in the region for several reasons. Not only will it create new jobs in the exploitation of the new resource; it will also create jobs in building infrastructure (railroads, ports, etc.) and in down-stream processing; it will give a boost to industries supplying the human needs of any new workers drawn into the region to fill these new jobs.

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1 The one-sector and two-sector models are formally developed in the Appendix.

Capital will also be drawn to the region to work with the increased labour supply. Hence, according to the traditional view, the discovery of a new natural resource in a particular region should cause a surge in the size of the regional economy, in the size of the region's population, and in its per capita income. A rise in world demand for the products derived from a particular region's under-utilized natural resources should have the same effect.

But is the traditional view entirely correct in a modern context? Will natural resource discoveries and increases in world demand for natural resource products always have these effects? Even if they do, how large will these effects be? Which effects are permanent and which are temporary? Neoclassical economic theory is of considerable help in evaluating these matters.

Part I

REGIONAL DIFFERENCES BETWEEN "NATURAL ENVIRONMENT", "NATURAL RESOURCES", AND "TECHNOLOGY": HOW DO YOU TELL THEM APART?

Let us make a distinction between "natural environment" and "natural resources" on the basis of whether or not entrepreneurs can appropriate the factor in question and market it. For example, businessmen cannot capture sunshine for the purpose of buying and selling it, but they can capture a forest and buy and sell bits and pieces of that -- assuming it has any value. The sunshine is clearly part of the "natural environment". If the local forest is so vast relative to population that all persons can get as much wood as they can conceivably use without anyone running short (as was once true in North America) then the forest has no market value and it becomes part of the "natural environment". However, once the population gets large enough, competition for the local forest will arise and businessmen will discover they can buy and sell the forest because it has become relatively scarce -- that it has become a "natural resource".

We will now demonstrate that this concept of appropriability allows us to distinguish the separate economic impacts of "natural resources" from those of "natural environment" and "technology", but mathematically we are unable to distinguish between the latter two.

Suppose we start with two identical regions facing identical product prices and having identical production functions

$$Q = AN^{\alpha}L^{\beta}K^{\gamma}$$

where Q is output, A is a shift parameter, N is natural resource inputs, L is labour and K is capital. In this case we will end up with identical factor prices where each factor is paid its marginal value product.

Now let one region experience a neutral improvement in technology that raises aggregate productivity by 100 θ per cent. The region's new production function will be

$$Q' = A'N^{\alpha}L^{\beta}K^{\gamma} = (1+\theta)A\ N^{\alpha}L^{\beta}K^{\gamma}$$

The market prices of labour and natural resources will be bid up. There will be an inflow of capital. There will be economic growth, both in aggregate terms and per capita.

Suppose instead that the region experienced some non-appropriable change in its "natural environment" like an improvement in climate, that raises total productivity by 100θ per cent. (To say that the change is non-appropriable is to say that there exists no way for entrepreneurs to secure control of the environmental change in order to buy and sell it. When the climate improves, the sun shines on all workers equally.) This case is exactly the same as that of technical advance cited above. Mathematically the production function could be shifted in exactly the same way.

Factor prices would rise in exactly the same way. Hence it is impossible to use statistical regression techniques to measure regional differences in technology separately from regional differences in "natural environment" (such as climate), unless one finds an effective way to measure the "natural environment" as a separate entity. (In the long run, if technological differences disappear as laggard regions "catch up" (if they ever do), then the remaining differences in productivity have to be due, ceteris paribus, to "natural environment".

Now consider a new discovery of some appropriable natural resource so that the region's new production function becomes

$$Q = A(N + \Delta N)^{\alpha}L^{\beta}K^{\gamma} = A(1+\Delta)^{\alpha}N^{\alpha}L^{\beta}K^{\gamma}$$

where $(1 + \Delta)^{\alpha}$ is the same size as the $(1 + \theta)$ defined previously. Mathematically the new resource discovery could have the same effect on total production as the improvement in climate or the improvement in technology. However, this time businessmen (or government agents) are able to capture the new resource discovered and sell it to the highest bidder. Since, by hypothesis, the new resource is scarce (carries a positive market price), the new discovery will not be accompanied by as large a wage increase because producers will have to pay out something for the new resource in addition to paying for the labour to work with it. Hence the discovery of the new natural resource will have quite a different impact on factor prices than would the improvement in technology or the improvement in the natural environment.

We are thus able to measure the separate impact of changes in the natural resource endowment, as long as we stick to our definition of a natural resource as some scarce element of land that can be appropriated.

Part II

AN OVERVIEW OF NEOCLASSICAL THEORIES OF INTERNATIONAL TRADE AND ECONOMIC GROWTH AND A SUMMARY OF THEIR IMPLICATIONS

The modern multidimensional neoclassical theory of general equilibrium that we shall use comes from the comparative static theory of international trade and the dynamic theory of economic growth.[2] The international trade models emanate from the theory of comparative advantage enunciated by David Ricardo (1817) and Robert Torrens (1808 and 1815.) In the hands of John Stuart Mill (1854), Frank Graham (1923) and Lionel W. McKenzie (1954), Ricardo's theory becomes a fixed-coefficient programming model. In the hands of Eli Heckscher and Bertil Ohlin, it becomes the continuous factor-proportions theory of trade. Using the Heckscher-Ohlin model, Paul Samuelson developed the very important factor price equalization theorem for n products and r factors. T.M. Rybcynski used it to demonstrate that an absolute growth in the endowment of one factor of production can result in a growth of national output without affecting factor prices. Robert Mundell used the same model to demonstrate that international (or inter-regional) migration of factors of production can have the same effect on factor and product prices as international (inter-regional) trade in products. Hence trade in factors of production is effectively a substitute for trade in end products. These models have important duality properties, spelled out by Ron Jones in 1965, enabling us to see clearly

2 All the references mentioned below are given in the selected bibliography to this paper.

how certain constellations of output levels have specific implications for factor pricing and vice versa.

Although Thomas Malthus had studied economic growth as far back as his famous essay in 1798, the modern conversion of the comparative static models of international trade into dynamic multisectoral models of economic growth began with the seminal articles in 1956 by Trevor Swan and Robert Solow, followed by Harry Johnson (1958) and Hirofumi Uzawa (1961 and 1963).

It is upon this literary heritage that our current natural resources study will draw. We see from the appendix that, if one chooses the special case of a one-sector growth model in which the economy's single output is a continuous function of land (natural resources) labour and capital, then the traditional results can follow: an increase in the natural resource endowment of a particular region can substitute for labour and raise the productivity of labour so there is a permanent rise in the wage rate, in per capita income and in gross domestic product.

However, Rybcynski's theorem proves that these results do not normally follow in a trading world containing more than one product. Hence the wage increase caused by a new natural resource discovery may only be temporary, lasting just long enough to encourage some workers to shift out of alternative pursuits and into the resource-intensive sector until a new competitive equilibrium has been reached. This result, plus Samuelson's factor price equilization theorem tell us that we must be aware that the long lasting

wage differentials between regions in Canada probably owe their existence to something other than the sizes of the natural resource endowments of the different regions. For as Samuelson demonstrates, in a perfectly competitive multi-dimensional world, all regions must have the same factor prices:

- if they use identical technology,
- if they face identical product prices,
- if none of them is completely specialized in the production of certain products,
- if technology is constant returns to scale,
- if markets are perfectly competitive,
- if the ith product and jth factor are homogenous across regions,
- if demand is sufficient to absorb all product produced at the prices prevailing ex post,
- if the number of products is as large as the number of factors of production, and
- if the regions' factor endowment ratios are not too different (to avoid the problem of factor intensity reversals).

These assumptions underlying the factor price equalization theorem spell out a multitude of hypotheses about why factor prices may differ from one region to another, quite apart from any regional differences in the quantity of natural resources per worker.

There is one more theorem that spells out even more clearly why natural resources may not be responsible for determining the basic level of wages in a region. One might call it a type of "separation theorem" in factor pricing. It shows that in a neoclassical world where some sectors of production use natural resources as inputs and where other tradeable goods sectors do not, the wage rate of labour is determined quite independently of anything that is happening in the natural resource sector -- in the long run. The importance of this theorem is that one can separate the economy into two sectors -- the non-primary tradeable goods sector that influences the long run real wage rate of a region and the primary sector which must take the basic wage rate as given. Hence one may legitimately measure the economic rents of natural resources as a residual after valuing the labour and capital in the primary sector at their opportunity cost in the non-primary tradeable goods sector.[3]

The above theorem does not argue against the existence of a long-run wage premium in the natural resource sector. Indeed workers normally demand a premium wage to compensate them for the more isolated and (apparently) less pleasant work in the natural resources sector. What the theorem

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3 This theorem does depend upon competitive equilibrium and the existence of a non-primary tradeable goods sector that is "large enough to matter". Part V deals with a case, possibly relevant for British Columbia, in which imperfect competition in the natural resource and labour markets causes wage rates to contain some of the natural resource rents, and hence to be very much influenced by the natural resource sector. In that case, one may look to a neighbouring region in an attempt to find a relevant opportunity cost for labour.

does say is that the natural resource endowment cannot be responsible in the long run for interregional differences for identical work.

