INFRASTRUCTURE, HUMAN CAPITAL
AND INTERNATIONAL TRADE

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It is by now a trite commonplace that we live in an increasingly integrated global economy, in which the barriers to the free movement of goods and capital, though not labor, are rapidly disappearing as a result of both policy reforms and the progress of technology in transport and communications. The rhetoric as well as the substance of national economic policy is now preoccupied with the problem of how each country can hope to survive and prosper in a world where capital controls and trade restrictions are off the agenda. Is the simple laissez - faire principle of simply doing nothing correct, or is there anything an activist government might usefully strive to accomplish? With the global pool of capital at any instant restlessly searching for the highest return, regardless of borders, a popular prescription has come to be the provision of public infrastructure and the training and education of the labor force. With these measures the nation can attempt to secure for itself a higher share of the global capital stock and thus ensure for itself higher wages and better quality jobs for its own labor force.

This approach to the role of public policy at the national level has been articulated most extensively in the well-known book by Robert Reich (1991), currently Secretary of Labor in the Clinton Administration. Though the book has been favorably reviewed in the popular press, it has basically been ignored by academic economists. This seems to me to be a pity since very

much of interest remains to be learned about the combined impact of such measures on trade flows, capital movements and factor rewards as well as the appropriate response in terms of these measures to exogenous external shocks. The recent preoccupation of trade economists with so-called "strategic trade policy" seems, by contrast, already to be somewhat *passè* with the waning of confidence in selective industrial policies that attempt to "pick winners". Measures such as the provision of public overhead capital and the education and training of the labor force raise the <u>general</u> level of economic performance even though some sectors may be more sensitive and responsive to such support than the economic system as a whole. These policies are entirely consistent with Adam Smith's delineation of the "duties of the sovereign" in Book IV of the <u>Wealth of Nations</u> and do not constitute distorting intervention in the working of competitive markets.

To even begin an adequate treatment of these issues one requires an analytical framework that explicitly incorporates the role of government in the economy as the provider of law and order, enforcer of contracts and so on without which the transactions of the private sector would take place under conditions of anarchy. An approach that I have taken in Findlay and Wilson (1987) and in several recent papers with Richard Clarida is to model government as providing a public intermediate input that constitutes a collective externality to all private industries and activities, thus enhancing their productivity.

The rest of this paper provides an integrated survey and summary of the main themes of this body of work.

(i) The Optimal Size of Government

Before considering applications to international trade and factor mobility it will be useful to look at the simplest possible demonstration of the role of government as the provider of public intermediate inputs. What follows is an outline of the approach first adopted in Findlay and Wilson (1987).

This model is specified by postulating an aggregate production function

$$Y = A(L_g)F[K, L_P] \qquad\qquad (1)$$

in which $F[K, L_P]$ is an ordinary neoclassical production function with positive first derivatives, negative second derivatives for each factor and a positive cross-derivative. The novelty is in the "scale coefficient" $A(L_g)$ in which

$$A'(L_g) > 0, A''(L_g) < 0, A(0) = 1$$

where L_g is labor hired by the government to provide the public intermediate input $A(L_g)$ that enhances the private production function $F(K, L_p)$, where K is capital and L_p is labor in the private sector. We also have

$$L_g + L_p = L \qquad\qquad (2)$$

where L, the total supply of labor, is given.

More L_g makes the private sector more productive but drains labor from the fixed pool. Thus $Y(L_g)$ is a concave function that has a well-defined maximum at the point where the marginal productivity of labor in the two uses, government and private, are equal. This first order condition is

$$F[K, L_p]A'(L_g) = A(L_g)\frac{\partial F}{\partial L_p} \qquad\qquad (3)$$

It is apparent that the optimal solution is for L_g to be at the level L_g^* that satisfies (3). This solution is implemented by a proportional tax on national income Y that is just sufficient to enable the government to hire L_g^* at the wage w, equal to the marginal productivity of labor in the private sector. Thus

$$tY(L_g^*) = wL_g^* \qquad\qquad (4)$$

completes the specification of the optimal size of government.

In Figure 1 the concave function is government revenue $tY(L_g)$ which is simply proportional to national income as a function of L_g, namely $Y(L_g)$. The positively sloped function wL_g is government expenditure. It is convex upward because the wage w increases with government employment L_g, because the marginal

productivity of labor in the private sector is an increasing function of L_g.

