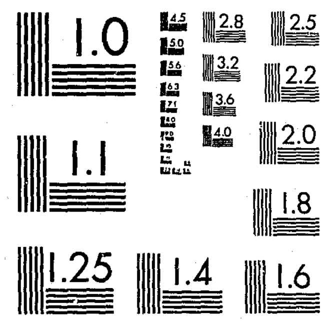

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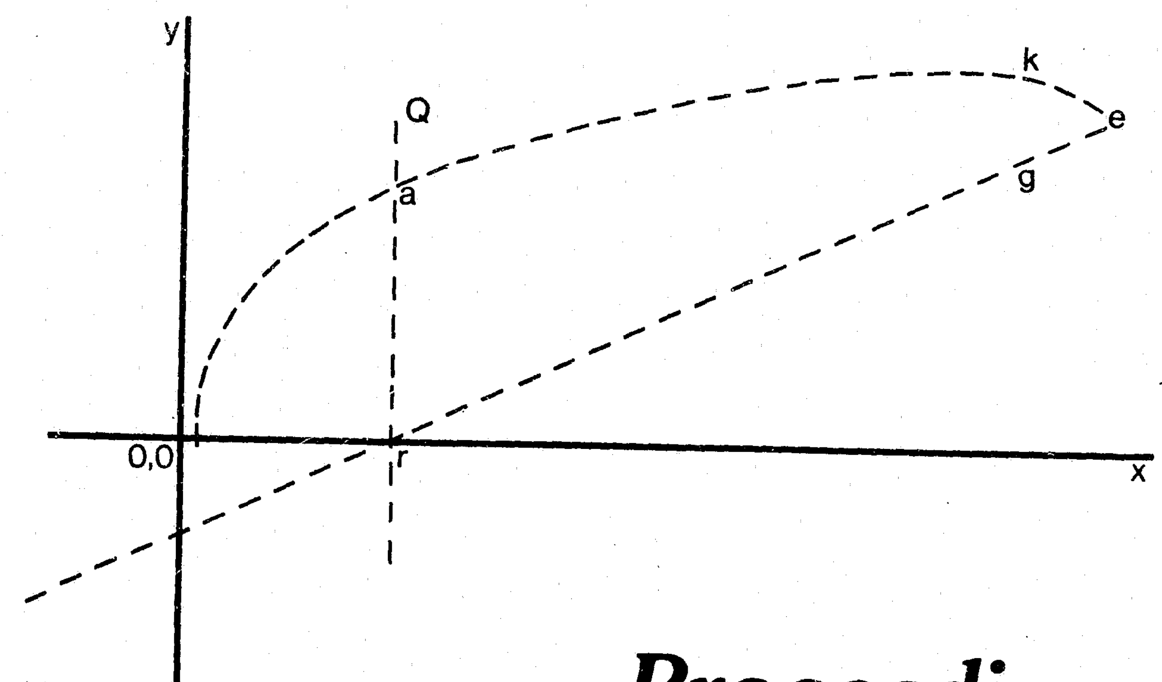

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The Relationship Between Prison Populations and Prison Capacities

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Pat Evans

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The Relationship Between Prison Populations and Prison Capacities

In 1976 Congress asked the National Institute of Law Enforcement and Criminal Justice to "survey existing and future needs in correctional facilities," and to report on the ability of federal, state and local programs to meet those needs. This Congressional mandate followed a five year period of accelerated growth in the incarcerated population which was without recent precedent in its suddenness and magnitude. It reflected a general concern that continued population growth would soon surpass the available housing for prisoners, if it had not already done so, resulting in unsafe or unsanitary degrees of crowding. Indeed, such crowding had already come to the attention of federal courts in Mississippi and Alabama, where crowding was found to be so intense as to violate the eighth ammendment's prohibition of cruel and unusual punishment.

Without exception* states were projecting unabated growth in the numbers of inmates in state custody, and were approaching their respective legislative committees with capital and operating budgets based on this continued growth. As we subsequently found, extensive prison construction was underway to provide housing for the populations which were anticipated over the next several years.

We might imagine employing a hypothetical projection device, feeding it appropriate data about a state's prison system, and producing an estimate of the numbers of inmates requiring shelter and care over the next n years. A state legislature sharing this proactive planning model might be expected to appropriate funds for additional constuction whenever they believed projected population levels would exceed the supply of available housing.