Similarly, the above separation theorem does not argue against the existence of a long-run risk premium for capital in the natural resource sector, if investment risks are truly higher there than in the non-primary sector. The theorem does say, however, that in a world of highly mobile capital, the natural resource endowment cannot be responsible for establishing the terms at which capital is offered to different regions.

The introduction into the model of non-tradeable goods (home goods that do not enter interregional trade) does not change the results. The basic long-run wage rate of a region with a competitive economy can only be influenced by the presence of natural resources if these resources are so abundant that the primary and home goods sectors together absorb all the labour in the region, driving the non-primary tradeable goods sector out of existence, or if the competitive market mechanism fails, as when institutional arrangements are such that unionized labour is able to negotiate wage rates in the primary sector that absorb some of the economic rent on natural resources, and if these primary sector wages are emulated to some degree, throughout the region.

The practical importance of this "separation theorem" in factor pricing is that it empowers us to calculate the natural resource "windfall" over and above the opportunity

cost of the capital and labour employed in the natural resource sector, knowing that, as long as a non-primary tradeable goods sector is present, those opportunity costs were not themselves determined by the size of the natural resource endowment in the long run.[4] This "windfall" includes the natural resource premia need to draw labour and capital out of more desirable and less risky(?) employment elsewhere in the regional economy and any economic rents associated with market access as well as the economic rents accruing to the natural resources themselves. While windfall measures are very crude, this theorem does demonstrate that they can be meaningful, and certainly they are very useful when one wants to measure, as a residual, the potential impact of natural resources on per capita regional income without going to the trouble of precisely identifying and measuring the inputs of the very heterogeneous natural resource endowment of each region.

We can, however, come to grips with the issue of precisely measuring each individual natural resource. Making use of Frank Graham's fixed-coefficient version of international trade theory and a modern computer algorithm of mixed integer programming, we can explicitly disaggregate the heterogeneous regional natural resource endowment into individual ore bodies, areas of forest,

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4 Again the theorem depends on the regional economy being essentially competitive. In frontier regions where the economy is small and where imperfect competition in wage setting and product pricing is serious, and where labour is largely supplied by in-migration, a better measure of labour's opportunity cost is the wage rate in the non-primary sector in the region(s) from which the migrants come.

pools of oil and so on, and evaluate them in the context of a neoclassical model of perfectly competitive economic growth under several different hypotheses about rates of market growth and primary product prices and rate of natural resource discovery. The programming model can also allow for differences in resource quality, existing technology (and some foreseen changes in technology), transportation costs, and returns to scale. The programming model thus takes into account and evaluates a number of the issues assumed away in the factor price equalization theorem.

Part III

SPECIAL ISSUES RELATING TO ECONOMIC GROWTH

1. Who Gets the Natural Resource Rents and Why?

Neoclassical growth models identify a factor payment to natural resources in the form of a shadow price. The linear programming model used in Part II of the Economic Council's natural resources study (of which this paper is a part) also assumes limits on the ability of markets to absorb product at going prices in any one time period. These limits also command shadow prices. Hence that model measures the economic rents of market access. (These rents are particularly large in certain imperfectly competitive markets such as nickel mining.) In agriculture, almost all the land owners are Canadians and in some cases provincial legislation prevents non-resident land ownership, so the rents on agricultural land presumably stay in Canada. In mining and forestry, royalties, stumpage fees, and other taxes are designed to collect some of these rents for provincial governments. If labour is made up of non-competing groups, shortages of natural resource labour may arise from time to time when there is an excess demand for it coupled with tight immigration policy and/or labour union action. In those cases, wage rates can rise above the next best alternative for labour in the region so that labour collects some of the economic rent that would otherwise accrue to the resources. As argued below, it may also be possible for labour unions to permanently

capture natural resource rents if the government landlord passively accepts as royalty or stumpage some residual after all other costs have been met, and allocates the resource using some mechanism other than a perfectly competitive market. The linear programming model used in a natural resource study currently being undertaken by the Economic Council does help us to unravel these issues, first, by measuring the rents, and second, by separating out those that arise through limited market access and those that may accrue to labour through labour shortage, from those rents that are allocated to the natural resources themselves.

2. How Much of a Region's Growth Rate is "Explained" by Its Natural Resource Endowment?

The fact that the economic rent on a ton of ore may be fifteen dollars in one region and fifteen cents in another says nothing whatsoever about whether resources are "causing" economic growth in one region and not in another. Whether the resources are allowed to cause economic growth depends very largely on government policy and the willingness of other factors of production to move into the region where the natural resources are discovered. If labour and capital are totally immobile between regions and nations, and if natural forces or government fiscal policy maintain full employment, then discovering a new natural resource -- say a rich ore body -- will cause very little economic growth and in fact as is demonstrated below, gross regional product (as opposed to regional domestic

product) will not rise at all if a foreigner is the one who discovers the resource and if he is able to claim all the economic rents emanating from it.

In the other extreme, the discovery of a rich ore body that requires lots of material inputs and infrastructure, and which generates lots of downstream processing activity, will generate a huge amount of growth in gross regional product if there was previously a lot of unemployment in the region, and/or if the government allows large scale in-migration of workers and capital to fill the new jobs created. Growth in per capita income could also occur, especially if a local resident is the one who discovers the natural resource and if he succeeds in appropriating any resource rents not captured by local taxation.

Finally, a second region that is an "innocent bystander" may experience growth effects associated with resource discovery in the first region. The effect of a natural resource discovery in Alberta, for example, could cause an increase in the growth rate of Ontario if Ontario's manufacturing industry has excess capacity and if it ends up supplying Alberta with a lot of materials and supplies. That same Alberta discovery could cause an absolute decline in the size of the Saskatchewan economy if hundreds of Saskatchewan workers and their families moved to Alberta to become permanently employed in exploiting the new resource.

There is no conceivable way to say how much growth is "caused" by natural resources until we know, or are willing to speculate on how the inter-regional and international migration of capital and labour will be affected by the new resource discovery.

2A. A Theoretical Case Where Discovery of a Rich New Resource Would Generate Big Economic Rents but Cause Virtually No Economic Growth

Consider a particular region that produces "resource goods" and "other goods" which require capital and labour in the same ratios. Both goods are freely traded on world markets at fixed prices and capital is in unlimited supply from the rest of the world at a fixed interest rate. Assume each region is gradually exploiting its non-renewable resources so as to maximize the present value of the future income stream generated for the regional economy as a whole. As the resources are gradually depleted, labour and capital gradually leave the "resource goods" sector and enter the "other goods" sector.

Now let a rich new mineral deposit be discovered. A lot of new mining jobs are created. If labour is inter-regionally immobile, then the region's own labour and capital will pour into the "resource goods" sector and for a time at least, the "other goods" sector will decline. Since capital and labour are used in the same proportion in both sectors, the flow of labour and capital from the "other goods" sector to the "resource goods" sector will

occur without creating a net demand for new capital. When the new equilibrium is established, the region's endowment of capital and labour has not changed one iota. Assuming constant returns to scale, its factor prices will not have changed either. Hence the region's gross domestic product will have risen only by the amount of the economic rent emanating from the newly discovered natural resource. If that resource is discovered by a foreigner who somehow gains the title to all that economic rent, the region's gross regional product does not rise at all. The increase in the value of mineral exports just finances the outflow of royalty payments to the foreigner.

If mining labour and general labour constitute non-competing groups then, when the new resource is discovered it may be the mining labour and not the resource that will be the effective binding constraint. In this case the new ore deposit goes unused and is worth zero if it is less rich than existing ore bodies. If it is richer than the old ore bodies but there is a permanent mining labour shortage, the economic rent accrues entirely to mining labour in the form of an increased wage. Some of the old existing mines close down as their labour is bid away by owners of the new mineral deposit. Owners of the mines which close down will lose any quasi-economic rents their facilities may have been earning. Since only part of the capital may be moved from an old mine to a new one, and since the "other goods" sector will be keeping all its labour and capital under the

current assumptions, there must be a net inflow of some new capital to the region to exploit the new resource.