The model can also be used to illustrate government as a self-interested "Leviathan" instead of an enlightened despot or Platonic guardian. Thus, in Figure 1, even if the Leviathan is obliged to obey the tax function $tY(L_g)$ he will not provide the socially optimal level L_g^* of public employment. Instead he will maximize his surplus, equal to the vertical distance between the revenue function $tY(L_g)$ and the expenditure function wL_g. This is the point at which their slopes are equal, at $\hat{L}_g$ level of public employment. The maximized surplus $tY(\hat{L}_g)$ minus $w\hat{L}_g$ is available for the personal disposition of the sovereign, on himself or his chosen favorites.

Alternatively, instead of a surplus-maximizing monarch or dictator, society may be at the mercy of a bureaucracy, *à la* Parkinson or Niskanen. Thus if the tax rate were to be higher than what is just sufficient to attain the optimum, the expenditure function wL_g will interest the concave revenue function $tY(L_g)$ on its falling portion. The bureaucracy, if it operates unchecked, will then exhaust the budget at public employment equal to $\tilde{L}_g$, even though this is a palpable waste of society's resources.

The model, though extremely simple, thus has the virtue of demonstrating not only the optimal size of government but also

the "political economy" of deviations from the optimum in either direction because of the principal-agent problem as it arises in the context of the state. Monitoring the state, or "guarding the guardian," is no easy task.

(ii) Infrastructure and Comparative Advantage

The one-good closed economy model of the previous section is extended into a much richer general equilibrium context in Clarida and Findlay (1991, 1992). The key idea here is to divide the private sector into two branches, one producing technologically advanced or "hi-tech" goods, which we take to be particularly sensitive to the provision of infrastructure in the form of the public intermediate input, and traditional goods that are less responsive in this regard. In addition, we distinguish between "productive" government expenditure such as we have been considering, on the one hand, and the provision of direct final public services of the "welfare state" type on the other. This enables us to look at differences in social "tastes" for the two types of government activity and to trace the consequences for production, trade and factor rewards.

The technology in this model is given by

$$T = A(L_A)K^{\delta}L_T^{(1-\delta)} \tag{5}$$

$$W = A(L_A)^{\mu}N^{\delta}L_W^{1-\delta} \tag{6}$$

where T and W stand for "Tech" and "Wheat", K for "capital" and

N for "land", which are the "specific factors" in the Ricardo-Viner model as introduced by Jones (1971). The Cobb-Douglas specification is for convenience and the common labor elasticity $(1-\delta)$ is to avoid gratuitous asymmetry between the two sectors. The key assumption is that

$$0 < \mu < 1$$

so that the Tech sector is more responsive to the public intermediate input $A(L_g)$ than Wheat.

We also introduce final public services as L_s into the model so that we have

$$L_A + L_S + L_T + L_W = L \qquad (7)$$

All agents have an identical and homothetic utility function

$$U = U(c_T, c_W) \qquad (8)$$

where c_T and c_W are the per capita consumption of Tech and Wheat.

The over-all utility function V is separable in final public services S (equal to L_S) and U so that we have, for convenience again

$$V = S^\lambda U^{(1-\lambda)} \qquad (9)$$

where λ is the weight attached to public services in overall

utility.

Profit maximization in the private sector will equate the
marginal products of labor in Tech and Wheat to the common real
wage, simultaneously determining also the returns to each of the
specific factors. Labor in the public sector, both L_A and L_S,
will receive the same real wage as in the private sector. The key
efficiency condition is therefore that the marginal productivity
of labor in providing the public intermediate input must be equal
to the wage, so that we have

$$pK^{\delta}L_T^{1-\delta}A'(L_A) + N^{\delta}L_W^{1-\delta}\mu A'(L_A)^{\mu-1} = w \qquad (10)$$

where p is the relative price of Tech and w is the wage.

Notice that the marginal productivity of L_A is the
Lindahl-Samuelson "vertical" sum of its contributions to <u>both</u>
production sectors.