*Based on 26 states which provided us information.

We might distinguish such proactive spending from the actions of a state where construction money becomes available only in reaction to some more or less catastrophic symptom of trouble in the prisons--murder, riot, scandal or litigation. Such a reactive system would build only as much as was needed to alleviate the crowding of inmates already in custody. To complete the array of planning types, we should include states where construction simply does not occur (of which there have been about eight over the last 20 years) and states where construction, when it occurs, is not in any direct sense a response to population change.

This hypothetical typology of planning behavior carries the implicit assumption that prisoners are in some sense an independent variable, and prison space a response made sooner or later and more or less accurately as the states' abilities and desires dictate. In contrast to this is a model, most recently articulated by William Nagel* in his support of the moratorium on prison construction, which suggests that available space will be filled, regardless of any of the usually assumed causal linkages between crime and punishment. This view is still consistent with national behavior by the criminal justice system if we imagine the incarceration decision as an optimization problem solved under the constraint of limited prison space. If such a constraint is operating, the expected sanction level (measured in time in prison) will vary inversely with the offense level, so that the prisoner population can remain stable.

Understanding the mechanics of the relationship between capacity and population was clearly central to both preparation and use of the projections of inmate population levels implied by the Congressional mandate. If some version of the planning model held, it made sense to look at transition

*Nagel, W. G., "On Behalf of a Moratorium on Prison Construction," Crime and Delinquency, April 1977, pp. 154-172.

probabilities in the criminal justice system--arrest given crime, prosecution given arrest, conviction given prosecution, and incarceration given sentence. We might seek for stability among these ratios, or look for possible alterations in their values as laws were changed, rules of judicial procedure modified, or criminal justice policy reformulated. Some sort of simple (or complicated) extrapolation of the time series of prison populations or admissions might give us a sufficient projection of future prison populations. If not, some more elaborate model of criminal processing might be needed, but projections would still treat the number of prisoners as a natural phenonmenon subject to natural laws like those found in the physical sciences.

If the contrary view prevailed, such exercises seemed inappropriate. If capacity constraints dominated, the number of prisoners clearly reflected a choice, not a natural phenomenon. Moreover, if a system's population routinely approximated these constraints, it would mean that the levels of crowding which prevailed might not be alleviated simply by the opening of new prisons, since these could relax the constraints and allow greater numbers of inmates to be held at the old levels of crowding. The complexity of the situation was further exacerbated by the possibility that projections which showed increasing populations--perhaps including our own--might be used to justify the very new construction required to allow the population increase to occur. This made it conceivable that any projection we produced might be correct if only enough people believed it.

Like many questions about governmental behavior, the task of describing the relationship between capacity and population is susceptible to evidence but not proof. The only information available is historical in nature: documents and statements by experts and decision-makers in the field,

and the records of past changes in capacity and population. These can never be wholly free of ambiguity. Experts have presented support for both sides of the case. Some correctional administrators have told us exactly which mechanisms they use to adjust populations to stay within their capacities. Others have somewhat cynically described episodes where capacities were adjusted to match populations. Some of these adjustments reflect construction, others are done with a pencil.*

All of the usual problems of trying to identify a system's operating characteristics only from its history alone are in force here. We cannot claim that either prisons or prisoners provide a random input to the system. Both may reflect public attitudes, the health of society, economic well-being, the politics of crime control and any number of other potentially confounding variables which we cannot even list, let alone measure.

Systematic biases may obscure real effects or create artifactual ones. For example, the date of a prison's opening is several years after any presumed perception of need and decision to act occur. An extremely efficient system can begin to populate a prison two years after the decision to build.(?) Five years is probably a more typical delay. This lag will vary from state to state and era to era, (depending on elections the construction industry, climate, and a host of other factors), further confusing the modeling task.

The period covered by our data (1955 to 1976) may be unrepresentative of current practice. The abruptness of growth in the incarcerated populations over the last five years has been taken by some observers to suggest that the rules of the game have been largely abandoned in the 1970's and that historical trends established earlier are unlikely to be reliable descriptions of current practice.

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*Automation is everywhere. One large corrections department has an on-line computer to keep track of rated capacity.