In this instance, where mining labour is in perfectly inelastic supply and cannot be drawn from the "other goods" sector, the region must experience some economic growth since the increased economic rents accrue at least partly to labour and cannot be entirely dissipated in payments to foreigners.

2B. A Theoretical Result when Labour is Perfectly Mobile between Industries and between Regions

Assume there is no immigration of labour into Canada, but perfect labour mobility within Canada. Suppose labour and capital are used in the same ratio in both the "resource goods" and "other goods" sectors. Now, if a rich new ore deposit is discovered in Ontario, for example, we expect labour and capital to be drawn from the "other goods" sector in both the rest of Canada and from Ontario. How much labour will come from outside the Ontario region cannot be predicted without knowing the relative speeds of adjustment within and between the regional labour markets. Clearly, this is a case where a rich new resource discovery in Ontario may cause a decline in the size of the labour force in some other region such as the Atlantic region, the severity of the decline being greater the more mobile the Atlantic labour force is. If, for some reason, the government wanted to avoid drawing labour out of the Atlantic Region, it could open the door to immigration from abroad

(which would increase Canadian economic growth in the aggregate) or impose tight fiscal policy in Ontario which would cause the Ontario mining industry to draw labour from its "other goods" sector, not from the Atlantic. This tight fiscal policy option would minimize the economic growth generated by the resource discovery.

2C. Linkage Effects

Discovery of a new natural resource usually creates a demand for materials and supplies to operate the new resource (a relatively short-run effect lasting perhaps less than three to five years) and it may call for the establishment of new industry to process the output of the new natural resource. If regional fiscal policy or natural forces were such as to avoid unemployment and inflation at all times, and if the region had a policy of zero in-migration, then discovery of the new natural resource would be accompanied by growth in infrastructure, support, and processing industries that would come at the expense of a decline in the rest of the regional economy. To avoid inflationary pressure, the government would have to raise general taxes and cut back on other government projects in order to release resources to the expanding natural resource-related activity. Another alternative would be to encourage increased imports to the region so the demand created by the new discovery would spill over into other regions or to the rest of the world without causing inflation in the region of discovery.

In practice, the reverse is more likely to happen. First, all regions have some unemployment so support and processing industries can obtain some local labour for expansion. Second, government is quite unlikely to curtail its own spending in other areas when a new resource is discovered. Rather, it will increase that spending because it now feels wealthier, and it will add to its spending the new infrastructure that it must provide to get the new resource industry going. Third, no region of Canada has a policy restricting in-migration. In fact, all regions actively seek economic growth in order to increase their economic and political power within Confederation.

2D. Alternative Approaches to Measuring Ancillary Economic Activity Drawn into a Region by Natural Resource Exploitation

As the natural resources model used in Part II of our study is currently designed, it measures the demand generated for materials and supplies and it assumes these demands are distributed regionally according to the historic input-output coefficients in Richard Zuker's Regional Input-output table.[5] It is possible that the discovery of new natural resources will cause a shift in the regional procurement pattern, although we might suspect that the regional coefficients showing how a dollar's worth of expenditure for materials and supplies would be distributed would not change much. The technique currently used assumes that the supply curve for materials and supplies in each region

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5 Richard Zuker and S. Simard, "Construction and Impact Results of a Revised Interprovincial Input-Output Table," mimeo., Economic Analysis Division, Department of Regional Economic Expansion, November 1974.

is perfectly elastic so the model already assumes that the location of the mining support industries is very flexible between regions.

A more important criticism on our modeling of ancillary industry is that it does not measure the number of service personnel and other ancillary workers that get drawn into a region when new resources are discovered there. How much of this "tag-along" ancillary industry gets pulled in along with each new primary sector job depends on the cost of providing goods and services locally relative to the cost of importing those goods and services from other regions. In other words, there is a "make-or-buy" decision that has to be resolved by the economy. It has been suggested that we take the ratio

frontier employment/frontier primary sector employment

as a type of "employment multiplier" measuring the total number of jobs that are drawn into an area by natural resource discovery. This technique is used. It is an alternative measure of the linkages of the natural resources industry. This multiplier appears to be at least as large as 1.2 (at Fermont, Quebec -- iron mining) and could be 1.85 (Thompson, Manitoba -- nickel mining), but probably differs from one natural resource industry to another. (We shall study its size in forestry towns like Mackenzie, B.C. as well.)

Part IV

THE SIMPLE ANALYTICS OF A NEOCLASSICAL FIXED COEFFICIENT WORLD

Economic theorists will recognize that really there is a single general equilibrium perfectly competitive model underlying all of the work in the current study. Both the continuous and fixed coefficient models, and both the static and dynamic versions of them are merely special cases of an optimization problem which finds the levels of inputs and outputs needed to maximize the present value of gross domestic product subject to the limitations of technology and of the availability of factors of production. It also measures the shadow prices on all the economic constraints. The problem could be summarized as an application of Pontryagin's maximum principle.[6] However, for our purposes it may be more enlightening to start the other way around, building very simple models and adding more complexity, one step at a time, until we finally arrive at the dynamic, spatially distributed, linear growth model used in the later chapters of the study.

Throughout we shall assume that there are three categories of factors of production, land (the natural resources themselves), labour and capital. We shall assume that the local region is entirely open to inter-regional trade, that it is not able to influence the long-run net price it faces

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6 See Michael D. Intriligator, Mathematical Optimization and Economic Theory, Prentice Hall, Inglewood Cliffs, N.J., 1971, Chapter 14.

for any tradeable product, nor the long-run interest rate its entrepreneurs must pay to obtain capital in world markets. In the more elementary models, constant returns to scale are assumed and world demand is assumed sufficient to absorb the region's total product at the prevailing prices. It is also assumed initially that the natural resource is like farm land which can render the same service year after year. In the programming model ultimately used in the later chapters of the study, returns to scale and limitations on product demand are incorporated, and the finite stock of non-renewable resources is incorporated.

1. The Two-Sector Inter-Regional Trade Model

Imagine a region which produces two products Q_1 and Q_2, both of which use land (N...for natural resources), labour (L), and capital (K) in their manufacture. Suppose the region takes world prices P_1 and P_2 and the world interest rate (r_o) as given. Assume production takes place in fixed proportions so that

$$Q_i = \text{Min}\left[\frac{N_i}{a_i}, \frac{L_i}{b_i}, \frac{K_i}{c_i}\right] \qquad i = 1,2 \qquad (1), (2)$$

where a_i, b_i and c_i are the minimal amounts of land, labour and capital needed to make one unit of output. Suppose the wage rate is denoted by W, the rent on one unit of natural resource services is denoted by R and that the factor supplies are given as

$$N_1 + N_2 = N_o \quad \text{natural resources} \qquad (3)$$

$$L_1 + L_2 = L_o \quad \text{indigenous labour} \qquad (4)$$

$$K_1 + K_2 = 0 \text{ if } r < r_o, \text{ and } 0 \leq K_1 + K_2 \leq \infty$$
$$\text{if } r = r_o, \text{ and } K_1 + K_2 \to \infty \text{ if } r > r_o \qquad (5)$$
$$\text{world capital supply}$$

Alternatively, relations (1), (2), (3) and (4) could be expressed as the linear programming constraints

$$a_1Q_1 + a_2Q_2 \leq N_o \qquad \text{natural resource limit} \qquad (6)$$

$$b_1Q_1 + b_2Q_2 \leq L_o \qquad \text{labour supply limit} \qquad (7)$$

At perfectly competitive equilibrium all factors of production will be priced so as to totally exhaust the value of the products produced. That is, each factor is paid at least as much as the opportunity cost in its most valuable employment. Algebraically these facts are expressed as

$$a_1R + b_1W + c_1r_o \geq P_1 \qquad (8)$$

$$a_2R + b_2W + c_2r_o \geq P_2 \qquad (9)$$

or

$$a_1R + b_1W \geq P_1 - c_1r_o \qquad (10)$$

$$a_2R + b_2W \geq P_2 - c_2r_o \qquad (11)$$

This model can be portrayed in the familiar Stolper-Samuelson box diagram (Figure 1) or the production possibility set (Figure 2), or the linear programming diagram of the

dual solution (Figure 3). The factor supplies of land and labour determine the dimensions of the Stolper-Samuelson box, and the coefficients of the production functions define the slopes of the expansion paths. The same data expressed as the linear programming constraints (6) and (7) define the boundaries of the production possibility set. If one superimposes the maximum isorevenue line

$$Z = (P_1 - c_1 r_o)Q_1 + (P_2 - c_2 r_o)Q_2 \qquad (12)$$

then Figure 2 portrays a perfectly competitive equilibrium at point A' (which is also the solution to the primal linear program that maximizes the value of output given the world product prices and the world interest rate, and subject to the limitations on the supplies of land and labour). The two perfectly competitive factor pricing relations (10) and (11) define the set of feasible points in factor price space in Figure 3. If one superimposes the minimum isocost line

$$ZZ = RN_o + WL_o \qquad (13)$$

The Figure 3 portrays a perfectly competitive equilibrium point A'' (which is also the solution to the dual linear program that minimizes total factor cost subject to the constraints of paying each fixed factor of production its marginal value product).