While the reader must turn to the originals for the details
of the solution, the flavor of the results can perhaps be
apprehended intuitively. One can construct the excess supply
function $E_T[p, L_A(p)]$ of Tech in which

$$\frac{\partial E_T}{\partial p} > 0, \frac{\partial E_T}{\partial L_A} > 0, \frac{\partial L_A}{\partial p} > 0$$

To derive these properties let us first hold L_S constant.
Next observe that when L_A is held constant the model behaves

exactly as in the standard Jones Viner-Ricardo model. Raising p will thus increase the supply of T and reduce the demand for it, while the opposite is the case for W. Thus, we see that the first property obviously holds. Increasing L_A while holding p constant expands Tech relatively more than Wheat because μ is between zero and unity while demand for both increases by a weighted average of the two supply increases, thus increasing E_T, so that the second property holds. The third property follows from the fact that the rise in p makes Tech more valuable and hence raises the social benefit at the margin from having more L_A.

The equilibrium value of p, and hence of L_A and the whole system, for the given value of L_S, is found by putting $E_T[p,L_A(p)]$ equal to zero. The per capita production levels of Tech and Wheat, fed into the utility function U of (8), give us $U(L_S)$, the equilibrium level of per capita utility for the given value of L_S.

It is obvious that raising L_S will reduce U, since K and N are fixed and $(L-L_S)$ is now smaller. We thus have a negativity sloped possibility frontier between U and L_S on which the overall utility function V can be superimposed to determine the optimal values of L_S and U. Letting the excess supply function $E_T[p,L_A(p)]$ be the one defined for the optimal value L_S^* of L_S we obtain p^*, L_A^* and the full optimal values of the rest of the

system.

We now introduce international trade. Of course differences in factor endowments or technology will obviously create a basis for trade, in this context as in more traditional settings. It is perhaps more interesting to explore the consequences of just a single difference, the relative weight of final public services λ in the overall utility function V defined in (9). Thus our two countries will be identical in endowments of K, N and L and in technology and "private" tastes as defined in the sub-utility function U in (8).

Under these circumstances the possibility frontier $U(L_S)$ will be the same for the two countries but the one with a higher value of λ in its overall utility function V will have a higher L_S^* and a lower U^* in autarky. It is apparent that the higher L_S^* will imply that its autarky excess supply function $E_T[p,L_A(p)]$ will be shifted to the left as compared with the other country since the lower $(L - L_S^*)$ will imply a lower value of L_A^*. Thus p^* in autarky will be higher, along with the lower L_A^*, as indicated in Figure 2.

Thus the preference for S will imply that the production functions for both T and W will be Hicks – neutrally inferior in this country, though differentially more so in T, because of the lower value of the public intermediate input L_A^*. The relative scarcity of Tech is reflected in the higher p^* in autarky. What

happens when free trade is opened between the countries? The equilibrium condition is now that world excess supply be zero, instead of each national one individually. The world equilibrium price p_W^* will be in between the two autarky prices, falling in the high λ country and rising in the low λ one, again as depicted in Figure 2.

Since trade raises p^* in the low λ country, i.e., it moves up its positively sloped excess supply function, L_A^* will increase as well and so it would appear that trade induces Hicks-neutral technological improvements in both T and W, though differentially more in T, as compared with autarky. In addition there is of course the rise in L_T because of the rise in p^*, for any given value of L_A, while L_W contracts.

In the high λ country, on the other hand, L_A falls along with p^* and so absolute efficiency declines in both production functions, relatively more so in T. The gain to the high λ country from trade is of course that it expands L_S^*, final public services, which it cares relatively more about at the margin.

Wages and the return to capital both rise in the low λ country as a result of trade and even the fall in the return to land is mitigated by the rise in L_A^* which augments productivity in Wheat. In the high λ country, on the other hand, wages and the return to capital both fall and only the return to land increases.

It is evident that this model has features that cannot be found in the standard trade models. The main novelty is the "endogeneity" of the technology in response to the relative price changes induced by the opening to trade. Notice that these are not assumed ad hoc but are the consequences of rational government action in a first - best setting that scrupulously respects the preferences of private agents. While "infrastructure" is sometimes, though not frequently, invoked in trade contexts it has never, to the best of my knowledge, been endogenized explicitly in a general equilibrium setting rather than merely playing a passive role as an underlying structural factor.