Finally, we have little more than intuition to guide us in selecting the functional form our model should take. As far as we could tell, the literature appeared to stop at articulating the problem, usually not in the form of an empirical question, but rather as a premise. To a considerable extent the exact form of the model is dictated by computational convenience rather than any actual knowledge of the appropriate forms. We have tried to minimize the impact of this uncertainty by using alternate forms, general rather than specific models, and definitions which remain invariant under some of the expected ambiguities, but we are under no illusion of having produced the definitive answer to these problems. What we present here is a mechanism for quantifying the questions which arise and some preliminary statistical results which suggest the possibility that the questions have interesting answers and policy implications.

As part of our study of prison populations, we gathered data on openings of prisons in every state in every year from 1955 to 1976. We also knew the number of inmates in the state prison system at the end of each year. We attempted to design an analysis which would allow us to describe the interrelationship of changes in population and capacity across these 1100 state-years of data.

We can attempt to formalize these questions in the following way:

Let $z(X_t) = X_{t-1}$

$$P(z)(X_t) = a_1 z + a_2 z^2 + \ldots (X_t)$$

$$= a_1 X_{t-1} + a_2 X_{t-2} + \ldots$$

where t is measured in years, and P denotes a polynomial of unspecified degree

We can describe the historical relationship between capacity and population as

$$\begin{bmatrix} P \\ C \end{bmatrix} = \begin{bmatrix} A(z) & B(z) \\ C(z) & D(z) \end{bmatrix} \begin{bmatrix} P \\ C \end{bmatrix}$$

where A:P — P is the autoregression function of population,

D:C — C the AR function of capacity, and

B:C — P and

C:P — C the lagged cross-correlations of population with capacity.

The matrix can take one of four forms:

Block diagonal: X O
O X

if C and P are unrelated

Block upper triangular: X X
O X

if Capacity provides a leading indicator of population but population does not lead capacity

Block lower triangular: X O
X X

in the converse case, or

Full: X X
X X

if feedback occurs in both directions with capacity "driving" population which in turn "drives" capacity, and so on.

Each of these four cases corresponds to a view of the corrections system represented in the projection literature we reviewed. The second case is in some ways the most interesting, since it matches the moratorium model of "you build 'em, we'll fill 'em." The third might be called the Naive Projectionist's Model, and corresponds to the view which seems implicitly to prevail in many--but not all--state corrections departments. The fourth model was incorporated in some of the early simulation models which were prepared for the Preliminary Report to Congress, and which we there identified as a "Dynamic Model" of the corrections system. Case 1, the block diagonal matrix, can be identified for these purposes as providing the null hypothesis against which the other models are to be tested.

This matrix formalism was suggested by Peter E. Caines,* and the tests for non-zero blocks are those of Granger** and Sims.*** A recent theorem by Caines**** simplifies and generalizes these tests. In essence the tests are reduced to a pair of analyses of covariance in which the semipartial correlations (in OLS) of past capacity changes on present population changes, "controlling for" past population changes, and past population changes on present capacity changes, "controlling for" past capacity changes. The F-tests are given by

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*Caines, P. E. and Chan, C. W., "Feedback Between Stationary Stochastic Processes," IEEE Transactions on Automatic Control, vol. AC20, no. 4, August 1975, p. 498ff.

**Granger, C. W. J., "Economic Processes Involving Feedback," Inform. Contr., vol. 6, pp. 28-48, 1963.

***Sims, C. A., "Money, Income and Causality," Amer. Econ. Rev., vol. 62, pp. 540-552, 1972.

****Cines, P. E., "Weak and Strong Feedback Free Processes," IEEE Transactions on Automatic Control, October 1976, pp. 737-739.

$$F_{P - C} = \frac{[\, R^2(C_t \cdot C_{t-1}, C_{t-2}, \ldots, P_t, P_{t-1}, \ldots) - R^2(C_t \cdot C_{t-1}, C_{t-2}, \ldots) \,] / df_n}{[\, 1 - R^2(C_t \cdot C_{t-1}, C_{t-2}, \ldots, P_t, P_{t-1}, P_{t-2}, \ldots) \,] / df_d}$$

where df_n, df_d are the respective degrees of freedom of numerator and denominator

and the same formula with P and C everywhere interchanged for $F_{C \rightarrow P}$.

