DIVISION DE EDUCACION CONTINUA
FACULTAD DE INGENIERIA U.N.A.M.

DINAMICA DE SISTEMAS (FORRESTER)

DINAMICA DE DESCONCENTRACION

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4. IMPACTO DE LA DESCONCENTRACION EN LAS CIUDADES SEDE

El objetivo del modelo de impacto de la desconcentración en las ciudades sede es definir los programas de inversión que se requieren para proporcionar la adecuada atención al empleado público y al habitante de las ciudades sede en las que radican unidades operativas de hecho desconcentradas. (Figura 5).

Para determinar los programas de inversión, se analiza la demanda de infraestructura y equipamiento urbanos que se genera como consecuencia del crecimiento natural de la población (habitantes y empleados públicos) y de las acciones del Programa Nacional de Desconcentración de la Administración Pública Federal.

Las acciones del programa que se consideran son la desconcentración del ejercicio del presupuesto con el fin de que su ejercicio se realice en el lugar al que estén destinadas las acciones y las obras; y la reorientación de la ubicación de la Administración Pública Federal al generar los nuevos empleos públicos fuera del Area Metropolitana de la Ciudad de México.

4.1: INFORMACION

La información que emplea el modelo describe las características de las unidades operativas desconcentradas y de la ciudad en donde radica.

Para describir las unidades operativas y las ciudades donde radican se requiere:

- La población actual de la ciudad y su tasa de crecimiento, expresados en número de habitantes y en porciento, respectivamente.

- El número de funcionarios y empleados con que cuenta actualmente la unidad operativa y su programa de crecimiento esperado.

- La fuerza de trabajo especializada disponible para desconcentrarse.

- La fuerza de trabajo especializada disponible en la ciudad donde radica la unidad operativa.

- La capacidad instalada de infraestructura y equipamiento urbanos de las ciudades donde radica la unidad operativa.

La definición de los componentes de la infraestructura y del equipamiento urbanos por incluir en el análisis es libre; en el sentido de que se pueden tomar en cuenta aquellos que se requieran o simplemente de los que se disponga de información.

En principio, en la conceptualización del modelo se contemplaron los que a continuación se relacionan; que como se mencionó en el párrafo anterior se pueden agrupar, desagregar o utilizar algunos de ellos.

Los componentes considerados son:

- Agua Potable
- Energía
- Tierra Urbanizada
- Vivienda
- Comercio y Abasto
- Educación y Cultura
- Salud
- Recreación y Deportes
- Comunicaciones
- Transportes
- Administración y Servicios Públicos

La demanda generada por la población de la ciudad en donde radica la unidad operativa y por el nuevo personal desconcentrado de infraestructura y equipamiento urbanos. Este dato expresado en términos del consumo por habitante (consumo unitario).

- El costo que representa incrementar la capacidad instalada de infraestructura y equipamiento urbanos para satisfacer la demanda de un habitante. (Costo unitario).
- Los requerimientos por empleado de equipamiento de instalaciones físicas y su costo. (Consumo y costo unitarios).
- Los requerimientos de la unidad operativa de instalaciones físicas y su costo.
- La capacidad instalada de instalaciones físicas en la ciudad donde reside la unidad operativa.
- El costo de incrementar el equipamiento de las instalaciones físicas por empleado. (costos unitario)
- El costo de incrementar las instalaciones físicas por empleado. (Costo unitario).
- El sueldo promedio por empleado que devenga la unidad operativa.
- El gasto corriente anual de unidad operativa.
- El programa anual de inversiones de la unidad operativa.

4.2. MODELO MATEMATICO

En la formulación del modelo de impacto de la desconcentración en las ciudades sede se emplea la técnica de Simulación Dinámica tipo Forrester que permite analizar diferentes alternativas de crecimiento de las unidades operativas, su impacto en la ciudad donde reside y su contribución al Programa Nacional de Desconcentración Territorial de la Administración Pública Federal, para cada uno de los períodos del horizonte de planeación.

El modelo está estructurado por cuatro módulos interrelacionados que son: Recursos Humanos, Satisfactores, Aspectos Demográficos y Recursos Monetarios. (Figura 6)

4.2.1 RECURSOS HUMANOS

El insumo primario a este modelo son los requerimientos de Recursos Humanos que demanda el programa de crecimiento esperado de la unidad operativa. Ante estos requerimientos se analiza la posibilidad de satisfacer la demanda desconcentrando, en caso de no ser factible se ve si existe disponibilidad de recursos humanos en la localidad, en caso negativo se retrasa la decisión de expansión de la unidad en cuestión.

En el caso de que existan suficientes recursos humanos-disponibles para desconcentrar se determinan los requerimientos de satisfactores y recursos monetarios que éstos generarán.

En el caso de que sea necesario recurrir a recursos humanos de la localidad se determinan los requerimientos de-instalaciones físicas, de equipamiento de instalaciones - físicas y de recursos monetarios que éstos generarán.

La decisión de reubicar-contratar depende por una parte,- como se apunta en los párrafos anteriores, de la disponibilidad de recursos humanos, y por la otra de la disponibilidad de satisfactores y de recursos monetarios.

La disponibilidad de satisfactores determinan la decisión-inmediata de reubicar-contratar, de no haber una cantidad suficiente de satisfactores para soportar esta acción, la - decisión recae en los recursos monetarios necesarios para incrementar su capacidad instalada, por lo que de su monto depende que sea necesario o nó retrasar dicha acción- uno o más períodos.

En la Figura 7 se muestra un estracto del modelo, en lo que se refiere al módulo recursos humanos.

4.2.2 SATISFACTORES

En este módulo se incluyen los conceptos de infraestructura y equipamiento urbanos que se relacionan en el apartado de información (inciso 4.2.1), las instalaciones físicas y el equipamiento de las instalaciones físicas requeridas por las unidades operativas.

La acción de reubicar recursos humanos implica demanda en todos los satisfactores y la acción de contratar recursos humanos de la localidad implica demanda en instalaciones físicas y en su equipamiento.

El insumo primario a este módulo es la demanda que genera la decisión de reubicar-contratar recursos humanos. Ante este requerimiento se analiza si la capacidad instalada es suficiente para soportar la acción de reubicar-contratar recursos humanos. En caso negativo se genera la demanda de recursos monetarios.

Si la capacidad instalada de los satisfactores es suficiente se indica que por lo que se refiere a este módulo la acción reubicación-contratación se puede llevara a cabo de inmediato. En caso contrario se analiza si es factible efectuar dicha acción parcialmente, lo que estará definido por el super avit de los satisfactores.

La demanda insatisfecha de satisfactores genera requerimientos para incrementar la capacidad instalada, lo que se hará en función de los recursos monetarios disponibles para este rubro. De existir suficientes recursos monetarios la acción reubicación-contratación se demorará el tiempo necesario para el acondicionamiento de dichos satisfactores. En caso contrario se acondicionarán los satisfactores que los recursos monetarios disponibles permitan y la decisión de reubicar-contratar se demorará hasta que exista la infraestructura y equipamiento urbanos demandados.

En la Figura 8 se presenta un estracto del modelo para el módulo de satisfactores en lo que se refiere a un rubro representativo de equipamiento e infraestructura urbanos.

4.2.3. ASPECTOS DEMOGRAFICOS

En este módulo se considera a la población de la ciudad en la que radica la unidad operativa con el objeto de que su crecimiento natural genere la demanda de satisfactores a fin de que se le dé adecuada atención.
Además, incorpora a la población al número de funcionarios y empleados de hecho desconcentrados.

4.2.4 RECURSOS MONETARIOS.

La función de este módulo es administrar los recursos monetarios que apoyan las acciones de la desconcentración y la atención a los habitantes de la ciudad donde radica la unidad operativa.

Los egresos están constituídos por el costo de las acciones y obras requeridas para que se proporcione la adecuada atención al habitante y al empleado público y para permitir la expansión o crecimiento de la unidad operativa.

Los ingresos están compuestos por los posibles financiamientos de apoyo a la desconcentración, el presupuesto asignado al gobierno local y los impuestos sobre bienes y servicios existentes y futuros, producto de la desconcentración y del crecimiento natural de la población.

El financiamiento y el presupuesto asignado al gobierno local se pueden manejar como una variable de información (dejar al modelo determinar el monto total requerido para proporcionar la atención adecuada al habitante) o como variable de decisión (definir a priori un programa de inversiones). Esto permite analizar una gran gama de alternativas de inversión y el grado de desconcentración que de ellas resulta.