Note that if the world product price ratio changes far enough in either direction it will induce a "corner solution" where only one product is worth producing and where only one factor of production is fully employed.

Figure 1

Factor Endowment

(Stolper-Samuelson Box Diagram)

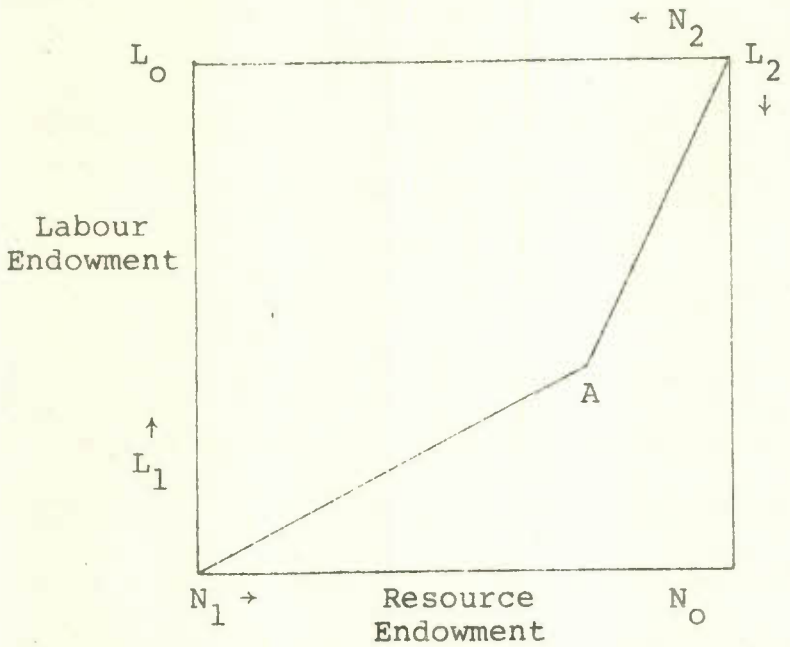


Figure 2

Production Possibility Set

(Solution to the Primal Problem in Linear Programming)

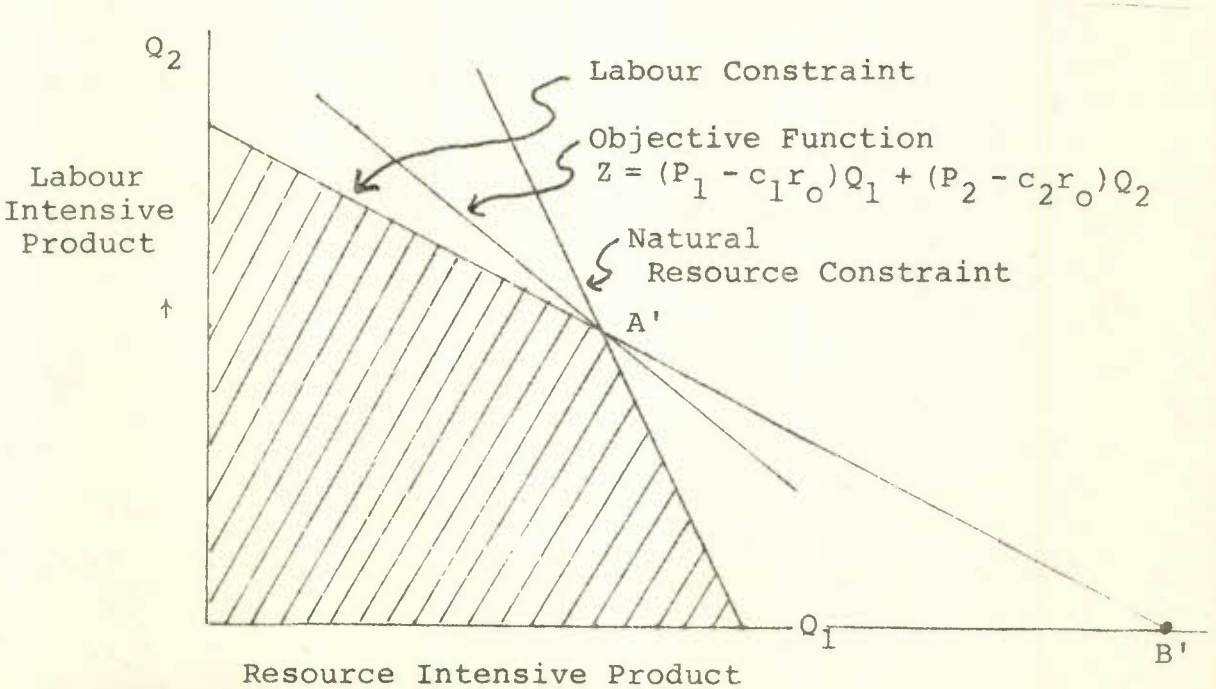
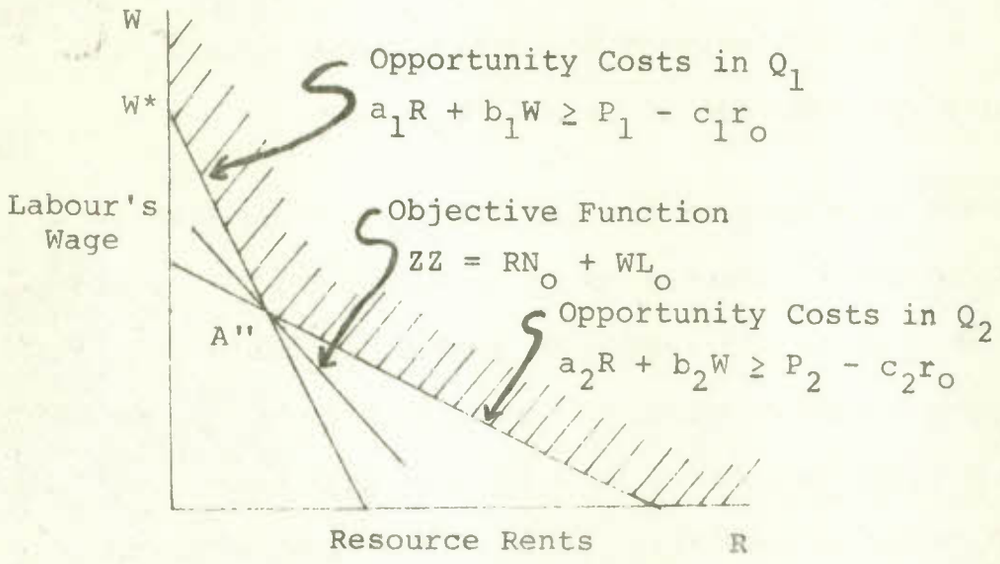


Figure 3

Factor Pricing

(Linear Programming Diagram of the Solution to the Dual Problem in Factor Price Space)



2. The Discovery of More Natural Resources Does Not Affect the Wage Rate in the Long-Run[7]

Figures 1, 2 and 3 can be used to demonstrate this surprizing result. As the natural resource constraint is moved to the right in Figure 2, the equilibrium point moves southeastward, implying an absolute reduction in the output of the labour-intensive good in order to release labour for the increased production of the resource-intensive good (the Rybcynski Theorem). However, in Figure 3, the increase in the natural resource endowment merely rotates

7 The model in the diagrams assumes that the economy is perfectly competitive, that there are no frictions to market adjustment, and that the natural resource is able to render the same service year after year, as farm land does. For a natural resource like the fishery which can grow and decline, or for an exhaustible resource like oil, a dynamic model is required. See for example the Symposium on the Economics of Exhaustible Resources, The Review of Economic Studies, 1974. The current author believes that his static result with respect to wages also applies in the dynamic models, but he has not proven the dynamic case.

the objective function clockwise so that there is no change in the long-term equilibrium factor prices. These results are general for neoclassical models with many products and factors of production because they are implied by Samuelson's Factor Price Equalization Theorem,[8] which proves that countries with different factor endowments will have the same factor prices, cet. par.