The prison population in each year substantially resembles that of the year before, in part because it includes many of the same people. By the very nature of the release process, we have each year's disturbance propagated through the future years potentially until the release of the last inmate in the cohort. (In practice we would expect effects to damp out much sooner since most inmates serve only two or three years, and time served may sometimes be adjusted to even out the population.) This means that a priori we can expect that the residuals of any population model ought to be serially autocorrelated, as in fact they are, with .9 r 1.0 for most states. Since significance tests in OLS assume independent residuals this autocorrelation will lead to bias unless corrected. Two-stage least squares is the standard solution for such situations. In this case, however, the functional relationship of populations from year to year is sufficiently close that we were able to remove most of the serial correlation simply by first order differencing of the population series. Thus wherever "P" or "population" occurs in this discussion, "first differences of population" is to be understood.

Capacity data likewise refer to first differences, but for additional reasons. Disturbances in the capacity of a system persist for even longer than those in the population--prisons stay around for decades, even centuries--and so differencing is called for on statistical grounds alone. It also makes the regression coefficients have direct interpretation since P and C are measured in comparable units. Finally, by dealing only with changes in capacity we are spared the necessity of producing an absolute measure of capacity. We knew from attempts to survey the capacities of state and federal institutions for other parts of this project that "capacity" denoted a particularly ambiguous and fluid concept. Some care was needed to insulate our tests from these ambiguities.

We might have chosen to employ some physical standard based on our own notions of decent housing conditions, or those of some outside body. However, if our goal was to describe actual populations, then what local administrators considered to be the capacity was probably more relevant than what outsiders considered it ought to be. This left two choices: official ratings and actual behavior. Official "rated capacities" are supplied to the American Corrections Association by most institutions. These ratings can change from year to year without reflecting any real physical changes in the plant. To standardize the definition we used the rating supplied at the earliest date which information was available.* The behavioral measure was simpler. We simply recorded the number of actual occupants present on December 31, 1978. It should be noted that although this latter definition of capacity has units measured in population, the capacity series thus generated can remain fully independent of the population series, since all the reference dates for capacity definition are at a single instant. In the discussion which follows, numerical results are based on the behavioral measure.

Figure 1 displays the OLS regressions of the capacity and population, first differences for lags of one to six years. Note that all coefficients in the capacity equation are close to zero, yielding an F-ratio virtually equal to one. Even the largest of the coefficients, C_t with P_{t-3} is less

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*In some cases this differed from the opening date because we did not have ACA directories for every year.

than .01. Its 95 percent confidence interval is (-.006, +.026). Every 95 percent confidence interval in the equation includes zero, and even the sum of the upper 95 points for all the population terms is under 0.1. The data are thus strongly in conformity with the part of the model which states that changes in population do not prefigure changes in capacity. This null result does not, of course, prove that no relationship exists, since we might need either more years* or a different functional form** to detect a hidden true effect.

The part of Figure 1 which shows the regression for P_t tells a different story entirely. Several of the coefficients are significantly different from zero, including three with $p < .001$. The first-order AR coefficient is large enough that some caution is still appropriate in reading the individual regression coefficients. Its partial correlation is .21, which does not introduce the kind of problems raised by the undifferentiated series, but should still warn of possible contamination. (By the time the regression is completed, the residuals are not significantly autocorrelated, and the significance tests based on the semipartial correlations are not biased by the serial correlation; therefore no further action was taken to whiten the P series.)

The clearly interesting coefficients are those describing the regression of past capacity changes on present population. There is little relationship between changes in capacity and changes in population in the same or the next year, but a substantial echo of capacity appears in the population

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*Six years of lag terms were entered in the equations. The C_t equation stops at P_{t-4} because the partial correlation of P_{t-5} = -.002, and SPSS refused to proceed without a parameter change.

**For instance, since prisons rarely close, we might want to recode all negative P's to zero before testing. That result will be available shortly.

