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## The Effect of Immigrants on Natives' Incomes Through the Use of Capital

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Abstract

This paper deals with questions about the effects of immigrants on three types of capital: the private capital immigrants work with, the public (government) capital that immigrant workers use, and the public capital used for services by immigrants.

Private capital dilution is unimportant. The overall effect is perhaps 1 percent or 2 percent, small enough to ignore.

In the government sector, workers can be assumed to obtain all the returns to capital, and about 8 percent of immigrants work in this sector. Therefore, for productive capital taken altogether, we estimate that immigrants capture the returns from only 8 percent of the capital they work with, the government capital; the result is a loss of perhaps 2 percent of an immigrant family's income for one year, which is about the same magnitude as the gain to natives through the private capital that immigrants work with.

The cost to natives of equipping an immigrant family with "demographic capital" -- schools, hospitals, and local roads -- turns out to be much more important. This quantity depends upon the cost of such equipment, the proportion financed by bonds, the average length of life of the capital, and the average life of the bonds. We develop an estimating equation, and calculate that the cost to natives in 1975 dollars is $4172, about a fifth of a year's income for an average family. This is not insignificant in magnitude. But this amount -- together with the effect through productive capital dilution discussed in the first part of the paper -- is considerably smaller than the benefits of immigrants to natives through their relatively low use of welfare services and their relatively high contribution of taxes.

# THE EFFECT OF IMMIGRANTS ON NATIVES' INCOMES THROUGH THE USE OF CAPITAL

Julian L. Simon and A. James Heins*

## INTRODUCTION

Immigrants are a bad deal for natives because they obtain benefits from capital they do not pay for, according to Usher (1977). Usher reached this conclusion for the U.K. by applying the concept of capital-returns capture developed by Borts and Stein (1966), and by Berry and Soligo (1969) B-S-B-S hereafter. The same conclusion would surely follow for the U.S. and other developed countries if one followed Usher's method.

This paper criticizes Usher's method of applying the capital returns concept, and proposes a new approach. This is also a criticism of Simon's earlier inadequate use of the same concept in the context of Russian Jewish immigrants into Israel (1976). The approach offered here leads to a less negative partial assessment of the effects of immigrants on native's incomes in the U.S. by way of the returns to capital than did the previous work.**

A key element in this approach is separating the analysis of "production" capital used on the job by immigrants from "demographic consumption"

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*We appreciate comments from Warren Sanderson, Oded Stark, Dan Usher, and a Hoover Institution seminar group.

**For perspective we should note that the effects through capital use are only a small part of the overall impact of immigrants upon natives. Elsewhere one of us shows (Simon, 1981) that the net balance of transfer payments and taxes is positive and outweighs the negative capital-returns aspect of the immigrant native's relationship to natives that we shall find here, leading to a positive net effect of immigrants' effect on natives, even without including the positive effect of immigrants upon productivity.

capital used in such services as schooling and medical care. Within the production capital analysis, a key element is distinguishing the effects in the private and public sectors. And with respect to demographic capital, a key element is recognizing that the benefits which immigrants obtain from existing public capital are irrelevant unless there is a congestion effect, because the existing capital's cost is sunk and largely has a public-goods character. This approach allows us to avoid difficult issues, including the interpretation of corporate taxes, which are present in Usher's and Simon's earlier approach.

## THE SIZE OF THE CAPITAL-RETURNS-CAPTURE EFFECT*

Estimating satisfactorily the amount of the capture of returns to capital by immigrants requires that we be very careful about our aim. We must agree that the main subject of inquiry is the creation of additional output by the immigrant, and its effect on natives. It is vital to recognize that the effect of this additional output upon the immigrant himself/herself is not part of the inquiry; Usher (1977) implicitly did not see it that way, nor did Simon earlier (1976), and therefore those papers simply estimated the proportion of the total capital in the society from which immigrants might receive returns either because the capital is owned privately or because of corporate and other taxes in the returns to capital. And of course the effect on the persons remaining in the land of emigration is not part of the subject here.