There is however a special case where the discovery of a new natural resource could be so great as to cause a permanent rise in the wage rate because it could cause the economy to become completely specialized in the production of the resource-intensive product. In that case, the natural resource constraint is extended beyond the new equilibrium point B' in Figure 2, and the objective function in Figure 3 rotates clockwise until a new equilibrium occurs at W*. In the specialized economy, the labour is so scarce as to command a very high wage and the natural resource is so abundant that its price falls to zero, and some of the resource goes unemployed.

3. Labour Mobility Tends to Prevent Natural Resource Discoveries From Causing a Rise in the Wage Rate

Even in cases where the new natural resource discovery is large enough to absorb the total labour force of a region and drive it to complete specialization so that there could be a permanent rise in the wage rate, this

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8 P. A. Samuelson, "International Trade and Equalization of Factor Prices," Economic Journal, Vol. LVIII (June 1948), pp. 163-84.

result can be prevented by in-migration. It becomes obvious that the amount of economic growth caused by a natural resource discovery in the long-run is very much influenced by the region's immigration policy and the elasticity of the supply of labour from outside the region.

It should also be mentioned that migration may have the power to dictate the long-run wage rate for a small region that can obtain unlimited amounts of immigrant labour at some threshold wage rate W_o. In that case, a new upper bound-type of horizontal constraint

$$W \leq W_o$$

is introduced into Figure 3. Similarly out-migration, at some threshold wage rate, can impose a lower-bound wage rate in Figure 3.

4. Changes in Product Prices, Interest Rates, Transportation Costs and the Exchange Rate Directly Affect Factor Prices

A further look at Figures 1, 2 and 3 will illustrate that a moderate increase in the price of the natural resource intensive product in a world of fixed coefficient technology cannot cause a change in output, but it immediately causes a change in factor prices by shifting the opportunity cost locus for product number one in Figure 3. It results in a rise in the economic rent on the natural resource and a fall in the wage rate.

If the price increase is great enough, it will drive the region to complete specialization and it will result in the unemployment of labour and a wage rate of zero. This counter-intuitive result arises from the fact that so far

our model contains no alternative industrial sector which can employ labour without using natural resources. We therefore shall augment the model in the next section by adding a non-primary sector which uses capital and labour as inputs and which buys raw materials on the world market at fixed prices.

Notice also that a change in the international price of capital will also have a direct effect on factor prices by shifting the opportunity cost constraints in the dual problem in Figure 3.

Note that the product prices in this model are the net prices facing the region after transport costs have been accounted for. Hence, an increase in the cost of transporting export goods will result in a fall in the net f.o.b. price of exports. A rise in the cost of transporting imports will result in a rise in the net c.i.f. price of imports, hence causing a rise in the price of import substitutes. Clearly, the effects of specific changes in transport costs can be traced out in the production possibility and factor pricing diagrams.

A single region is effectively on a fixed exchange rate and it takes net world prices as given. Hence, a depreciation of the Canadian dollar effectively raises both the local price of export goods and the local price of import goods, tending to leave the region's price ratio little changed. In the entire Canadian context, however, the depreciation will generally cause some relative price movements -- which way

depending on aggregate demand and supply elasticities. Note however that the rise in both product prices would necessarily raise the domestic currency value of both natural resource rents and labour's wage.

5. Introducing a Non-Primary Sector and Intermediate Goods Purchased on the World Market

Primary products use natural resources as inputs. Non-primary products do not. Let us assume that there are several primary products i = 1 ... m produced according to the fixed coefficient production functions

$$Q_i = \text{Min}\left[\frac{N_i}{a_i}, \frac{L_i}{b_i}, \frac{K_i}{c_i}, \frac{M_i}{d_i}\right] \qquad (14)$$

$$i = 1 \ldots j$$

and several non-primary products i = j + 1 ... n produced according to the production functions

$$Q_1 = \text{Min}\left[\frac{L_i}{b_i}, \frac{K_i}{c_i}, \frac{M_i}{d_i}\right] \qquad (15)$$

$$i = j + 1 \ldots n$$

where the terms M_i represent the intermediate materials and supplies that can be bought and sold freely in world markets at net prices P_m. (These prices are either f.o.b. or c.i.f. depending upon whether the region is a net exporter or a net importer of these intermediate products. It could be possible for some of the intermediate goods M_i to be produced locally: they could be outputs of either the local primary or non-primary sectors. We shall treat them as if they were all imports and we shall treat all local production as if it were exportable.)

The factor supplies are now

$$N_1 + N_2 + \ldots N_j \leq N_o \quad \text{Natural Resources} \tag{16}$$

$$L_1 + L_2 + \ldots L_j + L_{j+1} + \ldots L_n \leq L_o \quad \text{Indigenous Labour} \tag{17}$$

$$K_1 + K_2 + \ldots K_j + K_{j+1} + \ldots K_n = 0 \text{ if } r < r_o$$

$$0 \leq K_1 + K_2 + \ldots K_j + K_{j+1} + \ldots K_n < \infty \text{ if } r = r_o \tag{18}$$

$$K_1 + K_2 + \ldots K_j + K_{j+1} + \ldots K_n \to \infty \text{ if } r > r_o$$

World Capital Supply

$$M_1 + M_2 + \ldots M_j + M_{j+1} + \ldots M_n = 0 \text{ if } P_m < P_{mo}$$

$$0 \leq M_1 + M_2 + \ldots M_j + M_{j+1} + \ldots M_n < \infty \text{ if } P_m = P_{mo} \tag{19}$$

$$M_1 + M_2 + \ldots M_j + M_{j+1} + \ldots M_n \to \infty \text{ if } P_m > P_{mo}$$

Intermediate Inputs

At perfectly competitive equilibrium, the prices of all factors of production will be bid up to their opportunity costs in their best alternative uses. Algebraically that is