Figure 1

OLS Models of Capacity and Population

$$
\begin{aligned}
P_t = & & & -.015\ C_t \\
& +.211^{*}\ P_{t-1} & & +.046\ C_{t-1} \\
& -.047\ P_{t-2} & & +1.020^{*}\ C_{t-2} \\
& +.021\ P_{t-3} & & +.321\ C_{t-3} \\
& +.151^{*}\ P_{t-4} & & +.021\ C_{t-4} \\
& -.095\ P_{t-5} & & +.043\ C_{t-5} \\
& +.036\ P_{t-6} & & -.363\ C_{t-6} \\
& +113 & &
\end{aligned}
$$

$^{*}p < .001$ $\qquad F = 7.49^{*} \quad df = 13;668$

$$
\begin{aligned}
C_t = & -.0007\ P_t & & \\
& +.0056\ P_{t-1} & & +.0406\ C_{t-1} \\
& +.0048\ P_{t-2} & & +.0218\ C_{t-2} \\
& +.0097\ P_{t-3} & & +.0703\ C_{t-3} \\
& -.0010\ P_{t-4} & & +.0189\ C_{t-4} \\
& & & +.0378\ C_{t-5} \\
& & & +49
\end{aligned}
$$

$F = 1.07 \quad df = 10;671$

series after two years, perhaps extending to the three year term ($p < .05$) the fact that the coefficient is near 1.0 is particularly reassuring, since it corresponds with the intuitive notion of one inmate per unit of capacity.

Figure 2 shows similar univariate regression coefficients for a model employing only three years of lag terms. Arranged in the matrix display, it is clear that the upper triangular form most nearly approximates the results. In Figure 3 we show another three year lag estimation, this time using multivariate regression instead of OLS. The results differ in numerical value, but not in the relative magnitudes of the off-diagonal terms.

In Figures 4, 5, and 6 we present a test of the sensitivity of the results to increasing the number of lag terms. Figure 4 displays the R^2 obtained with the pure AR models of population and capacity, respectively. Figure 5 shows R^2 for the joint models, and Figure 6 superimposes the two. The F-test of the semipartial correlations is generated directly by the increase in R^2 of Figure 5 over Figure 4. For the $C \rightarrow P$ model, after two years $F = 15.865$, $df = 2,676$, $p \ll .001$. Thereafter the F ratios decline as additional degrees of freedom are consumed, but remain significant beyond the .001 level. For the $P \rightarrow C$ model the F-ratios are negligable, as Figure 6 indicates.

Both estimation and logical problems remain. The regression equations yield residuals whose variance increases with the size of the state, violating an OLS assumption. To correct this, the same equations were rerun replacing each variable by

sign(X)*log(abs(X + .5))

compressing the larger variances. While this rendered the regression coefficients difficult to interpret, it left the structure of the equations virtually unaltered: terms in the capacity equation were still negligible, while the population equation was dominated by one-year-lagged P and two-year-lagged C. Significance levels were approximately the same as for the untransformed variables.

	ΔP_{t-1}	ΔC_{t-1}	
ΔP_t	.202	.070	one year lag
ΔC_t	.006	.042	
	ΔP_{t-2}	ΔC_{t-2}	
ΔP_t	-.050	1.012	two year lag
ΔC_t	.005	.024	
	ΔP_{t-3}	ΔC_{t-3}	
ΔP_t	.056	.318	three year lag
ΔC_t	.010	.071	

FIGURE 2
Univariate Regression Coefficients
of Capacity and Population

	ΔP_{t-1}	ΔC_{t-1}	
ΔP_t	.364	.130	one year lag
ΔC_t	.053	.051	
	ΔP_{t-2}	ΔC_{t-2}	
ΔP_t	-.107	.261	two year lag
ΔC_t	.037	.014	
	ΔP_{t-3}	ΔC_{t-3}	
ΔP_t	.033	.098	three year lag
ΔC_t	.009	.079	