La actividad primaria de este módulo es proveerse de recursos monetarios a fin de mantener la capacidad instalada alcanzada de los satisfactores. Lo que garantiza que no se deteriorará la atención al habitante.

La actividad secundaria de este módulo es asignar los recursos monetarios disponibles para satisfacer la demanda de satisfactores, producto del déficit actual y de la desconcentración.

La asignación de recursos monetarios se efectúa con base en un sistema prioritario de inversiones que define el orden en que se considera se deben ir satisfaciendo los requerimientos de servicios. El orden, en principio definido, incluyendo la remuneración del personal reubicado y del contratado en la localidad, es el siguiente:

- Mantenimiento de la capacidad instalada
- Remuneración a personal reubicado
- Remuneración a personal contratado en la localidad
- Equipamiento instalaciones físicas
- Instalaciones Físicas

- Tierra Urbanizada
- Vivienda
- Agua Potable
- Energía
- Comercio y Abasto
- Educación y Cultura
- Salud y Seguridad Social
- Comunicaciones
- Transportes
- Recreación y Deportes
- Administración y Servicios Públicos

Este orden no es definitivo y depende de los satisfactores que se consideren en un análisis particular.

El aspecto importante de la definición de este sistema prioritario de inversiones reside en el hecho de que por lo general no se cuenta con los recursos necesarios para satisfacer toda la demanda, por lo que se irá incrementando la capacidad instalada de los satisfactores conforme al sistema prioritario y a los recursos monetarios disponibles.

En la Figura 9 se muestra un extracto del módulo de 12
recursos monetarios, haciendo resaltar sus funciones más que el detalle de la formulación del modelo.

ALTERNATIVAS

DE

DESCONCENTRACION

- PRESUPUESTO
- RECURSOS HUMANOS
- INVERSIONES

IMPACTO DE LA DESCONCENTRACION EN LAS CIUDADES SEDE

- EMPLEOS GENERADOS
- RECURSOS HUMANOS REUBICADOS
- REQUERIMIENTOS DE SATISFACTORES
  - VIVIENDA
  - EDUCACION
  - SALUD Y SEGURIDAD SOCIAL
  - AGUA POTABLE
  - ENERGIA
  - .
  - .
- INVERSION REQUERIDA
  - INSTALACIONES FISICAS
  - EQUIPAMIENTO INSTALACIONES FISICAS
  - INFRAESTRUCTURA URBANA
  - EQUIPAMIENTO URBANO

FIGURA 5

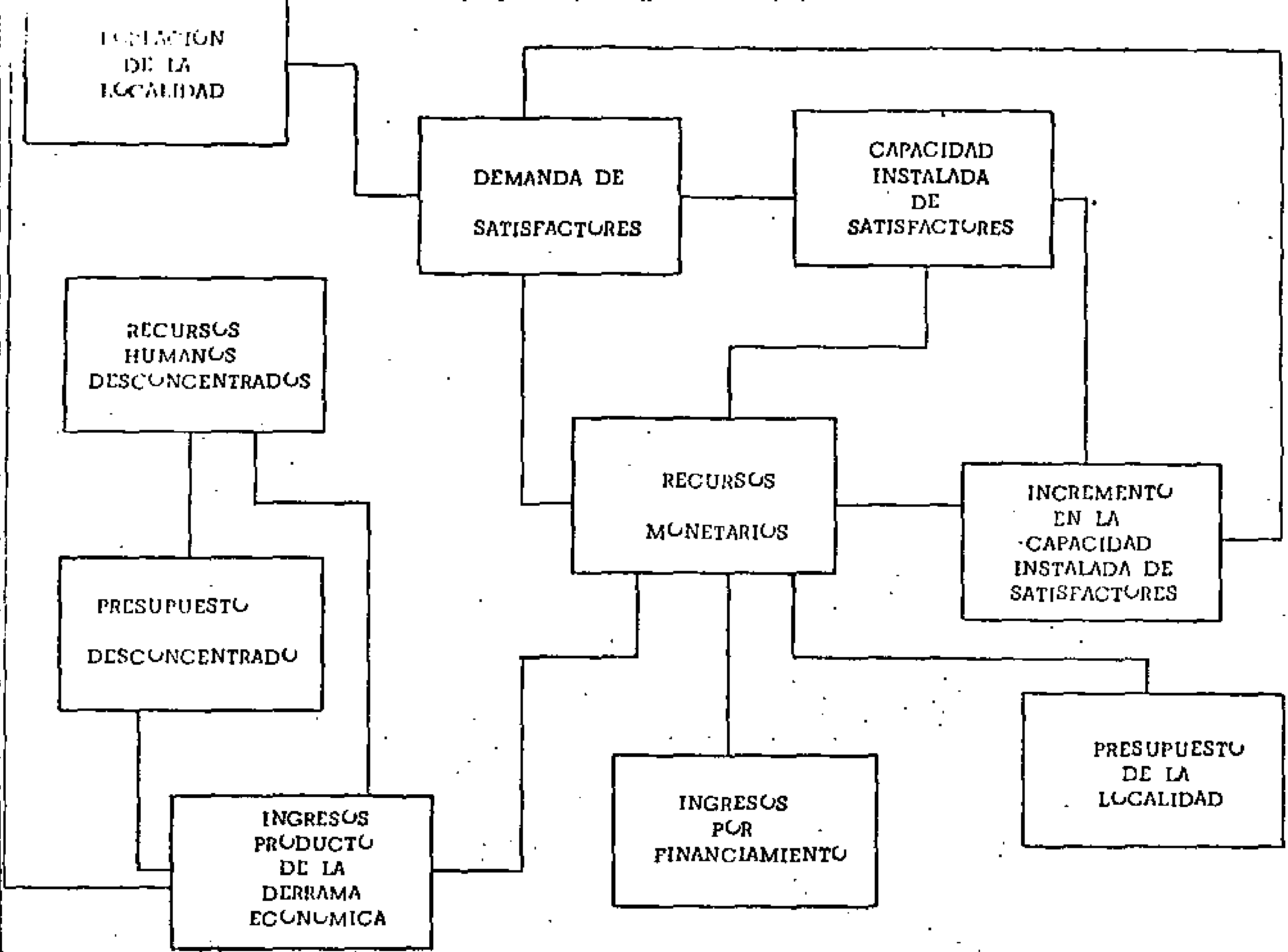
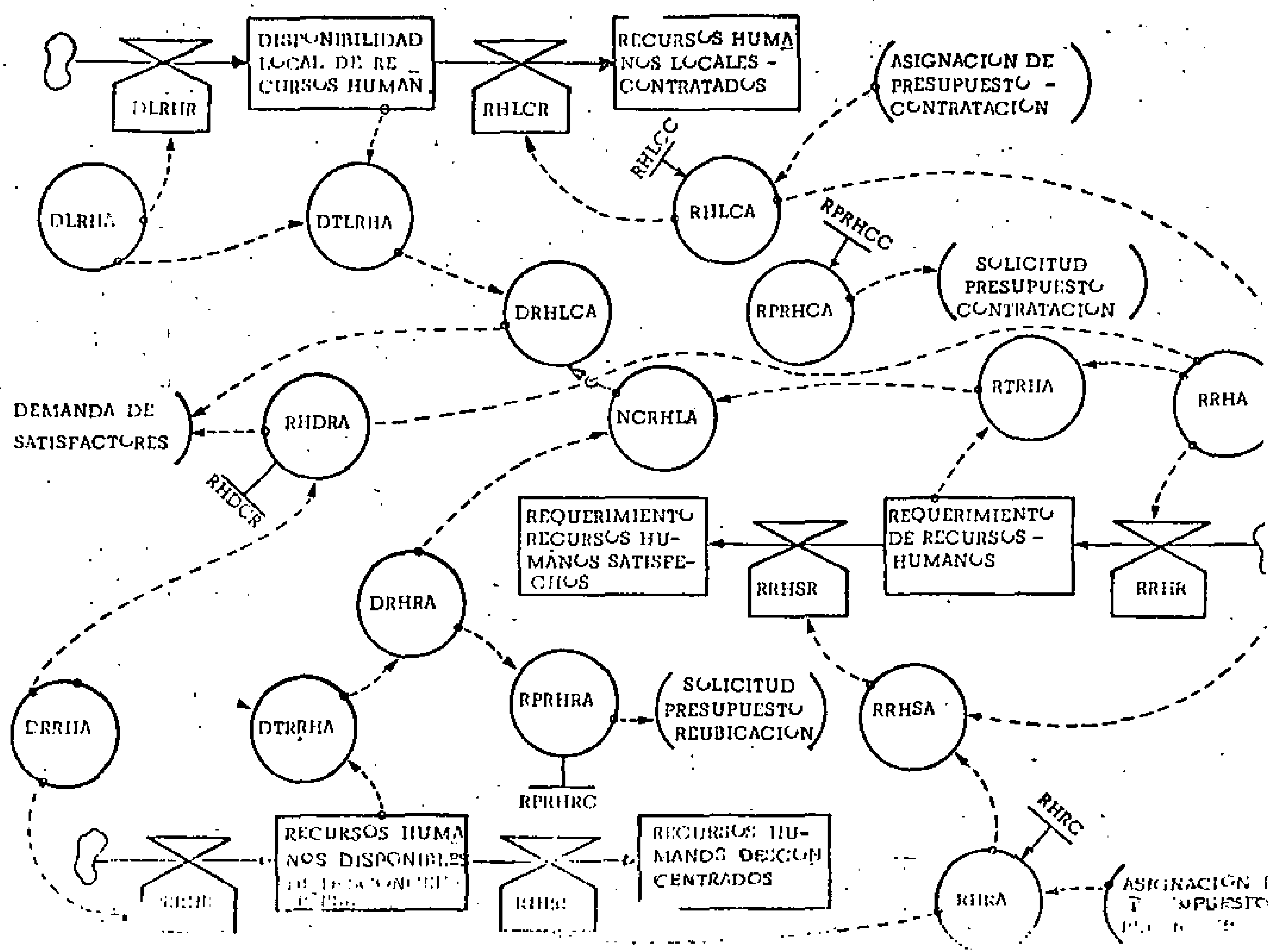