$$a_i R + b_i W \geq P_i - c_i r_o - d_i P_m$$

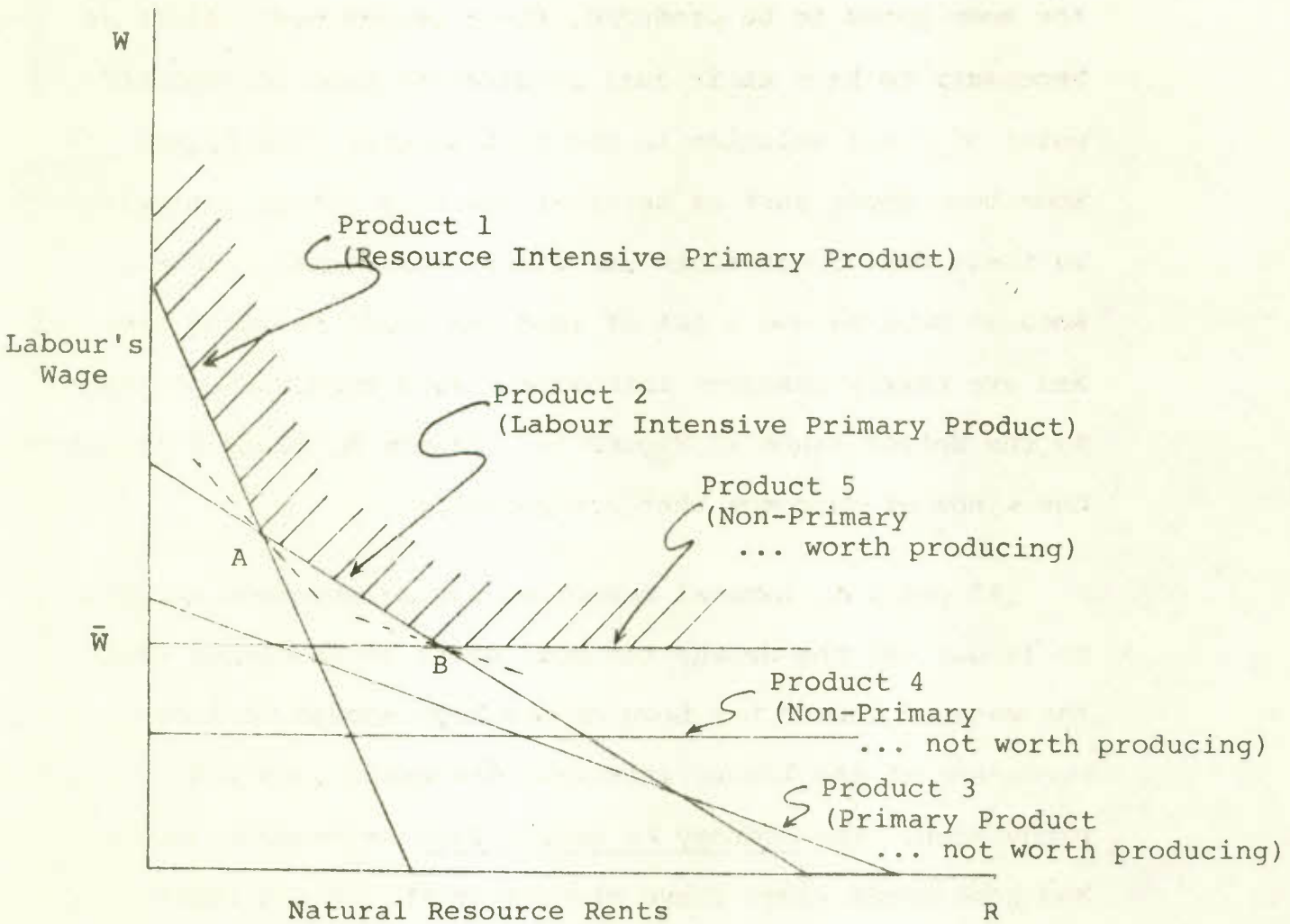
$$i = 1 \ldots n$$

In this multi-commodity world the two dimensional Stolper-Samuelson box can no longer be drawn. The production possibility diagram cannot be drawn beyond three commodities. However, the two-dimensional factor price diagram (see Figure 4) is retained to show that:

- the wage rate will fall to $\bar{W}$, the maximum rate that can be paid by the non-primary sector if the primary sectors are unable to use all the labour available, and
- if the non-primary sector is worth operating at all, it alone determines the equilibrium wage rate.

Figure 4

The Non-Primary Sector Alone Determines the Region's Wage Rate



------ alternative dual objective functions depending on factor endowment ratios.

Each solid line represents the perfectly competitive equilibrium condition.

$$a_i R + b_i W \leq P_i - c_i r_o - d_i P_m$$

($a_i = 0$ for non-primary commodities)

6. Introducing Non-Tradeable Goods

A non-tradeable or home good is one that, by definition, does not enter inter-regional trade. The effects of introducing these goods into the model are easily ascertained by looking at the diagram of the dual problem. In order for home goods to be produced, their prices must adjust as necessary to have their dual constraints pass through the point of final solution in the dual program (see Figure 5). Some home goods such as services are very labour intensive so their dual constraints are almost horizontal. Others such as housing use a lot of land and local building materials and are fairly resource intensive. Both kinds are portrayed by the dotted lines in Figure 5. Points A, B and C illustrate the kinds of outcomes that are possible.

At point A, natural resources are so abundant relative to labour and the demand for home goods is so strong that the wage of labour has been driven high enough to force producers of the labour intensive tradeable good out of production. The economy is specialized in resource goods and home goods under these circumstances. Since there is no import competing sector to draw labour from, any new resource discovery will automatically drive the wage higher because of the increased demand for labour, both to process the resource and to produce home goods. Increased incomes from resources will raise the demand for home goods; the increased wage will force the prices of labour intensive home goods to rise. Some people claim that point A portrays the situation typified by British Columbia -- an economy which

is specialized in resource goods and home goods, with no import competing industry and with high priced home goods and services. These people then argue, with some justification, that the wage rate and the standard of living of British Columbia are determined by the natural resource endowment, and that further natural resource discoveries would permanently raise both the wage rate and the price of labour intensive home goods. Opponents of this view observe that point A represents a condition of full employment of labour. They note that British Columbia has a large amount of unemployment and, at least to a limited extent, it does have some import-competing industry from which labour can be drawn in the event of new resource discoveries. They would argue that British Columbia's high wages are caused by imperfect competition -- that some of the natural resource rents are being received as wages in the primary sector, and that it is the emulation of these rent-containing wages in the unionized non-primary sectors that is causing the dearth of secondary industry and the presence of unemployment. The high wages also induce in-migration.

At point B, all three kinds of goods are being produced. Any increase in the natural resource endowment would raise income and increase the demand for home goods. However, increased output of resource goods for export at fixed prices and of home goods for local consumption can be achieved with no increase in the wage rate and no increase in the cost of home goods in the long run because the labour needed for them can be obtained by reducing the size of the import competing sector. Hence, the wage rate is determined by labour productivity, not by the natural resource endowment.

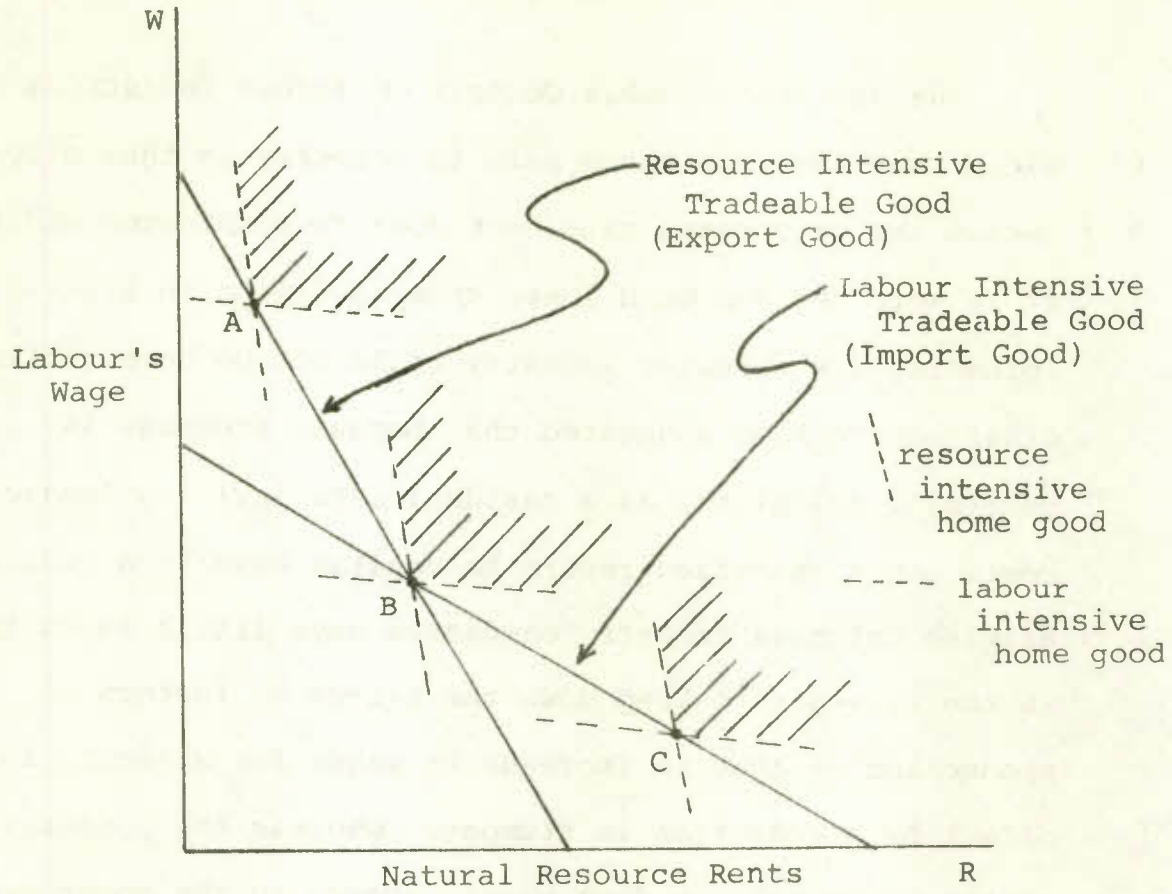
At point C, demands for the labour-intensive tradeable good (assumed to be an import good) and for home good is so strong as to drive the region into autarky. Home demand for natural resource-using tradeables is so high as to price the natural resources out of the export market. Under autarky, the change in the endowment of any factor of production will have some effect on factor prices, assuming smooth demand functions and intermediate price and income elasticities (elasticities that are neither zero, nor infinite).

The important conclusion of this section is that in the presence of home goods, an increase in the endowment of natural resources in a perfectly competitive economy will not affect the long-run wage rate unless the regional economy is so specialized as to produce either no importable good at all or as to produce no exportables at all (to be an autarkic region).