FIGURE 3
Multivariate Regression Coefficients
of Capacity and Population

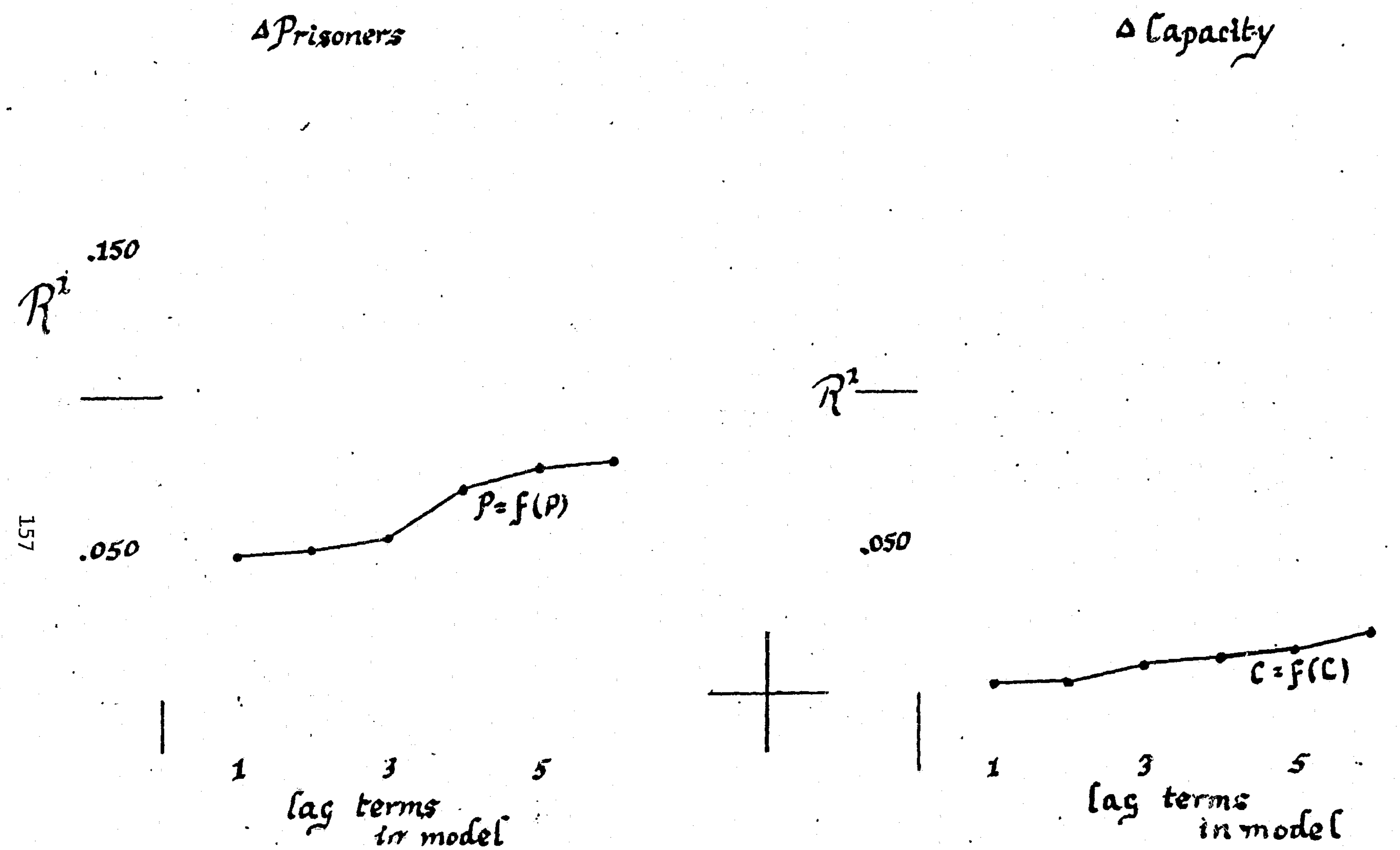


Figure 4