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*Capture of capital returns" means simply the receipt of payments made to owners of private productive capital through dividends, interest and rent.

Let us begin (adopting Usher's notation, diagram and general approach for comparability) by noticing that the output with an immigrant ($Q + \Delta Q$), just as output without the immigrant ($Q$), is divided among three types of recipients--the immigrant employee, the owner of the industrial capital, and the "government."

(1) $$Q = Q_p + Q_g = wL_p + rK_p + Q_g(=T)$$

$$Q + \Delta Q = Q_p + \Delta Q_p + Q_g + \Delta Q_g = (w+\Delta w)(L_p+\Delta L_p) + (r+\Delta r)(K_p+\Delta K_p) + (T+\Delta T)$$

where $Q$ = native output

$p$ = the private sector

$g$ = the government sector

$w$ = the wage level without immigrants

$L$ = labor force without immigrants

$r$ = after-tax rate of return to capital without immigrants

$K$ = capital stock without immigrants

$T$ = total taxes without immigrants

$\Delta$ = an incremental quantity, the difference between the situation with immigrants compared to the situation without immigrants.

We define private capital's "share" as what owners of capital receive after taxes. It would not seem sensible to discuss whether the taxes paid to government--corporate and "indirect"--come out of "capital's full share" or not; no definition of "capital's full share" would seem to make sense here, as consideration of these two notions shows: (1) No economist would like to argue that "capital's full share" is "capital's just share." (2) The share of the output that capital would receive if

government took no taxes is not obviously different (to a first approximation) from the share that capital receives after taxes, because we can assume that capital owners will bid up to their margins for the immigrant's services, and their marginal calculations will include the tax effects of hiring the immigrant. So there is little reason to argue that the share that capital actually receives is different than an ideal "capital's share" or "capital's full share."

Focusing now on the private sector, if capital's share is what it receives, then the only way that an immigrant working in the private sector can receive some part of the additional private product ($\Delta Q_p$) other than his own marginal product is through corporate tax payments. Therefore, we must inquire into the nature of the additional corporate taxes paid ($\Delta T_p$) due to the immigrant's arrival and consequent additional outputs.

The total additional taxes ($\Delta T$) following on the immigrant's entry at least balance the additional expenditures (e.g., on schooling and transfer payments) that occur because of the immigrant. (Simon's recent work, 1981, finds that immigrant families pay distinctly <u>more</u> in taxes than they receive in services, largely because of their age composition). There seems no reason not to think of the corporate taxes that go toward the extra services for immigrants being in the same proportion to total taxes as they are for all persons' services. That is, $\Delta T \geq \Delta G$ and $\frac{\Delta T_p}{\Delta T} = \frac{T_p}{T}$. If so, there is certainly no loss to natives by way of corporate taxes, that is, $\Delta T_p$ is at least as large as the cost of any services to immigrants that it might be expected to cover.

Some of the additional corporate tax payments may be thought of as rent on publicly-owned capital used by the corporation, e.g., roads and dams. And part of this rent may be gained by immigrants, in similar proportion to other citizens. But what matters here is the effect on natives. And the amount of such "rent" obtained by natives is likely to be of a small order of magnitude, by any test, and hence we shall ignore it for convenience (though noting that excluding this factor reduces the apparent benefit of immigrants on natives, because we are ignoring a flow that benefits natives).

The argument so far adds up to the fact that since $\Delta T \geq \Delta Q_g$, which allows us to say that $\Delta T = \Delta Q_g$ and $T = Q_g$, we can rewrite (1) as

(1a) $$Q_p = wL_p + rK_p$$

$$Q_p + \Delta Q_p = (w+\Delta w)(L_p+\Delta L_p) + (r+\Delta r)(K_p+\Delta K_p).$$

If all immigrants worked in the private sector, and we could therefore treat the government sector simply as if it were a foreign company that sells inputs to the private sector, the B-S-B-S analysis would now follow without further ado; immigrants would benefit natives as a whole by the celebrated "triangle" in Figure 1.