Figure 5

The Dual Linear Program

Factor Pricing When Non-Tradeable Goods are Present



Part V

THE CASE WHEN RESOURCE RENTS ARE ABSORBED IN THE PRICES OF OTHER FACTORS OF PRODUCTION, OR PASSED ON TO OTHER INDUSTRIES

The British Columbia Council of Forest Industries has noted that the wage rates paid in forestry in that province exceed the wage rates paid next door in Washington and that if it were not for much lower stumpage rates in British Columbia, its forestry industry could not be competitive. Other people have suggested that because stumpage is generally calculated as a residual after all legitimate costs and a specified return to capital have been deducted, British Columbia forestry companies have little incentive in the struggle to keep down the prices of factors of production -- that an increase in wages for example, is offset by a reduction in stumpage, whereas the potential profits from holding down wages accrue to the government in the form of stumpage.

The problem is further complicated by the fact that the major forestry companies in British Columbia are vertically integrated so that their logging divisions sell logs to their sawmilling divisions, and that the same labour union represents both the forestry workers and the sawmill workers. Broadly speaking, the government stumpage calculations on the British Columbia coast are a residual after an allowance for costs and a normal rate of return to capital. The residual is based upon the prices of logs in the Vancouver log market which is dominated by

the major forestry companies and which is, to some degree, an imperfectly competitive barter market.[9] Economic theory would lead one to expect the large vertically integrated companies to act collusively to surpress the prices of logs in order to suppress the amount of stumpage they pay. That way, natural resource rents could be transferred from the logging industry (where they would be absorbed by government stumpage fees) to the sawmill industry where they would only be partially taxed by corporation income tax. Vertically integrated companies could also transfer some of these rents to their subsidiaries in still other industries or other countries by selecting transfer prices judiciously.[10] If the logging companies were not vertically integrated, current stumpage laws would give them little incentive to resist negotiated wage increases for their workers since the wage increases would be entirely offset by reduced stumpage. The only way a logging company could increase its net logging income would be to increase the amount of capital it uses, in order to receive more under the "profit allowance" (some 16 to 23 per cent return on

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9 Peter H. Pearse, Arvid V. Bachman and Edward L. Young, Timber Appraisal Policies and Procedures for Evaluating Crown Timber in British Columbia, second report of the Task Force on Crown Timber Disposal, July, Victoria 1974. See also Peter H. Pearse, Timber Rights and Forest Policy in British Columbia, Volumes I and II, Report of the Royal Commission on Forest Resources, Victoria 1976.

10 L. W. Copithorne, "International Corporate Transfer Prices and Government Policy," Canadian Journal of Economics, IV (August 1971), pp. 324-41. See also Lawrence W. Copithorne, "La théorie des prix de transfert internes des grandes sociétés," L'Actualité Économique (juillet-septembre 1976), pp. 324-352.

capital) which stumpage authorities allow.[11] Hence, we would expect British Columbia Coastal logging operations to be overcapitalized. However, if vertically integrated companies granted large wage increases to their loggers, their sawmill workers which are represented by the same union would demand large wages also. Whereas loggers wage increases would be paid from reduced stumpage fees, sawmill workers wage increases would be paid from the companies' sawmill profits. We would expect it to be the effect of a new labour contract on sawmill profits that would encourage companies to resist loggers wage demands.

In the case where land rents are partly passed on in the form of extra large payments to other factors of production, the land itself cannot be allocated by the competitive market mechanism. The landlord has to use some non-market technique to allocate the resource, possibly dividing it among existing resource companies in accordance with informal quotas or some licence-negotiating process.[12] If this technique were instituted in a regional economy which had a vigorous non-primary tradeable goods sector and competitive labour markets, not much would happen to the pattern of production or the income distribution (provided the companies were not allowed to negotiate a return to capital that was substantially above its international opportunity cost so that the economic rents truly could be absorbed by the

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11 See Pearse, 1974, page 17, op. cit.

12 As is true in the British Columbia forest industry. See Pearse, 1976, op. cit.

landlord as a passively collected residual). However, if the labour force became unionized, it would have little difficulty in negotiating wages in the primary sector that exceeded labour's opportunity cost in the non-primary tradeable sector, perhaps by a wide margin (if the true rents on natural resources were large). If labour unions in the non-primary sectors sought to emulate the high wages established in the primary sector, they would drive the non-primary tradeables sector out of business, leaving only a high priced home goods sector, the export sector, and a substantial amount of unemployment. If the wage rate established were substantially higher than elsewhere in the same country, workers would tend to migrate into the high wage resource region in spite of the unemployment, if the expected income (the probability of being unemployed being taken into account) were higher than elsewhere.

It does appear possible, therefore, that a region may become specialized in natural resource based exports and high priced home goods, not because of the abundance of the natural resources themselves, but because of the government's passive method of pricing them. Should this actually be the case in British Columbia, then acceptance of the Pearse Commission's recommendations to increase the competitiveness[13] in the market for forestry resources would, rather ironically,

13 The Pearse Commission sought to reduce the forest tenure rights of the more powerful segments of the forest industry, and to increase competition in the bidding for timber. It recommended for example that Tree Farm Licences be reviewed and renewed every five years. It proposed the abolition of the current quota system in favour of new "Forest Licence" timber sales, providing matching-bid priviledges to holders of expiring licences. It recommended the controls on log exports be eased to stimulate the coastal log market.

help to establish (or increase the size of) the non-primary tradeables sector, lower the cost of home goods, reduce in-migration and reduce unemployment, as well as increase the revenue government collects from its ownership of the province's forests.

Part VI

A NOTE ON APPARENT LABOUR SHORTAGES IN NATURAL RESOURCE INDUSTRIES

In spite of high average wages, natural resource companies in British Columbia experience labour shortages and very high labour turnover in remote natural resource areas. This anomaly becomes understandable when we look at the effects that province-wide "master agreements" (that pay essentially the same wage rates in all regions) have on the distribution of labour between areas that differ in their remoteness and desirability from established centres of population (see Figure 6).

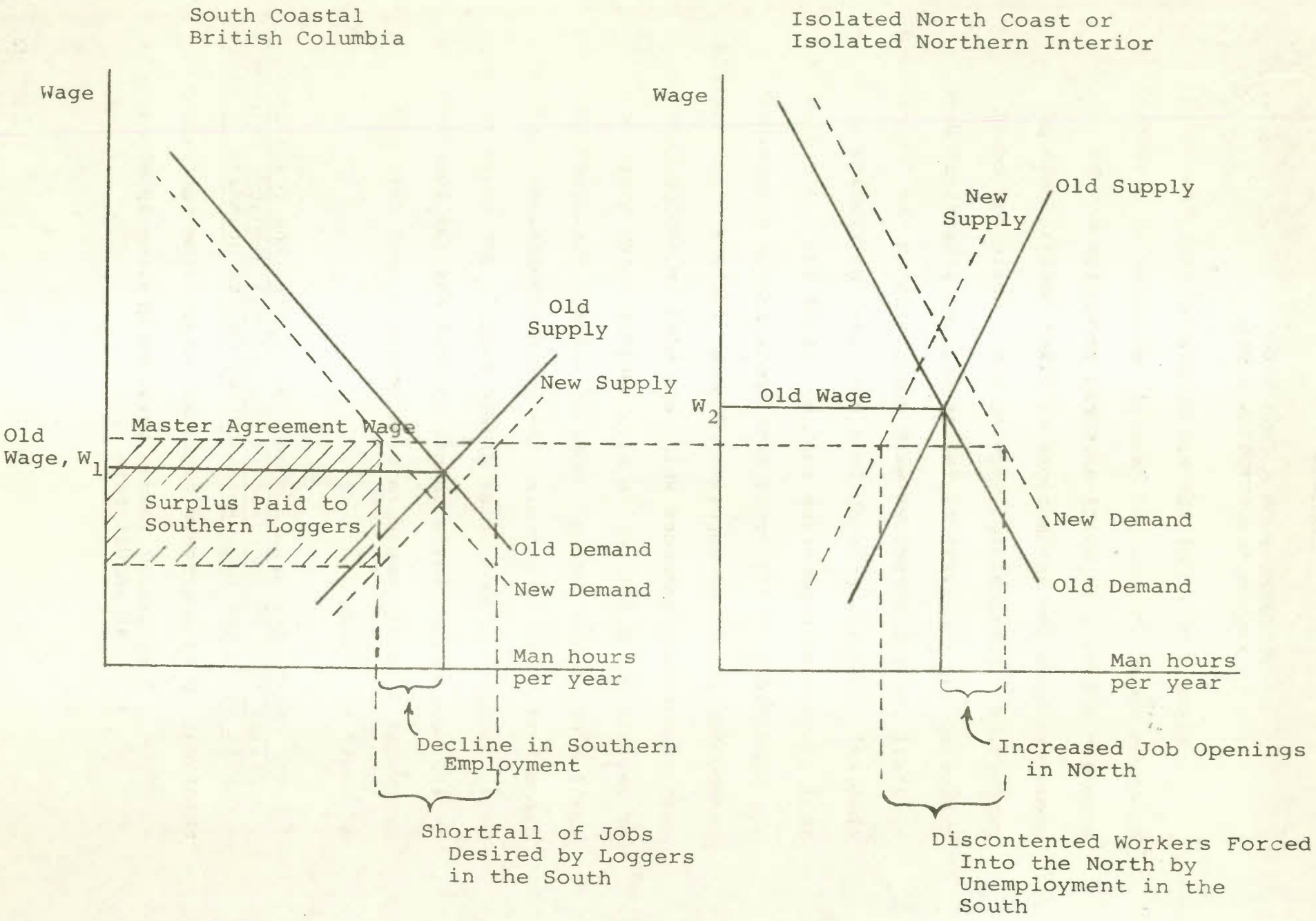
If wages were determined competitively in different zones of British Columbia, the wage rate would be low in the southern coastal region and high in isolated regions. However, if one forces the same intermediate competitive wage on all regions, loggers who manage to keep their jobs in the south get paid a surplus, employment falls in the south and increases in the north. The system deliberately creates more jobs in the zones where workers do not want to go and it reduces the incentive for them to go there.[14] A certain number of loggers are forced to