DE LA
LOCALIDAD
DEMANDA DE SATISFACTORES
CAPACIDAD INSTALADA DE SATISFACTORES
RECURSOS HUMANOS DESCONCENTRADOS
RECURSOS MONETARIOS
INCREMENTO EN LA CAPACIDAD INSTALADA DE SATISFACTORES
PRESUPUESTO DESCONCENTRADO
PRESUPUESTO DE LA LOCALIDAD
INGRESOS POR FINANCIAMIENTO
INGRESOS PRODUCTO DE LA DERRAMA ECONOMICA

FIGURA 6



DISPONIBILIDAD LOCAL DE RE CURSOS HUMAN
DLRHR
RECURSOS HUMANOS LOCALES CONTRATADOS
RHLCR
ASIGNACION DE PRESUPUESTO CONTRATACION
DLRHA
DTLRHA
RHLCC
RHLCA
RPRHCC
DRHLCA
RPRHCA
SOLICITUD PRESUPUESTO CONTRATACION
DEMANDA DE SATISFACTORES
RHDRA
RHDCR
NCRHLA
RTRHA
RRHA
REQUERIMIENTO RECURSOS HUMANOS SATISFECHOS
RRHSR
REQUERIMIENTO DE RECURSOS HUMANOS
RRHR
DRHRA
RPRHRA
SOLICITUD PRESUPUESTO REUBICACION
RRHSA
DRRHA
DTRRHA
RPRHRC
RHRC
RECURSOS HUMANOS DISPONIBLES
RECURSOS HUMANOS DESCONCENTRADOS
RHRA

R E C U R S O S   H U M A N O S

```
NOTE    REQUERIMIENTOS
A       RRHA.K = TABHL (RRHT.TIME.K,O,2,1)
T       RRHT = # / # / #
R       RRHR.KL = RRHA.K
L       RRHL.K = RRHL.J + DT * (RRHR.JK - RRHSR.JK)
N       RRHL = RRHLC
C       RRHLC = #
R       RRHSR.KL = RRHSA.K
L       RRHSL.K = RRHSLC
C       RRHSLC = #
A       RTRHA.K = RRHL.K + RRHA.K
NOTE    DISPONIBILIDAD DE REUBICACION
A       DRRHA.K = TABHL (DRRHT, TIME.K, O,2,1)
T       DRRHT = # / # / #
R       DRRHR.KL = DRRHA.K
L       DRRHL.K = DRRHL.J + DT * (DRRHR.JK - RHRR.JK)
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```
N      DRRHL = DRRHLC
C      DRRHLC = #
R      RHRR.KL = RHRA.K
L      RHRL.K = RHRL.J + DT (RHRR.JK)
N      RHRL = RHRLC
C      RHRLC = #
A      DTRRHA.K = DRRHL.K + DRRHA.K
NOTE   DISPONIBILIDAD LOCAL
A      DLRHA.K = TABHL (DLRHT, TIME.K, 1,2,1)
T      DLRHT = # / # / #
R      DLRHR.K = DLRHA.K
L      DLRHL.K = DLRHL.J + DT * (DLRHR.JK - RHLCR.JK)
N      DLRHL = DLRHLC
C      DLRHLC = #
R      RHLCR.KL = RHLCA.K
L      RHLCL.K = RHLC1.J + DT * (RHLCR.JK)
N      RHLCL = RHLCLC
C      RHLCLC = #
```

```
R       RHLCR.KL = RHLCA.K
L       RHLCL.K = RHLCL.J + DT * (RHLCR.JK)
N       RHLCL = RHLCLC
C       RHLCLC = #
A       DTLRHA.K = DLRHL.K + DLRHA.K
NOTE    DECISION REUBICAR_CONTRATAR
A       DRHRA.K = CLIP (RTRHA.K, DTRRHA.K, DTRRHA.K, RTRHA.K)
A       RPRHRA.K = RPRHRC * DRHRA.K
C       RPRHRC = #
A       NCRHLA.K = CLIP (RTRHA.K - DRHRA.K, O, RTRHA.K, DTRRHA.K)
A       DRHLCA.K = CLIP (NCRHLA.K, DTLRHA.K, DTLRHA.K, NCRHLA.K)
A       RPRHCA.K = RPRHCC *  DRHLCA.K
C       RPRHCC = #
NOTE    REUBICAR-CONTRATAR
A       RHRA.K = RHRC * RMRHRA.K
C       RHRC = #
A       RHLCA.K = RHLCC * RMRNCA.K
```

```
C       RHLCC = #
A       RRHSA.K = RHRA.K + RHLCA.K
NOTE    REQUERIMIENTO DE SATISFACTORES
A       RHDRA.K = CLIP (DRRHA.K, RRHA.K, RRHA.K, DRRHA.K)
A       RHLDCA.K = RHLCR.JK
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.
.
.
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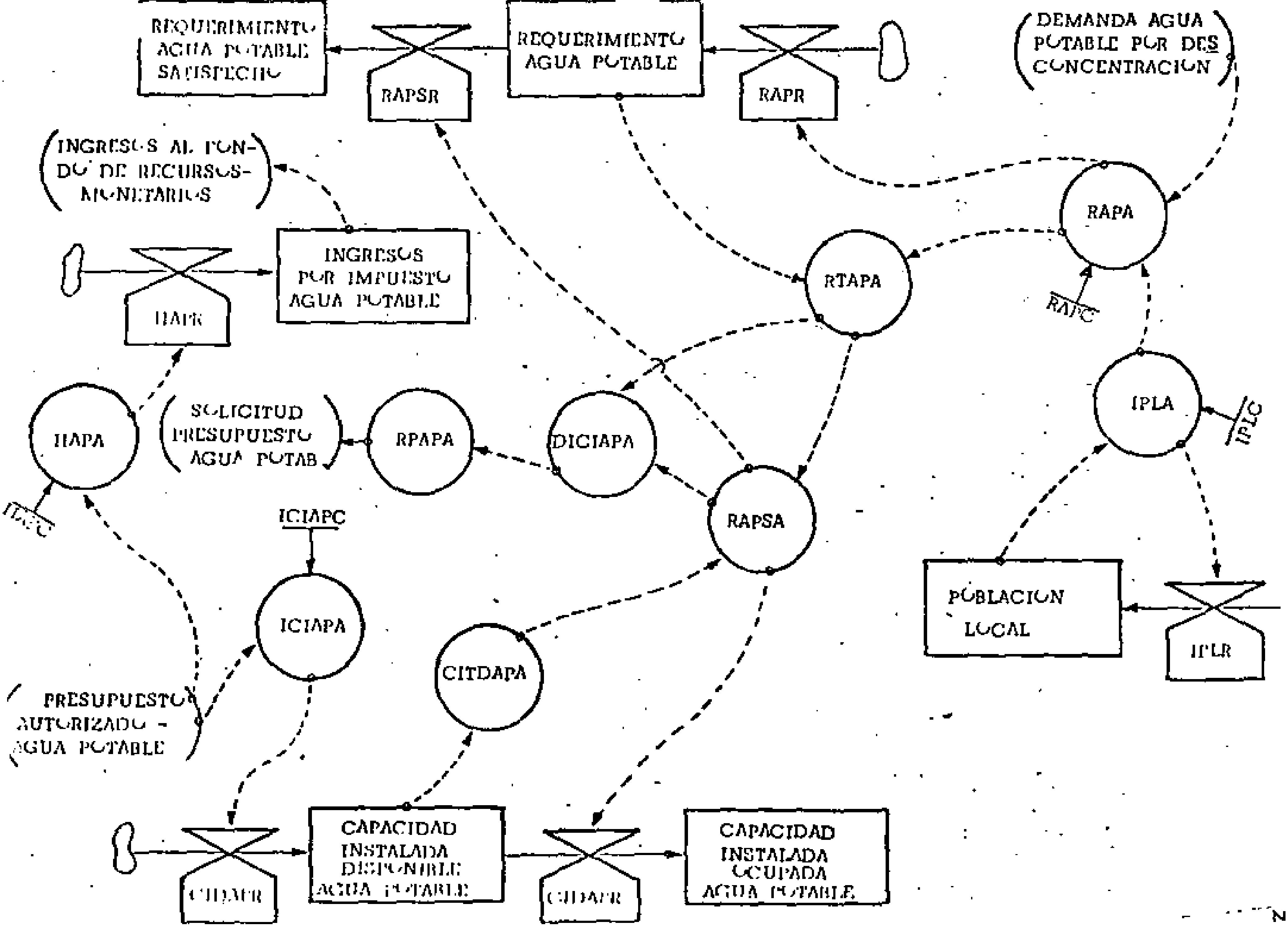

REQUERIMIENTO AGUA POTABLE SATISFECHO
RAPSR
REQUERIMIENTO AGUA POTABLE
RAPR
DEMANDA AGUA POTABLE POR DESCONCENTRACION
INGRESOS AL FONDO DE RECURSOS MONETARIOS
RAPA
INGRESOS POR IMPUESTO AGUA POTABLE
RTAPA
RAPC
IIAPR
IPLA
IIAPA
SOLICITUD PRESUPUESTO AGUA POTAB
RPAPA
DICIAPA
IPLC
RAPSA
ICIAPC
POBLACION LOCAL
IPLR
ICIAPA
CITDAPA
PRESUPUESTO AUTORIZADO - AGUA POTABLE
CAPACIDAD INSTALADA DISPONIBLE AGUA POTABLE
CAPACIDAD INSTALADA OCUPADA AGUA POTABLE
CIDAPR

A G U A   P O T A B L E