But some immigrants work for the government. In that sector there are no returns to capital that natives capture but the immigrant in question does not. A key magnitude then, is the proportion of immigrants that work for the government. This must be compared to the gain from the "triangle" in order to calculate an overall assessment of the impacts of immigrants through their involvement with the capital used in production.

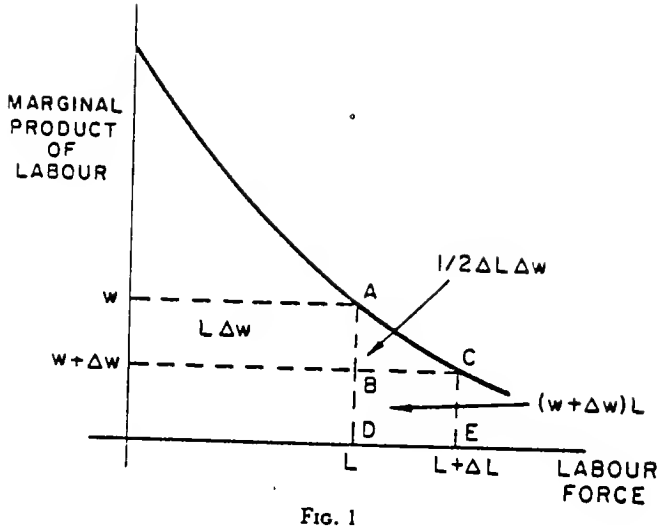
MARGINAL PRODUCT OF LABOUR
1/2ΔLΔw
w
A
LΔw
w+Δw
C
B
(w+Δw)L
D
E
L
L+ΔL
LABOUR FORCE

FIG. 1

Calculation of the Capture of Capital Returns

Let us begin by taking notice, as Usher demonstrated by expanding (1a) in a Taylor series, that the "triangle" of additional returns to the owners of private capital is small when the immigration is realistically small; in the context of Usher's Cobb-Douglas production function example the gain is about 1/219 of the loss in labor income to natives. And in a simulation (1976) Simon found that a flow to immigrants of less than a 2% share of the returns to private capital is enough to offset the triangle. Therefore we can ignore the B-S-B-S effect for practical purposes. In short, then, the gain to native capital and the loss to native labor almost wash each other out, and immigrants who work in the private sector have little effect on native per capita income.

But we must still deal with the public sector, and to do that we must estimate the returns to public capital, by analogy with private capital. Let us make the simplifying assumption that the capital/labor ratio is the same in government as in industry. And for reasons of data availability let us estimate the ratios we need from the non-financial sector and project them to the entire private sector. Let

$W_p$ = the amount paid for their labor to employees in wages and salaries in industry, \$1387 million in 1979

$R_p$ = returns received after corporate taxes by owners for the use of their capital, \$390 million

$Q_p$ = total of employee compensation and after-corporate-tax returns to capital = $W_p + R_p$ = \$1777

$\frac{R_p}{Q_p}$ = proportion of total returns that go to capital = 22%

On standard classical assumptions we may identify the share received by labor as labor's marginal product. That is, the marginal immigrant

receives (100% - 22% =) 78% of the total additional product due to him or her, and the owners of the capital receive 22%. We could also use the stylized 25%-75% split used by Usher without changing our result. And to repeat a point made earlier, if natives own the capital, then the gain to native capital owners balances out the loss to native workers. But if there are no returns to native capital owners, and the immigrant receives the returns to both his/her labor and to the capital he/she works with--as is the case in the public sector--there is a loss to natives due to the capital-dilution effect, which makes the marginal product of labor lower than otherwise. If we assume a Cobb-Douglas production function and the quantity of capital temporarily fixed, returns to native workers would fall by an amount roughly equal to the amount implied by the 22% gain to capital owners.*