14 The dotted lines in Figure 6 represent the new labour supply and demand curves after the uniform master agreement wage has been established. Lower wages in the north increase the supply of labour in the south by reducing incentives for workers to go north. At the same time, they reduce the demand for labour in the south because northern costs have become lower. Mirror image arguments explain the shifts of the demand and supply curves in the north. In the real world, some of the old wage differential still exists in the form of higher fringe benefits such as housing assistance for example.

leave the south where they are unable to find jobs and move to the isolated regions where they can. Because these workers are forced out of the south by unemployment rather than attracted to the north by high wages, we would expect turnover to be high in the north. How the total wage bills move depends on the self-elasticities and cross-elasticities of demand and supply which can only be determined by empirical estimation.

Figure 6

Illustrative Breakdown of Labour Market for Loggers in British Columbia



Appendix

THEOREMS FROM A CONTINUOUS FACTOR SUBSTITUTION WORLD

A major concern of the reader may be that the above theorems about the role of natural resources in regional economic activity in multi-sectoral economies may be dependent upon the assumptions of fixed coefficients of production. Fortunately, they do not. While one could redevelop the neoclassical factor pricing literature here, we shall content ourselves with demonstrating the "separation theorem" in factor pricing in a neoclassical trading world -- that factors of production such as labour which are used in the production of all goods have their prices determined independently of the supplies of other factors of production such as natural resources which are used in the production of certain goods but not in all. Before doing that, we shall present the "wrong" model of natural resources to demonstrate how, by choosing the wrong assumptions (implicitly assuming a one-sector growth model), one could be led to the conclusion that a change in that natural resource endowment actually would raise a region's wage rate and standard of living.

1. The One-Sector Growth Model Can Support the Traditional Belief that an Increase in the Natural Resource Endowment Will Raise the Wage Rate and Per Capita Standard of Living

Notation: Q is aggregate regional output (the numeraire),

L is annual labour services growing exogenously at annual rate λ,

K is annual capital services supplied exogenously in unlimited amounts from outside the region at a given interest rate r_o,

D is annual resource services growing exogenously at rate μ,

F(L, K, D, t) is a constant returns to scale aggregate production function subject to technological change which makes some of its parameters a function of time, t, and

$d = \frac{D}{L}$ is resource services per man.

The Model:

Output

(1) $Q(t) = F[L(t), K(t), D(t)]$

Factor Supplies

(2) $L(t) = L_o e^{\lambda t}$

(3) $K(t) \to \infty$ at $r = r_o$

(4) $D(t) = D_o e^{\mu t}$

Perfectly Competitive Factor Price Relations

(5) $W(t) = F_L$ (wages = marginal product of labour)

(6) $r_o = F_K$ (interest = marginal product of capital)

(7) $R(t) = F_D$ (royalties = marginal product of resources)

Equilibrium Growth Rates

(8) $\dot{Q}/Q = H(d, r_o)\ \mu + G(d, r_o)\ \lambda$

(9) $\dot{W}/W = H^*(d, r_o)\ \mu + G^*(d, r_o)\ \lambda$

where H, G, H*, and G* are continuous functions.

Comments: The model traces the dynamic path of maximal potential growth because demand for output is unlimited at the price of unity and the model is at continuous full employment equilibrium.

If technical advance is ignored, the rate of growth of output and wages can in principle be separated into a part accounted for by growth in resource services and a part accounted for by growth in the labour force, as shown in (8) and (9).

2. The Two Sector Growth Model Confirms the Fixed Coefficient Result: Wages Are Determined in the Non-Primary Sector

Notation: Subscripts 1 for primary sector, 2 for nonprimary sector.

Time notation, t, suppressed, but all variables are a function of time.

p = price of primary product relative to the price of nonprimary product which is numeraire.

The Model:

(1) $Q_1 = F(L_1, K_1, D)$ primary output

(2) $Q_2 = G(L_2, K_2)$ secondary output in value-added form

(3) $L_1 + L_2 = L_o e^{\lambda t}$ labour supply

(4) $K_1 + K_2 \to \infty$ at $r = r_o$ capital supply

(5) $D = D_o e^{\mu t}$ resource supply

(6) (7) $W = pF_L = G_L$

(8) (9) $r_o = pF_K = G_K$

(10) $R = pF_D$

competitive equilibrium in factor markets

(11) $p = p_o$ demand condition for final products.

Solution is Sequential:

Assuming constant returns to scale, Equation (9) becomes

(12) $r_o = G_K = g'(k_2)$

where $g'(k_2)$ is the marginal product of capital and k_2 is capital per man. Hence, by (12) the external interest rate uniquely determines k_2^*, the equilibrium capital per man.

Using k_2^* from (12) in (7), one ascertains that

$$(13)\quad W = G_L = g(k_2^*) - k_2^* g'(k_2^*)$$

where $g(k_2)$ is output per man. Hence, the equilibrium level of k^*_2 establishes the equilibrium wage W without mention of primary sector number one.

Given equilibrium factor prices W* as determined in (13), the exogenously determined interest rate r_o and terms of trade p_o, Equations (6) and (8) jointly determine equilibrium capital per man k_1^* and resources per man d* in the primary sector. They can be rewritten as two simultaneous equations in two unknowns:

$$(14)\quad W^* = p_o[f(k_1, d) - k_1 f_1(k_1, d) - df_2(k_1, d)]$$

$$(15)\quad r_o = p_o f_1(k_1, d)$$

where the function f defines output per man in the constant returns to scale primary sector.

Given resources supply D* from (5) and resources per man d* from the solution of (14) and (15), the equilibrium labour allocation to the primary sector is

$$(16)\quad L_1^* = D^*/d^*$$

and the equilibrium output of the primary sector is determined as

$$(17)\quad Q_1^* = L_1^* f(k_1^*, d^*)$$

The remaining labour is

$$(18)\quad L_2^* = L - L_1^*$$

which determines the level of output in the secondary sector as

$$(19)\quad Q_2^* = L_2^* \, g(k_2^*)$$

Comments: Since wages are determined entirely outside the primary sector, resource endowments cannot influence it as long as the economy produces both products.

Regional economies that have the same technology and face the same relative product prices and interest rates must have the same factor prices regardless of their relative resource endowments.

An increase in a region's resource endowment, ceteris paribus will increase the size of the primary resource sector and diminish the size of the nonprimary sector. It will generate a capital inflow and an increase in interest payments to foreigners if the primary sector is relatively more capital intensive.

The sole increase in gross regional product caused by an increase in natural resource endowment is accounted for by the increase in royalties paid for natural resource services.

To the extent that wages in the real world differ from region to region by reason of differences in natural resource endowments, or differences in the rates of discovery of natural resources, those differences must be linked to other factors such as differences in transport costs, differences in technology, different market impediments, slow speeds of adjustment, etc., which are explicitly excluded by the assumptions of this model. Differences in natural resource endowments alone cannot explain regional wage differentials.

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