```
NOTE          DEMANDA

 A      RAPA.K = RAPC * (RHDRA.K + IPLA.K)

 C      RAPC = #

 R      RAPR.KL = RAPA.K

 L      RAPL.K = RAPL.J + DT * (RAPR.JK - RAPSR.JK)

 N      RAPL = RAPLC

 C      RAPLC = #

 R      RAPSR.KL = RAPSA.K

 L      RAPSL.K = RAPSL.J + DT * (RAPSR.JK)

 N      RAPSL = RAPSLC

 C      RAPSLC = #

 A      RTAPA.K = RAPL.K

NOTE    CAPACIDAD INSTALADA

 A      ICIAPA.K = ICIAPC * RMAPA.K

 C      ICIAPAC = #

 R      CIDAPR.KL = ICIAPA.K
```

```
L      CIDAPL.K = CIDAPL.J + DT * (CIDAPR.JK - CIOAPR.JK)
N      CIDAPL = CIDAPLC
C      CIDAPLC = #
R      CIOAPR.KL = RAPSA.K
L      CIOAPL.K = CIOAPL.J + DT * (CIOAPR.JK)
N      CIOAPL = CIOAPLC
C      CIOAPLC = #
A      CITDAPA.K = CIDAPL.K
NOTE   DECISION DE INCREMENTAR LA CAPACIDAD INSTALADA
A      RAPSA.K = CLIP (RTAPA.K, CITDAPA.K, CITDAPA.K, RTAPA.K)
A      CICIAPA.K = CLIP (O,RTAPA.K - CITDAPA.K, CITDAPA.K, RTAPA.K)
A      RPAPA.K = RPAPC * DICIAPA.K
C      RPAPC = #
.
.
.
.
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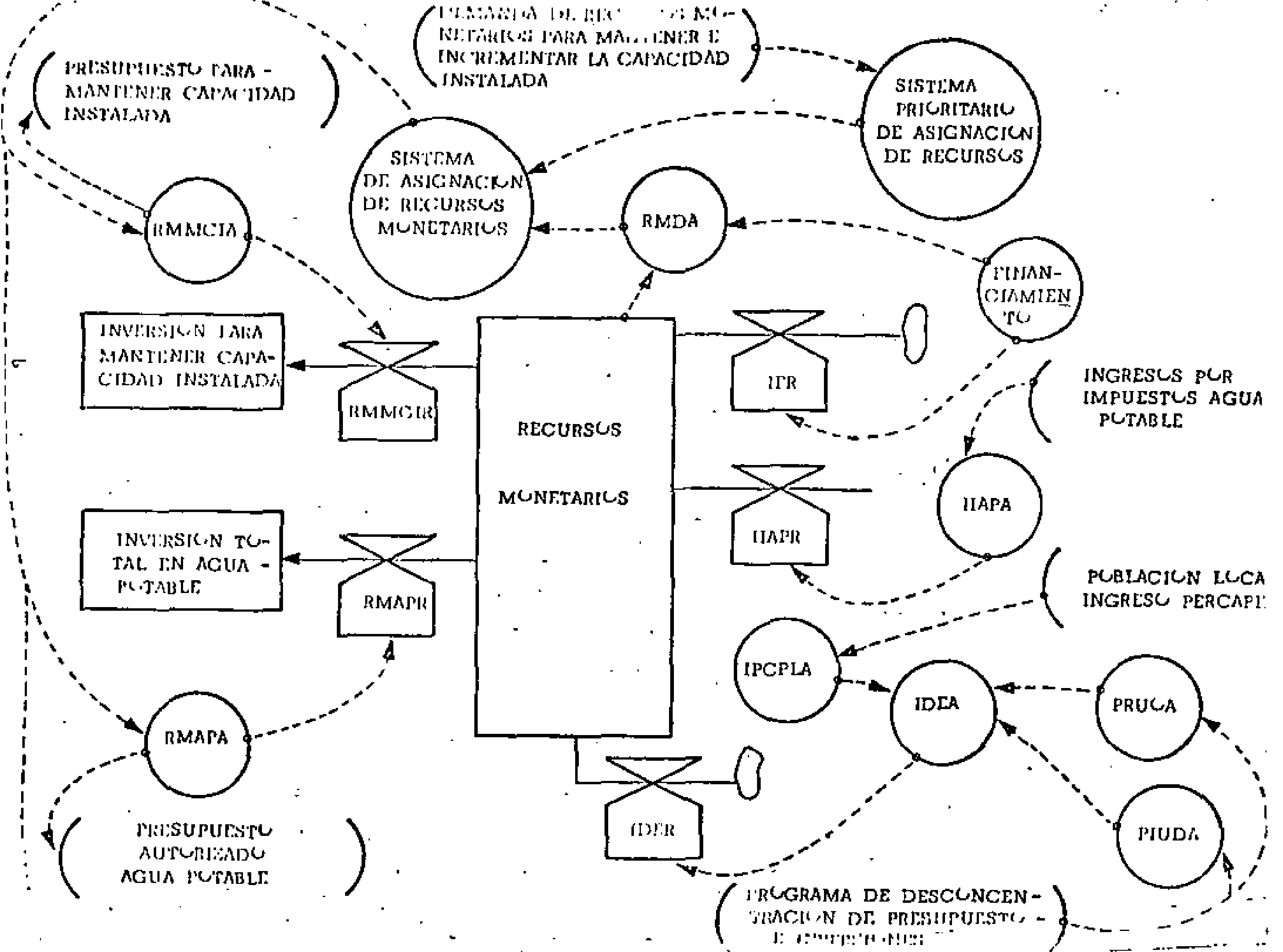
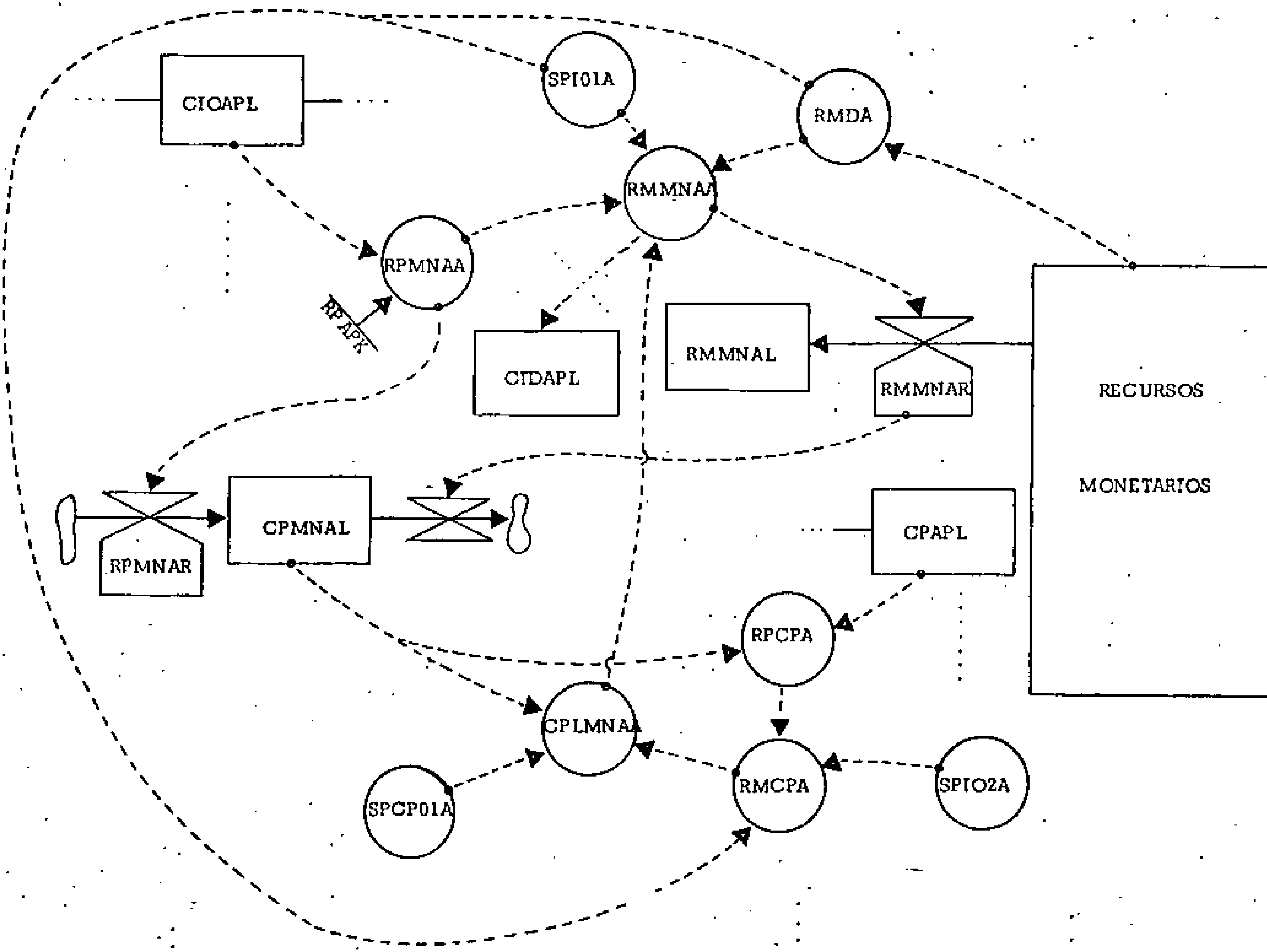