To allow for the immigrants working in the public sector, we must obviously know the proportion working in the public sector. From the cohort of persons who arrived between 1965 and 1970, there were in 1970 38,427 males and 24,256 females, out of 454,872 and 309,090 total persons in the cohort employed of age 16 or over, who worked for the government--that is, 8.22%, which is much lower than the 16.5% among natives (U.S. Bureau of the Census, United States Summary, Table 93). For those who arrived 1960-64, 1955-1959 and 1950-1954, the percentages are 6.8%, 7.8%, and 9.0% respectively. Say an average of 8% for all immigrants. (Immigrants arriving more than twenty years earlier are not very relevant to a policy analysis.)

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*Distributional effects are not considered here. In thinking about that topic, it is important to keep in mind that the "worker" class actually obtains much of the returns to capital through capital ownership by pension funds.

If we now assume that the returns to the capital with which the government worker cooperates come to the workers, and assume also the same capital/labor ratio and average salary as in industry, then 8% of the total returns to private plus public capital due to immigrant production flow to the immigrant. This is a far cry from the 58% figure that emerged from Usher's method applied to the U.K.

A more meaningful comparison is the total amount that natives' incomes fall relative to the total wages of immigrants (or relative to the total additional product caused by the immigration). The effect on native's incomes may be calculated as

Effect on natives = Income of natives afterwards minus income of natives before the immigration = total output after minus total output before minus amount going to immigrants in wages and capital capture

$$= (Q+\Delta Q) - Q - [\Delta L(w+\Delta w)] - \phi[K(r+\Delta r)]$$

$$= \Delta Q - \Delta L(w+\Delta w) - \phi[k(r+\Delta R)$$

$$= \Delta L(w+\Delta w) + \Delta K(r+\Delta r) - \Delta L(w+\Delta w) - \phi[R(r+\Delta r)]$$

where $\phi$ is the proportion of the returns to capital captured by the immigrants.

And because $\Delta K = 0$ we can simplify

Effect on natives = $\phi[K(r+\Delta r)]$

which is the total amount of the returns to capital that is captured by immigrants. In Usher's calculation $\phi = .58$, whereas in our calculation $\phi = .08$*. The ratio of the effect on natives to the total wages of immigrants, then, is $\frac{\phi[K(r+\Delta r)]}{\Delta L(w+\Delta w)}$. With Usher's $\phi$ this ratio is about

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*Usher's calculation is for the U.K., whereas ours is for the U.S., but that difference is a minor matter in this context.

.199, whereas with our $\phi$ the ratio is about .028 using Usher's 75% share to labor, or .025 using the above-calculated 78% share to labor.

The difference in implications between Usher's figure and ours is major no matter how you look at it, whether from an average native's point of view, an average native worker's point of view, or anyone else's pocketbook point of view. And a major policy implication of this difference appears in a more global analysis of the effects of immigrants. In the U.S. the balance of taxes and welfare expenditures is such that natives gain considerably from the presence of the average immigrant family, on a present value basis. On Usher's calculation, the loss to natives on the production-and-income side would more than off-balance the tax-and-welfare gain. Using our calculation this is not so; the average family's net contribution to the public coffers far outweighs the loss to natives through immigrant's capture of the returns to capital.

## CALCULATION OF THE BURDEN OF DEMOGRAPHIC CAPITAL WIDENING DUE TO IMMIGRANTS

Above we discussed the dilution of public and private "production" capital as it affects the earnings of natives. We must now also consider public capital that immediately yields consumption benefits to natives and immigrants, and whose use is subject to congestion. This includes such "demographic capital" as schools and hospitals; more immigrants imply that more of such capital is needed if service standards are not to fall. On the other hand, the Statue of Liberty, intercity highways, and space exploration installations pretty clearly are public goods whose use by natives is unaffected by the number of immigrants. Some

capital, such as new highway construction around cities, and new physics laboratories at universities, is difficult to classify, but luckily most public capital falls pretty clearly into one or another of these two categories.