Squared Multiple Correlations
AR Models

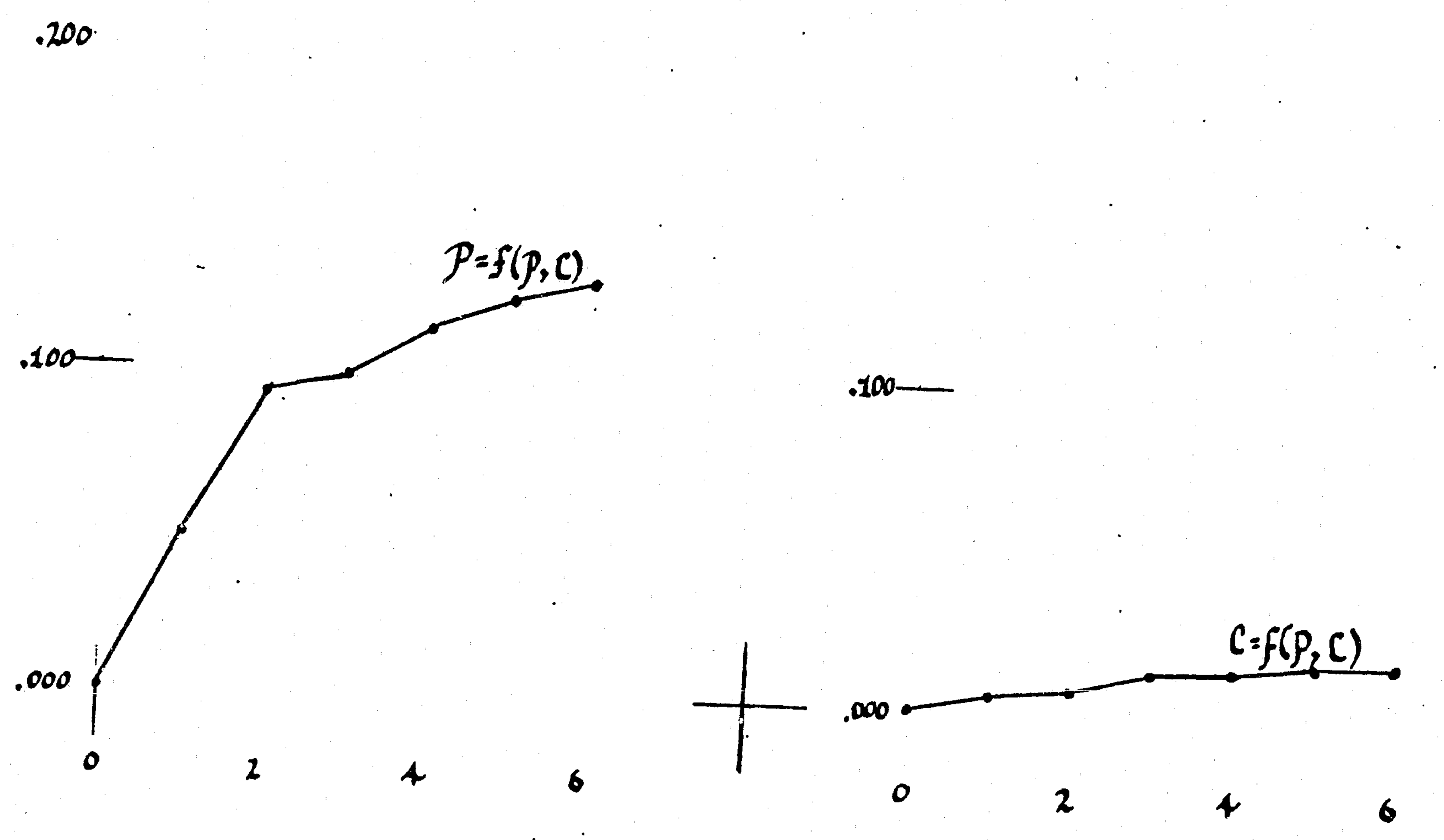
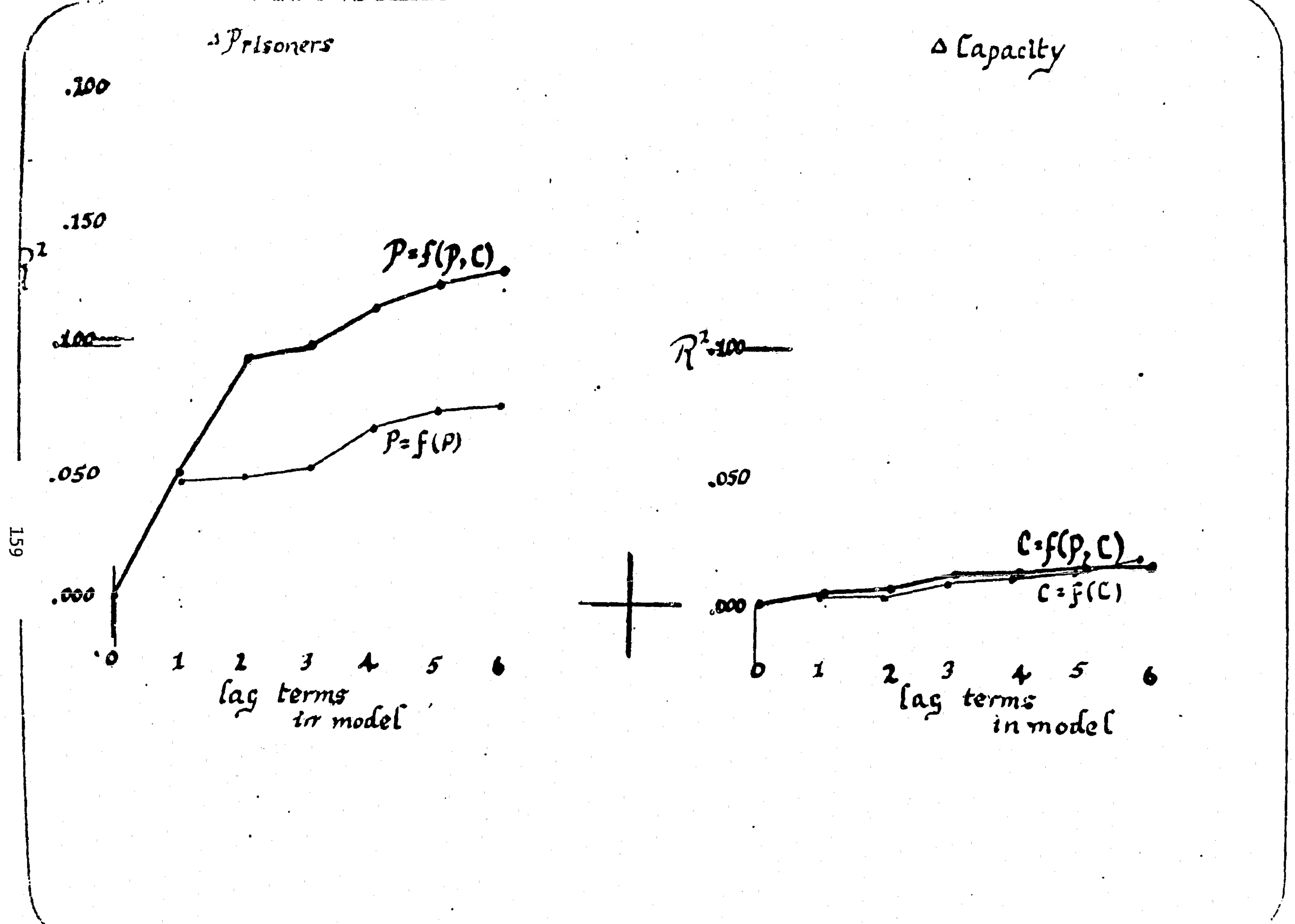