International capital mobility can also be introduced quite readily into the model. As we have seen the rate of return to capital is boosted by trade in the Tech exporter and lowered in the Wheat exporter. This occurs not only because of the relative product price change, as in the standard Viner-Ricardo model, but more importantly because of the induced productivity changes due to the expansion or contraction of the public intermediate input. If we postulate the perfect mobility of capital across borders, in addition to free trade in goods, the Tech exporter will receive an inflow of capital from the Wheat exporter. This of course leads to more Tech production at constant relative product prices in the low λ country and less in the high λ country. Thus, L_A will expand in the former and contract in the latter, inducing further adjustments of Tech production in the same

direction as induced by the opening to trade. Capital mobility, however, because it leads to a world excess supply of Tech at the original free trade price ratio, will induce a deterioration in the terms of trade of the Tech exporter relative to free trade alone. This cannot, however, overturn the direction of the sharp changes in productivity, wages and the return to capital noted earlier.

(iii)   Infrastructure, Human Capital and International Capital Mobility

The role of human capital in international trade first came into prominence in connection with explanations for the Leontief Paradox. Thus Kenen (1965), for example, added measures of human to physical capital for exports and import-competing production and found exports to be slightly more capital-intensive on the whole than the import-competing sectors, thus "resolving" the Paradox . Several other papers strongly established the proposition that the U.S. enjoyed a clear comparative advantage in skill-intensive products and that developing countries, on the other hand, were competitive in products that were more intensive in raw labor. Findlay and Kierzkowski (1983) first incorporated endogenous wage differentials and human capital formation into an explicit two-country general equilibrium trade model, thus providing a theoretical basis for these empirical results.

While the model of the previous section incorporates "infrastructure" into a standard trade model, it leaves open the

interesting interactions between infrastructure conceived as a
public intermediate input and education and human capital
formation which, though often publicly financed and provided, are
nevertheless essentially private goods. As we have seen, Robert
Reich and other policy advocates have made much of both
infrastructure generally and education of the work force as
ingredients of a strategy towards trade and growth that does not
involve selective intervention or "picking winners" as in
so-called strategic trade policy.

Both the work of Reich and the German concept of
Standortswettbewerb, or "locational competition", stress the role
of infrastructure and education in acting as "magnets" to attract
the pool of global capital to be diverted within their borders.
Thus the Marxist historian Eric Hobsbawm (1994), in his
stimulating new book on the history of the present century, could
not be more wrong when he states (p. 281) that "The most
convenient world for multinational giants is one populated by
dwarf states or no states at all." On the contrary ,
multinationals like strong, politically stable states that can
provide infrastructure and educated labor forces, neither of
which are extensively available in most of the feeble and corrupt
"soft" states that are all too evident in much of the Third
World. Thus, Singapore, the favorite locale for multinational
corporations from all over the developed world, is a proverbially
tough, independent and intrusive state. What makes it so popular
as a host country for direct foreign investment is precisely its

superb infrastructure and educated population, neither of which could have been built up without a conscious effective state policy.

Once again, we need an appropriate framework within which to study the role of these factors. In Findlay (1994) I develop a model that attempts to do this. It postulates a small open economy that takes relative product prices and the interest rate as given by the outside world. It produces two goods, one a "hi-tech" sector and the other a "traditional" sector. Both use physical capital, in perfectly elastic supply at the world interest rate, but the advanced sector uses skilled labor and the traditional one only raw labor. There is an endogenous process of human capital formation determined by relative wage differentials and the cost of education. The government can provide final public services or a public intermediate input that impacts differentially on the two sectors as in the model of the previous section.

The production functions for the two sectors, now designated X any Y are:

$$X = A(L_A)F_X[K_X, S] \tag{11}$$

$$Y = A(L_A)^\mu F_Y[K_Y, L_Y] \tag{12}$$

in which $A(L_A)$ has the same properties as before and μ is again between zero and unity. Skilled labor, used exclusively in the

X sector, is denoted S, while L_Y is raw labor allocated to production in the Y sector. L_A as before is employment engaged in providing the public intermediate input. K_X and K_Y denote physical capital allocated to the respective sectors. Denoting unskilled labor used to provide final public services as L_S we have the labor force constraints

$$S + L = N \qquad\qquad (13)$$

$$L_A + L_S + L_Y = L \qquad\qquad (14)$$

where N is the total number of workers, skilled and unskilled, that is available.