A simple yet satisfactory rule of thumb* is that most chunks of federal capital are true public goods, while most chunks of local and state capital are demographic and subject to congestion. The state-and-local category corresponds fairly closely to the categories of education and hospitals and local roads. It would probably be possible to work with the latter functional categories rather than with the federal versus state-and-local distinction, but the results would not likely be substantially different.

It may help to begin with this question: Why does any community allow additional native American persons to move into the tax district without assessing penalties to pay for the public capital the person will use? A church or synagogue or mosque that builds a new building free and clear from savings or current assessments is likely, for a number of years after the new building is built, to assess a new member a special building fee over and above the dues that old and new members pay. Why does not a city or state do the same (assuming away legal impediments)? The answer would seem to be that new members of a community pay on average "rent" for the capital they use, at least enough to cover a considerable part of the additional cost of any necessary capital widening on this account. This is because--in

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*Fred Giertz suggested this.

contradistinction to a religious congregation that finances a new building without borrowing--a large part of public capital is built with borrowed money. And with their taxes, new dwellers help pay the service of this debt to an extent that the new dweller is not a burden on old dwellers in this respect.

If all demographic construction--such as schools and hospitals and other local facilities whose size must be affected by numbers of people (called just "construction" or "structure" hereafter)--were financed by consol bonds, the immigrants would be paying more taxes than if they used only structures built for them and if they also paid entirely for that construction which they used. (Underlying the latter part of this sentence is a model of constant immigration under simple conditions. For now this is only to be a vague statement of self-financing as the benchmark.) This is simply because immigrants and their descendants would then be paying a full share for all new construction, and would be paying also for some structures that had obsolesced and were no longer in use; by the same token, they would be paying more than their share for partly-obsolesced structures.

On the other hand, if all construction were paid for on a current basis, immigrants would underpay for the structures they use, because they would pay only a part (on a per head basis equal to natives) for the new construction necessary for them, whereas all of the cost of the new construction would be due only to them (causing increased expenditure by natives for the new construction) while not paying at all for existing structures they would be using. And if the number of immigrants were small and there were little or no physical depreciation, natives would pay almost

the entire cost of structures for immigrants. This point comes out clearly if we notice that if all construction depreciated in say a year (the tax period), natives would not be footing any of the bill for immigrants; all would then be on an equal footing. But since depreciation takes longer than the current period, and since natives have already built and paid for much of the construction they need, the additional construction for natives would be more than they would otherwise need (by a proportion greater than the proportion of new immigrants to natives). This last statement has not been stated rigorously, but should be made convincing by this third possibility: With respect to construction financed by debt, if the length of life of construction equals the length of time during which the debt is serviced, asssuming equal payments on the debt each year (that is, assuming that the building collapses the day it is paid off), and if the cost of construction and quality of buildings remain constant, then an immigrant would exactly pay for the cost of new construction built on his or her account. He/she would a) pay a full share for new buildings built this year, like any native; b) pay nothing for buildings no longer in use; and c) pay proportional to the remaining length of life for older buildings still in service.

Therefore, we wish to combine the necessary elements--length of capital life, length of bond period, proportion of capital financed by borrowing, together with the cost of equipping an average immigrant family--into an estimating equation, develop estimates of the elements, and calculate the burden on immigrants per immigrant family. We begin with notation:

| | | |
|---|---|---|
| Cost of contruction per unit of capital necessary for an additional family | = | $C$ |
| Proportion of construction cost financed by bonds | = | $c$ |
| Length of life of a unit | = | $\ell$ |
| Bond period | = | $b$ |
| Total native population of families | = | $P_t = P_{t-1}$ |
| Units in existence | = | $Q$, and $Q/P = 1$ |
| Units built | = | $q$ |
| Number of immigrant families | = | $I = 1$ |
| Expenditures | = | $E$ |
| Taxes, total paid | = | $T$ |
| Without immigrant superscript | = | $o$ |
| With immigrant superscript | = | $I$ |

$$Q_t = P_t$$

$q_t^o = \frac{1}{\ell} Q_{t-1}^o$ in steady state, the number of units necessary to replace units worn out after $\ell$ years,