Figure 5
Squared Multiple Correlations
Joint Models



Δ Prisoners
.200
.150
R^2
.100
.050
.000
P=f(P,C)
P=f(P)
0 1 2 3 4 5 6
lag terms in model
Δ Capacity
R^2 .100
.050
.000
C=f(P,C)
C=f(C)
0 1 2 3 4 5 6
lag terms in model

Figure 6

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We also substituted our official definitions of capacity for the behavioral definition, again with no discernable structural change in the models. The first differences of the two capacity series correlate .90, so that we appear to have escaped the ambiguities of capacity definition.

Other possible intervening variables may be hypothesized to be driving both capacity and population. From the unlimited pool of such potential confounding effects we have tested two: the number of reported Part I index crimes and the number of persons unemployed. Neither shows significant relationships to either of our main variables.

We have yet to test the stability of these results at different periods and in different regions of the country. Inspection of the correlation matrices shows no reason to expect an interaction of the main effects with time. In studying other aspects of the prison problem we have repeatedly found that "the South is different." This finding may well apply again. We also need to subject these preliminary results to further refinements of the estimation procedures, and explore further for possible hidden relationships in the P — C series. In the absence of such refinement, we consider these results as tentative but useful evidence for the role of physical constraints as a population limiter, and for the idea that prisons once built, soon find inmates.

END