NETARIOS PARA MANTENER E
INCREMENTAR LA CAPACIDAD
INSTALADA
PRESUPUESTO PARA -
MANTENER CAPACIDAD
INSTALADA
SISTEMA
PRIORITARIO
DE ASIGNACION
DE RECURSOS
SISTEMA
DE ASIGNACION
DE RECURSOS
MONETARIOS
RMDA
RMMCIA
FINAN-
CIAMIEN
TO
INVERSION PARA
MANTENER CAPA-
CIDAD INSTALADA
RMMCIR
IPR
RECURSOS
MONETARIOS
INGRESOS POR
IMPUESTOS AGUA
POTABLE
IIAPA
IIAPR
INVERSION TO-
TAL EN AGUA -
POTABLE
RMAPR
POBLACION LOCA
INGRESO PERCAPI
IPCPLA
IDEA
PRUCA
RMAPA
IDER
PIUDA
PRESUPUESTO
AUTORIZADO
AGUA POTABLE
PROGRAMA DE DESCONCEN-
TRACION DE PRESUPUESTO -

FIGURA

SISTEMA DE ASIGNACION RECURSOS MONETARIOS



SISTEMA DE ASIGNACION DE RECURSOS MONETARIOS

```
L     CIOAPL.K = CIOAPL.J + DT * (CIOAPR.JK)
N     CIOAPL = CIOAPLC
C     CIOAPLC = #
R     CIOAPR.KL = RAPSA.K
.
.
A     RPMNAA.K = .... + ROAPK * CIOAPL.K + ....
.
.
A     SPIO1A.K = RPMNAA.K
A     SPIO2A.K = SPIO1A.K + RPCPA.K
A     SPIO3A.K = SPIO2A.K + PPAPA.K
.
.
.
.
.
A     RMMNAA.K = CLIP (RPMNAA.K,RMDA.K, RMDA.K, SPIO1A.K) + CPLMNAA.K
```

```
A      RMCPA.K = CLIP (RPCPA.K, RMCPY.K, RMDA.K, SPIO2A.K)

A      RMCPY.K = CLIP (RMCPZ.K,O, RMDA.K - SPIO1A.K,O)

A      RMCPZ.K = CLIP (RMDA.K - SPIO1A.K,O, RPCPA.K,O)

A      RMAPA.K = CLIP (RPAPA.K, RMAPY.K, RMDA.K, SPIO3A.K) + CPLAPA.K

A      RMAPY.K = CLIP (RMAPZ.K,O, RMDA.K - SPIO2A.K,O)

A      RMAPZ.K = CLIP (RMDA.K - SPIO2A .K,O, RPAPA.K,O)

.

.

A      RMDA.K = IFA.K + RMK  .

A      IFA.K = TABHL (IFT, TIME.K,O,3,1)

T      IFT = # / # / # / #

L      RM.K = RM.J + DT * ( IIAPA.K + ....      - RMMNAR.JK - RMCPR.JK - RMAPR.JK .. .)

.

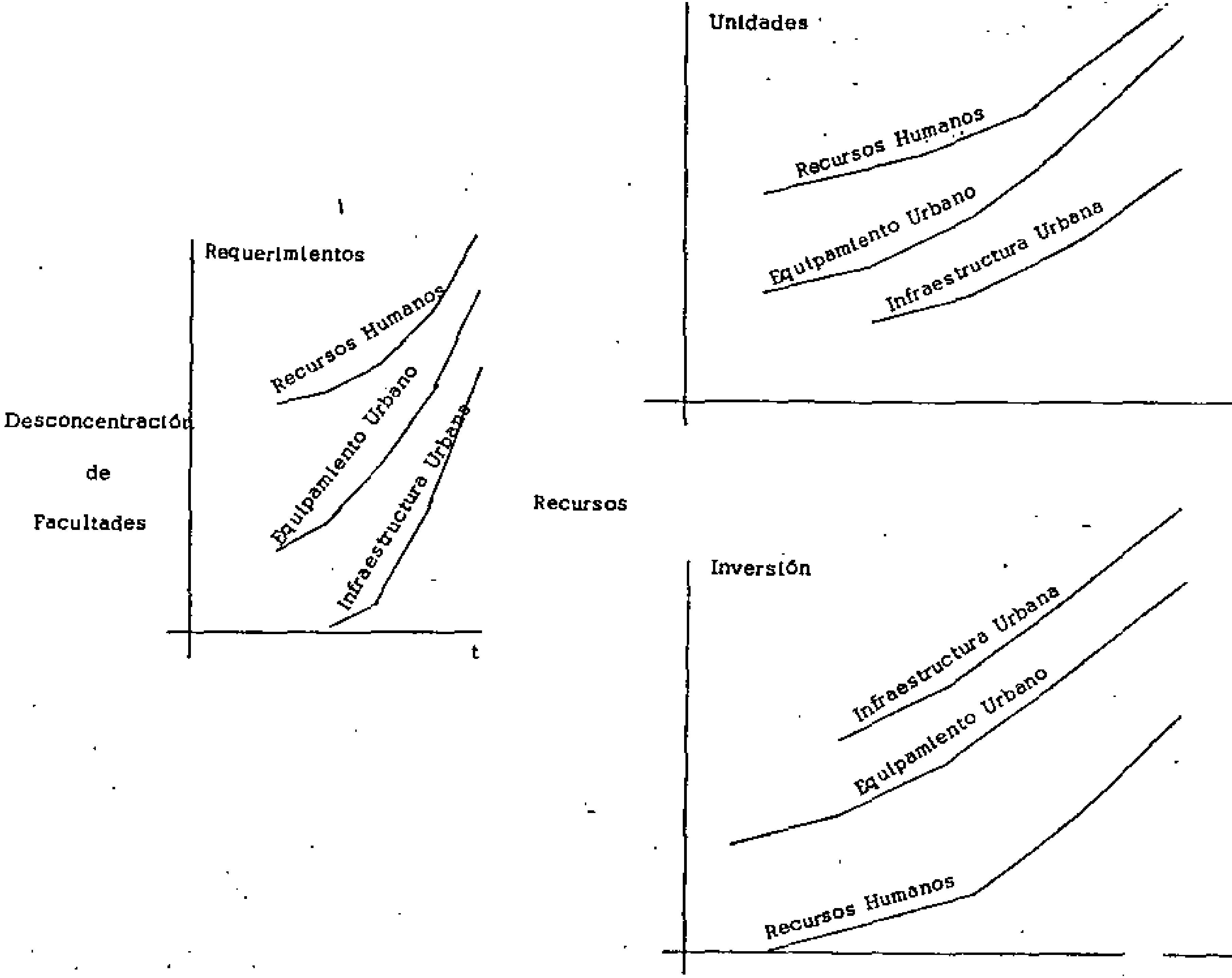
.

.

L      CPMNAL.K = CPMNAL.J + DT * (RPMNAR.JK - RMMNAR.JK)

N      CPMNAL = CPMNALC
```

```
C       CPMNALC = #
.
.
.
A       CPLMNAA.K = CLIP (CPMNAA.K, RMCPA.K, RMCPA.K, SPCO1A.K)
A       CPLAPA.K = CLIP (CPAPA.K, CPLAPY.K, RMCPA.K, SPCPO2A.K)
A       CPLAPY.K = CLIP(CPLAPZ.K,O,RMCPA.K - SCPO1A.K)
A       CPLAPZ.K = CLIP (RMCPA.K - SPCPO1A.K,O, CPAPA.K,O)
.
.
.
L       CPAPL.K = CPAPL.J + DT * (RPAPR.JK - RMAPR.JK)
N       CPAPL = CPAPLC
C       CPAPLC = #
.
.
.
```


Desconcentración
de
Facultades
Requerimientos
Recursos Humanos
Equipamiento Urbano
Infraestructura Urbana
t
Recursos
Unidades
Recursos Humanos
Equipamiento Urbano
Infraestructura Urbana
Inversión
Infraestructura Urbana
Equipamiento Urbano
Recursos Humanos