1) $E_t^o = \frac{1}{\ell} Q_{t-1}^o C$ expenditures each year in steady state without the immigrants

2) $E_t^I = \frac{1}{\ell} Q_{t-1} C + C$ expenditures with the immigrants, because one additional unit is needed for I

3) $T_t^o = \frac{1}{b} cE_{t-b} + \frac{1}{b} cE_{t-b+1}^o \ldots \frac{1}{b} cE_t^o + (1-c)E_t^o = E_t^o$ in steady state, that is, total taxes yearly without immigrants, which includes

debt payments on capital financed in the past plus current payments on the portion of current expenditures not financed by debt*

$$\frac{T_t^o}{P_t} = \frac{\frac{1}{\ell} Q_{t-1}^o C}{P_t} = \frac{1}{\ell}C \text{ because } Q^o = P_t = P_{t-1}, \text{ taxes per person}$$

without immigrant in steady state

4) $T_t^I = E_t^o + \frac{1}{b} cC + (1-c)C$ because the first payment on the financial portion of additional unit will be made in t, plus the non-financial portion's payment

5) $T_t^I - T_t^o = \frac{1}{b} cC + (1-c)C$ increase in total taxes in t due to immigrant

6) $\frac{1}{b} cC + (1-c)C - \frac{\frac{1}{\ell}PC}{P+1}$ $(\frac{c}{b} + 1-c - \frac{1}{\ell})C$ is the increase in burden of taxes to natives in first year because of an immigrant. The total burden over the years to natives is

7) $b(\frac{1}{b} - \frac{1}{\ell})cC + (1-c)C$ because of the payment on the finance portion of the increment until the additional unit is paid for. Aside from that, immigrant henceforth simply constitutes a proportional increase in the society and has no effect on natives.

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*We shall assume that the bonds are amortized at a constant rate over their lives, that is, equal payments in each period until retirement, in the manner of a house mortgage. In reality, a given bond issue is floated with bonds of a variety of maturities, and the tax burden declines as more bonds are retired. But the constant-amortization assumption must be a satisfactory approximation for our purposes here.

8) The overall magnitude of the loss to natives (if there is one) depends, of course, upon the proportion of capital investment that is funded with debt, and upon the cost of the units, but also heavily upon $\ell$, the length of life of the structure. If $\ell$ is very short, the immigrants pay for structures already destroyed, even if the bond period is also short. If the length of life is very long, then the cost to natives approaches the full cost of the structure. Therefore, to estimate the effect, we need to know C, b, $\ell$. I/P may be assumed to be very small.

9) We may estimate C in several rough ways which, if they generally agree, should allow us to have some confidence in the composite estimate. (1) The current replacement value of government capital (structures, inventory and equipment) at the end of 1975 was estimated by Kendrick (1976) to be $981 billion. Dividing that total among units of government on the basis of capital outlay figures by the various units of government plus tentative depreciation yields an estimated $781.5 billion as the value of state and local capital at the end of 1975. Its ratio to GNP in the corresponding year was 38.1 percent. Therefore, one may assume that it costs an amount equal to that proportion times the representative family's income to equip an additional representative family.

A rough check for this magnitude uses the observation that employment in the state-and-local sector is 14.1 percent of all employment. If the capital-output ratio is 2 in that sector as in the rest of the economy, and if average income is the same in that sector as is the rest of the economy, then a sum equal to 2 x 14.1% = 28.2% average income is the value

of such capital for the average family. The value in 1979 for the median primary family (Statistical Abstract of the U.S., 1980, p. 451; the mean value for all families would be better, but will not be sufficiently different to make a difference here) was (.381 x $19,684 =) $7500.