Letting $\bar{p}$ denote the fixed world relative price of X and $\bar{r}$ the interest rate, profit maximization results in

$$\bar{p}\frac{\partial X}{\partial K_X} = \bar{p}A(L_A)\frac{\partial F_X}{\partial K_X} = \bar{r} \qquad\qquad (15)$$

$$\frac{\partial Y}{\partial K_Y} = A(L_A)^{\mu}\frac{\partial F_Y}{\partial K_Y} = \bar{r} \qquad\qquad (16)$$

$$\bar{p}\frac{\partial X}{\partial S} = \bar{p}A(L_A)^{\mu}\frac{\partial F_Y}{\partial S} = v \qquad\qquad (17)$$

$$\frac{\partial Y}{\partial L_Y} = A(L_A)^{\mu}\frac{\partial F_Y}{\partial L_Y} = w \qquad\qquad (18)$$

where v and w denote the factor rewards of skilled and unskilled labor respectively. Note that because of constant returns to scale the marginal products of the two private inputs in each

sector are functions only of the ratio of these inputs in each case.

Efficiency in the provision of the public intermediate input requires that

$$\bar{p}F_X A'(L_A) + F_Y \mu A'(L_A)^{\mu-1} = w \qquad (19)$$

where the left-hand side is the marginal value product of labor in infrastructure. Note that it is the Lindahl-Samuelson "vertical" sum of its contribution at the margin to each of the two private production sectors that it influences. Total government expenditure is

$$E = w(L_G + L_A) = t[\bar{p}X + Y] \qquad (20)$$

which has to be equal to revenue obtained by a proportional tax t on total national income $[\bar{p}X + Y]$.

The preference side of the model is exactly analogous to the model of the previous section so that equations (8) and (9) apply.

Finally, we introduce the endogenous formation of human capital. The rate of return on human capital is defined as

$$\rho = \rho(\theta, S) \qquad (21)$$

where θ is the ratio of the skilled wage v to the unskilled wage w. It is natural to postulate that

$$\frac{\partial \rho}{\partial \theta} > 0, \frac{\partial \rho}{\partial S} < 0$$

i.e., that a rise in the ratio of v to w raises the return on human capital while a rise in the stock of skilled workers reduces it, due say to congestion in the education system that trains the flow of new entrants that would be needed to replace departures in the steady state, as in Findlay and Kierzkowski (1983).

The equilibrium condition for the supply of skilled labor is that

$$\rho(\theta, S) = \bar{r} \qquad (22)$$

i.e., the return on human capital must be equal to the world rate of interest and hence to the domestic marginal product of physical capital in the two sectors.

The solution of the model can once again be briefly outlined. In spite of the difference in structure, it is essentially similar to the solution of the previous model. First, take L_S and L_A as fixed. Once again we then essentially have the Jones (1971) model. The ratio of S to K_X and of L_Y to K_Y, are uniquely determined by (15) and (16) for the given value of L_A, and hence the wage rates v and w as well from (17) and (18). The ratio of v to w determines θ and so the value of S that satisfies (22). From (13) and (14) this determines L and L_Y and so K_X and K_Y from the production functions. After allowing

for net interest payments to or from abroad we can compute
national income and hence per capita consumption and the level of
utility U.

Continuing to hold L_S constant we now vary L_A. Computing
the Lindahl - Samuelson marginal product of L_A from (19) and
comparing it with the wage w we can decide whether L_A is to be
increased or reduced. Suppose the left hand side of (19) exceeds
w, so that L_A has to be increased. Note that this will raise
both v and w by equations (15) to (18), but v proportionately
more than v because μ is between zero and unity. Hence

$$\frac{\partial \theta}{\partial L_A} > 0$$

and so S must rise to make (22) continue to hold and L_Y must
fall. This raises X and reduces Y but increases U since the
endowment of the economy is now more favorable because of the
improvement in the skill composition of the labor force induced
by the increase in L_A which is still below the optimal level. If
L_A continues to increase, its marginal product will fall because
$A''(L_A)$ is negative and will eventually equal the wage in the
private sector, which <u>rises</u> as L_A is increased. Thus U reaches
a maximum, for the given value of L_S, when (19) is satisfied.
This gives us one point on the $U(L_S)$ possibility frontier as
defined in the case of the previous model. Raising L_S and

repeating the argument we must get a lower maximal value of U because total labor input $(N-L_S)$ is less. Thus we can trace out the whole $U(L_S)$possibility frontier as before and obtain the optimal solution as the point where it is tangential to an indifference curve as specified by the overall utility function (9).