PROGRAMA DE INGRESOS-EGRESOS DE LA LOCALIDAD

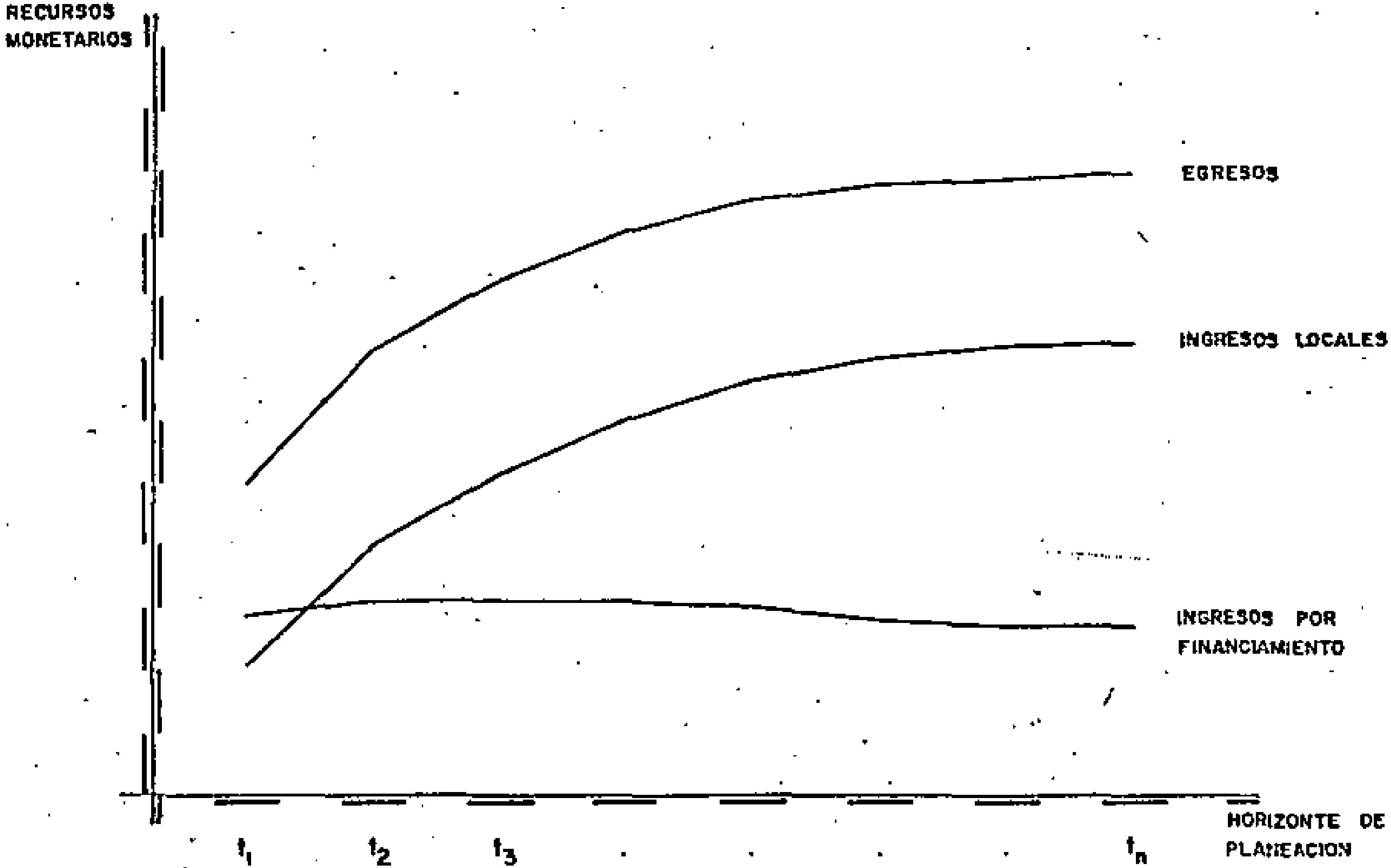
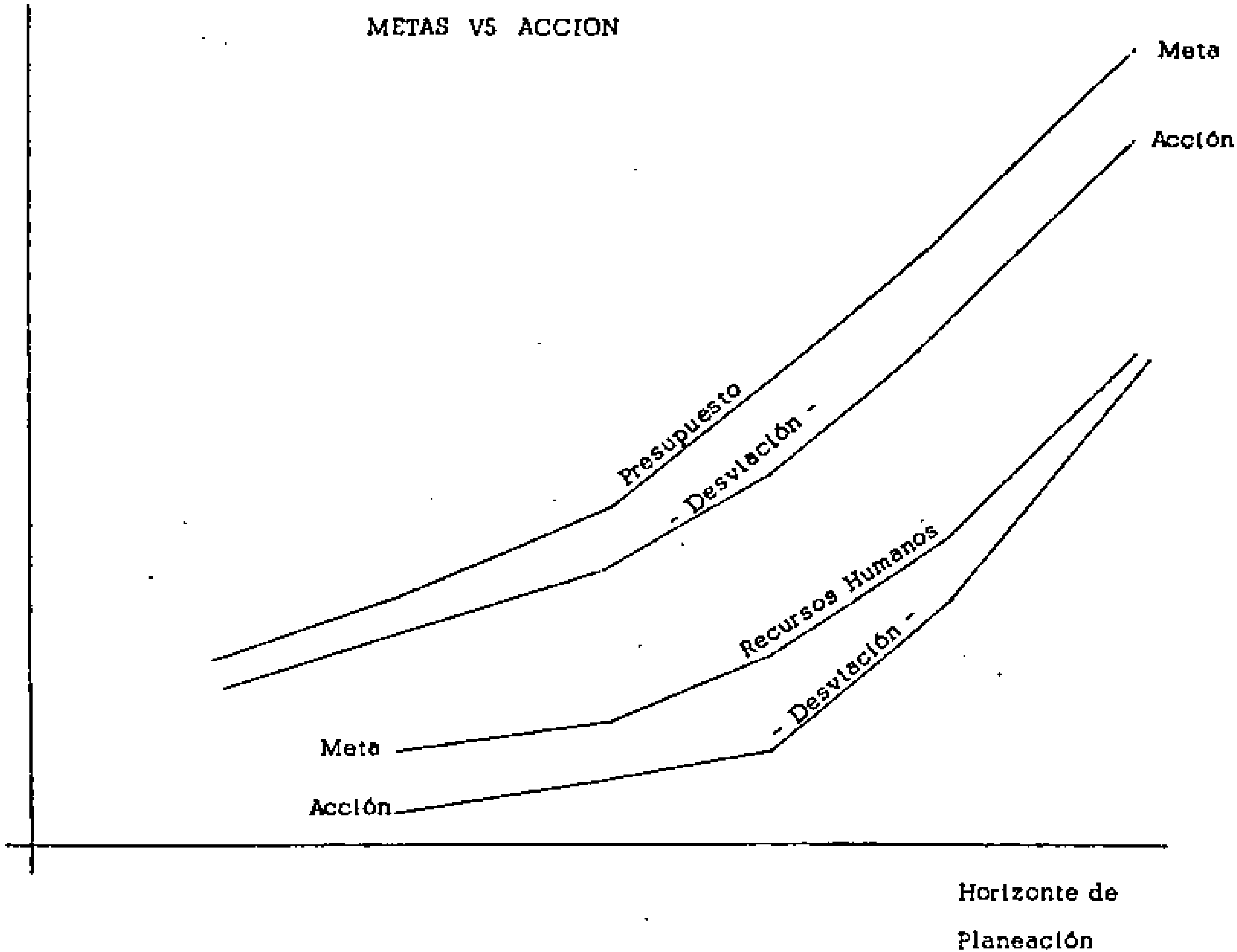
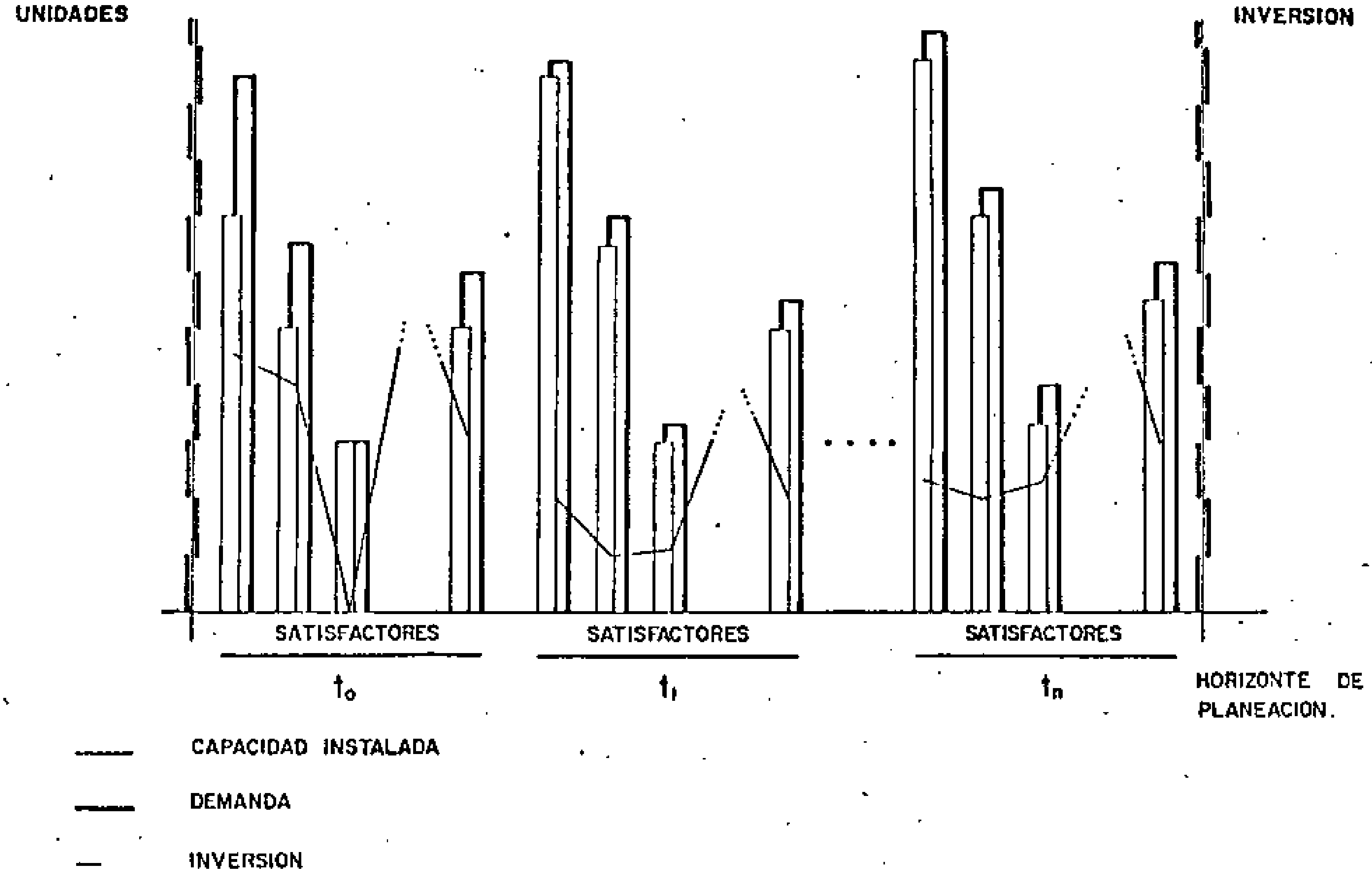


FIGURA 10


METAS VS ACCION
Meta
Acción
Presupuesto
- Desviación -
Recursos Humanos
- Desviación -
Meta
Acción
Horizonte de Planeación

CAPACIDAD INSTALADA Y DEMANDA DE SATISFACTORES

PROGRAMA DE INVERSIONES



PROGRAMA DE INGRESOS - EGRESOS EN OAXACA, OAX.

- MILLONES DE PESOS -

CONCEPTO	PERIODOS	
	1	2
INGRESOS		
. Total	20.8	22.5
. Municipales	15.7	16.2
. Impacto de la Desconcentración	5.1	6.3
EGRESOS		
. Total	274.3	284.0
. Municipio	20.8	22.5
. Sectores	253.5	261.5
FINANCIAMIENTO	8.3	14.0
EGRESOS MUNICIPIO		
. Agua Potable	6.6	6.8
. Energía	8.9	7.4
. Educación	5.3	6.6
. Servicios Públicos	0.0	1.7
EGRESOS SECTORES		
. Salud	10.5	11.3
. Vivienda	243.0	250.2

TABLA 5

DEMANDA Y CAPACIDAD INSTALADA DE SATISFACTORES EN OAXACA, OAX.