10) The average bond period b is 10.53 years, estimated as described in the appendix.

11) The average length of life of state-and-local capital is 14.76 years, estimated as described in the appendix.

12) The value of c, the proportion of the capital that is financed with debt, is approximated .62, as described in the appendix.

13) Calculating now by inserting the necessary values into (7) the average cost to natives of equipping an immigrant family, assuming the family's income and use of services is average, is then $4172 or 21% of a year's income for a family, without discounting the future payments.

Without further ado or the relatively minor adjustments called for by a variety of factors working in both directions, let us hit upon one fifth of the average family's inocme as the cost of equipping the community for an additional average family's needs. For this to be an appropriate cost for an average immigrant family requires that it be of the same size and composition as an average native family. This is probably not so far from the fact as to make inappropriate 21% of family income as the estimate.

This cost is certainly not negligible even when the returns to government capital from government immigrant workers are added. However, it is considerably smaller than the present value of the net of taxes

paid and transfers received by immigrants--which are perhaps 1.5 or 2 times the average native family income (Simon, 1981)--and hence the capital effect does not dominate the overall impact of immigrants upon natives' standard of living, which is positive on balance even without considering the effect on natives through increased productivity, and the latter almost surely swamps all other effects in the long run (Simon, 1982).

## SUMMARY AND CONCLUSIONS

There are three questions about capital and immigrants we must answer: The effect through private capital which immigrants work with, the effect through public capital that immigrant workers use, and the effect through public capital used for services by immigrants.

The first question, the issue of private capital dilution, can be dealt with swiftly. Borts and Stein, and Berry and Soligo, showed that while workers as workers lose through lower wages due to immigrant workers, owners of capital benefit by something more than the workers lose, and hence per-person income goes up in the society. The overall effect is small by Usher's and Simon's reckonings, perhaps 1% or 2%, small enough to forget.

If all immigrants worked in private industry, and if there were no corporate income taxes, we could now also forget about the entire subject of production capital dilution. Usher tackled the second and third of these problems together by analyzing the properties of public and private capital for the U.K. Simon did much the same for Israel, independently. Usher arrived at the conclusion that 58% of the returns to all the capital they work with are captured by immigrants even if they

own no private capital, and therefore immigrants are a major burden upon natives. And of course in Usher's model there is no positive effect of immigrants upon productivity to counterbalance the effect Usher calculated. For the productive capital, we estimate that immigrants capture the returns from only 8% of the capital they work with, which is the government capital only; the result is a loss of perhaps 2% of an immigrant family's income for one year, which is about the same size as the gain to natives through the private capital that immigrants work with.

The cost to natives of equipping the immigrant family with "demographic capital"—schools, hospitals, and local roads--depends upon the cost of such equipment, the proportion financed by bonds, the average length of life of the capital, and the average bond life. We develop an estimating equation, and calculate that the cost to natives in 1975 dollars is $4172, about a fifth of a year's income of an average family. This is not insignificant in magnitude, but this amount--together with the effect through productive capital dilution discussed in the first part of the paper—is considerably smaller than the benefits of immigrants to natives through their relatively low use of welfare services and their relatively high contribution of taxes.

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## APPENDIX

### Estimating the Length of Life of Capital

1') $$K = C_0 + (1-d)C_1 + (1-d)^2 C_2 + \ldots \text{ Adam and Eve}$$

where:

$K$ = current value of total demographic capital

$c_i$ = construction cost of demographic capital i periods ago

$d$ = rate of depreciation.

Now, let:

2') $$C_i = C_{i+1}(1+g)$$

where:

3') $$g = d + p + r + s$$

Here we argue that the rate of growth of construction is equal to the rate of depreciation plus the population growth rate (p) plus the rate of inflation (r) plus the rate of increase of the standard of unit provision (s).