Note that the lower is the weight λ assigned to L_S the greater is U, L_A, S, X, v and w in the optimal solution. The less weight given to final public services and the more to private consumption and hence infrastructure, the greater is the skill composition of the labor force, the higher is both the skilled and the unskilled wage and the larger is the output of the "high-tech" X sector.

In closing, it is of interest to consider a little further the basis for the overall utility or social welfare function V that we have simply been postulating until now. One possibility is that all individuals have the same sub-utility function U for consuming private goods X and Y but that they differ in λ, the relative weight attached to public services. Under these circumstances we could represent the λ of the model as that of the median individual, the so-called "median voter" approach in political economy. More appealing to me, however, is the thought that there is an "autonomy of the state" in choosing what implicit λ to adopt. Thus, a welfare state of the Scandinavian type could choose a high λ, giving considerable

weight to public services and thus sacrificing infrastructure and hence productivity in the private sector and comparative advantage in the "hi-tech" production. The East Asian "capitalist developmental state" of Chalmers Johnson (1982), on the other hand, would choose a low λ and thus emerge as a highly competitive Tech exporter due to the heavy infrastructure and highly skilled labor force it obtains as a result of this implicit choice. In short, "government matters".

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$tY(L_g)$

0

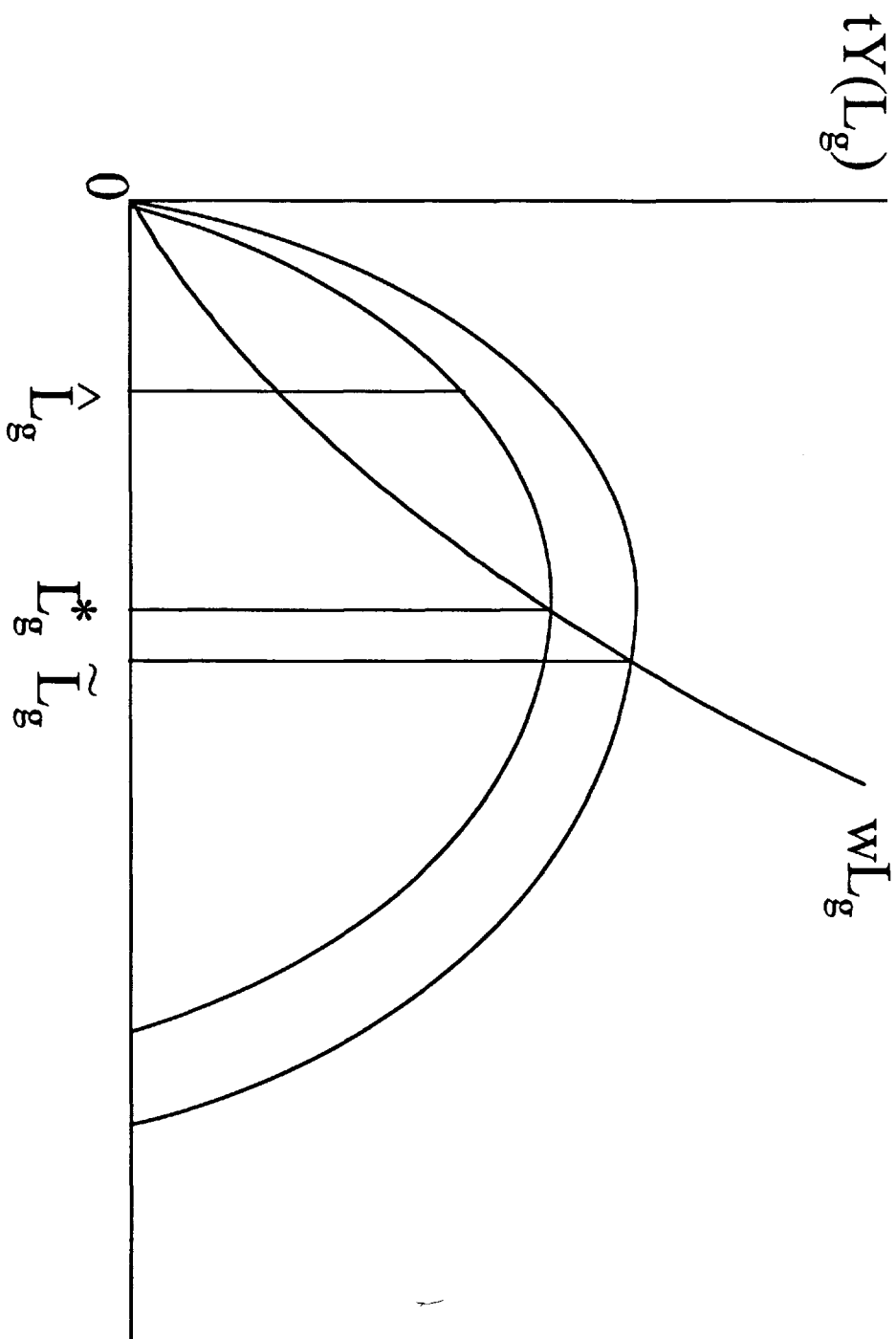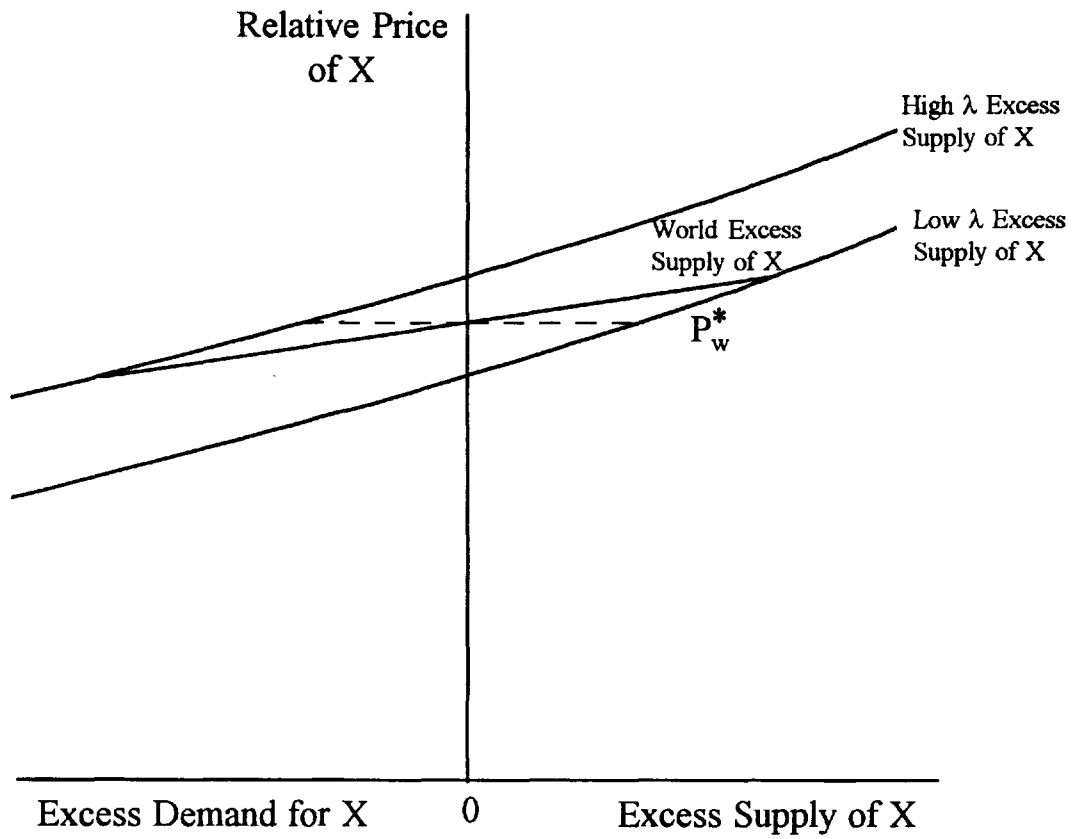$\hat{L}_g$

$L_g^* \tilde{L}_g$

wL_g

Figure 1

Figure 2

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