Inserting 2' and 3' into 1' and solving the infinite series yields:

4') $$K = \lim_{n\to\infty} \sum_{0}^{n} \left[\frac{1-d}{1+r+p+s+d}\right] C_i$$

$$= C_0 \left[\frac{1+2(r+p+s)+3d}{r+p+s+d}\right]$$

Solving:

5') $$d = \frac{1+(2 - \frac{K}{C_0})(p+r+s)}{\frac{K}{C_0} - 3}$$

Finally:

6') $\ell = \frac{1}{d}$

Here we estimate the values of $\ell$ and d by using national wealth estimates from Kendrick, et. al. (1976), population growth data from the Bureau of the Census, and price data from the Bureau of Labor Statistics, and income data from the Department of Commerce. Kendrick estimates that the value of government wealth in structures, inventories, and equipment was $815 billion in 1973, valued in current dollars. Gross investment in 1973 was estimated to be $85.5 billion.* Since Kendrick does not provide separate estimates of state and local wealth, we assume the average depreciation rate to be the same in all government sectors.

From 1960-73, the U.S. population grew (p) at an estimated annual rate of 1.19 percent. The average price of government purchases (r) increased at a rate of 4.73 percent. We use as a proxy for the increase in the standard of public good provision (s) the increase in real per-capita gross national product from 1960 to 1973, estimated to be 1.49 percent.

Inserting these estimates into formulae 5' and 6' yields

$d = 6.78$ percent

$\ell = 14.76$ years.

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*These estimates were derived by continuing the relationship revealed in Tables 2-1 and 3-A in Kendrick (1976).

## Estimating the Bond Period

Let:

1") $D_0 = I_0 - R_0 + I_1 - R_1 + \ldots$ Adam and Eve

where:

$D_i$ = current value of debt end of period i

$I_i$ = gross borrowing i periods ago

$R_i$ = debt retirement i periods ago.

This says that the current value of the debt is equal to the sum of all past borrowing minus debt retirements. It follows that:

2") $I_i = D_i - D_{i-1} + R_i$

This says that gross borrowing in period i equals the value of ending debt minus beginning debt plus bond retirement during period i.

If we assume a maturity period equal to b--the value to be estimated--we get:

3") $R_i = I_i + b$

recalling that b = bond period.

That is, debt retirement in period i equals gross borrowing b periods previous. Then, it follows that:

4") $$D_0 = \lim_{n\to\infty} \sum_{0}^{n} I_i - \lim_{n\to\infty} \sum_{b}^{n} I_i$$

$$= \lim_{n\to\infty} [\sum_{0}^{\infty} I_i - \sum_{b}^{\infty} I_j]$$

To facilitate the solution we assume:

5") $I_i = I_{i+1}(1+g)$, where

$g$ = the rate of growth of borrowing

Then:

6") $$D_0 = I_0 + \frac{I_0}{g} - \frac{I_0/g}{(1+g)} b$$

and, finally:

7") $$b = \frac{\ln(\frac{I_0}{g}) - \ln(I_0 + \frac{I_0}{g} - D_0)}{\ln(1+g)}$$

Using the above formulae we estimate the average maturity of debt (b) based on data for the period 1960-73. Census of government data show state and local net debt of $158.7 billion in 1973, new issues of $21.8 billion in fiscal 1973, and a grand rate of 8.07 percent in new issues over the is period. Plugging these figures into formula 7" yields:

$b$ = 10.53 years.

## Financing Capital Outlay

Next we estimate the percentage of capital outlay that is financed by bond issuance. We assume that all debt retirement is tax financed as part of the normal amortization process. It follows that proceeds of all long-term debt issues are used to finance capital outlay. We use figures from 1973 for purposes of comparability with data we used to estimate other parameters in our argument.* Thus:

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*Data are taken from U.S. Bureau of the Census, Compendium of Government Finances, 1972-73.

$$C = \frac{\text{new bonds issued}}{\text{capital outlay}} = \frac{\$21.8 \text{ billion}}{\$35.3 \text{ billion}} = .62$$