SATISFACTORES		DEMANDA	INCREMENTO DEMANDA	CAPACIDAD	INCREMENTO CAPACIDAD	INVERSION ($ 000,000)	DEFICIT CAPACIDAD	INVERSI REQUERI ($ 000,0
Agua Potable	0	27 076		27 076				
	1	27 886	810	27 886	810	6.6	0	0
	2	28 720	834	28 720	834	6.8	0	0
Energía	0	27 076		27 076				
	1	27 886	810	27 886	810	8.9	0	0
	2	28 720	834	28 558	672	7.4	162	1.8
Salud *	0	541		541				
	1	555	14	555	14	10.5	0	0
	2	570	15	570	15	11.3	0	0
Vivienda *	0	27 076		27 076				
	1	27 886	810	27 886	810	243.0	0	0
	2	28 720	834	28 720	834	250.2	0	0
Educación	0	2 436		2 436				
	1	2 510	74	2 469	33	5.3	41	6.6
	2	2 586	76	2 510	41	6.6	76	12.2
Servicios	0	27 076		27 076				
	1	27 886	810	27 076	0	0.0	810	1.7
	2	28 720	834	27 886	810	1.7	834	1.8

TABLA 6

* Acciones concertadas con otros sectores.

CAPACIDAD INSTALADA Y DEMANDA DE SATISFACTORES EN OAXACA, OAX.

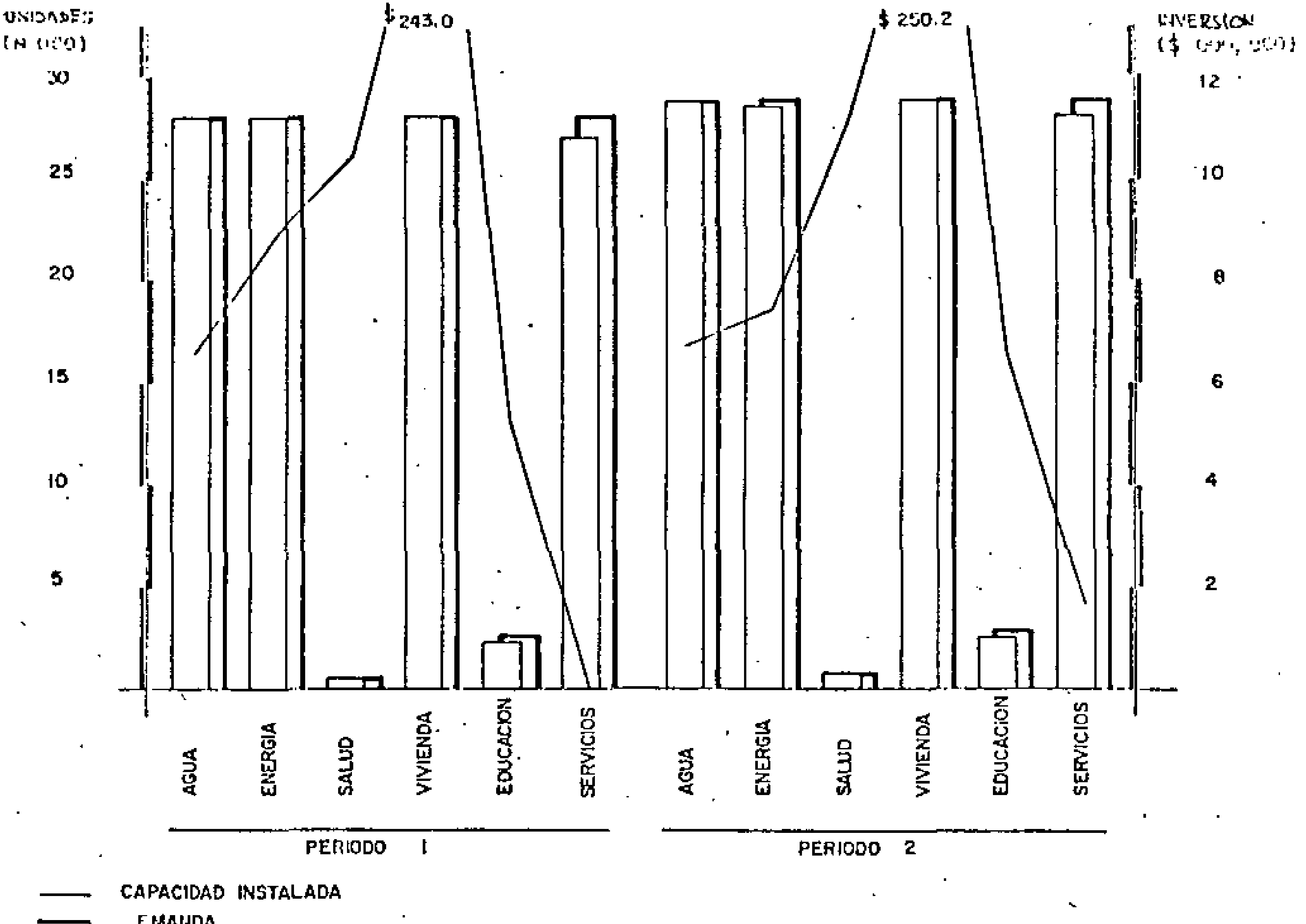


FIGURA 10

DIVISION DE EDUCACION CONTINUA
FACULTAD DE INGENIERIA U.N.A.M.

DINAMICA DE SISTEMAS (FORRESTER)

DESARROLLO DEL PETROLEO EN MEXICO

M. EN C. MARIO LEÓN ESTRADA

MARZO, 1984

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(i)

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INTRODUCTION

The discovery and initial exploitation of vast oil and gas reserves within Mexico during the 1970's precipitated a large variety of hopes and expectations regarding the benefits that oil development could bring to Mexico. Some people expected that ample domestic energy supplies combined with foreign exchange earnings derived from oil export would become an intrument for rapid growth and elevating the income and job prospects of unemployed or underemployed. Oil resources promised a mechanism for eliminating chronic balance of payments and government deficits, while providing additional revenues to the government to control inflation. In contrast to these high expectations, another group of people pointed out the difficulties ahead in effecting judicious use of Mexico's oil resources, and further pointed to the experience of other oil exporting countries that counselled extreme caution in the allocation and disbursement of oil revenues. Venezuela for example, had failed to use oil wealth wisely; it had suffered rampant inflation and had become increasingly dependent on imports of food and consumer goods, without simultaneously developing a strong domestic economic base.

The impacts of oil development on the Mexican economy to date give some justification to both viewpoints expressed above. On the one hand, growth in real GDP accelerated from 3.3% per year in 1977 to 7.3% per year in 1978 and nearly 8% in 1979. But on the other side, inflation has simultaneously risen to the range of 30% per year, domestic credit availability remains tight, and nominal interest rates have increased along with inflation. Moreover, balance of payments on the current account worsened from -2% of GDP in 1977 to -4% of GDP in 1979 and again in 1980, despite revenues from oil exports of over 10 billion dollars in 1980.

In many respects, it is too early to appreciate the significant ramifications of future oil development and export for Mexico. National energy policy is still evolving along the tenent of the Global Development

Plan and National Energy Plan, and significant delays will intervene between policy implementation and eventual consequences.

The purpose of this paper is to discuss the important role that oil has in the Mexican economy, and based on a simulation model, show the long term consequences of the policies stated in the plans developed by the government. To finalize, there are some further policies that could be implemented to solve some of the problems that oil alone does not.

OIL AND ECONOMIC DEVELOPMENT IN MEXICO

Oil started its development during the Diaz regime by giving concessions to foreign companies, and allowing importation of drilling and refining equipment duty free, and exemption of oil company capital stock from taxes. With these benefits and the discoveries of large oil reserves, oil production rised enough to supply 25% of world oil production by 1917. Despite the revolutionary war, from 1917 to 1921 the production incresed from 55.3 to 193.4 million barrels. With the approval of the article 27 of the constitution that considered the natural resources in the subsoil property of the Mexican nation, and the companies were granted a lease to exploit them, plus the protection given to the workers in article 123, generated adverse feelings in the oil companies that leaded them to look for new sources of oil as Venezuela, and decrease the production in Mexico.

Despite the great oil wealth in the country, Mexicans gain very little from it, because literally all the oil industry was in foreign hands. They had tax excemptions so the government could not benefit, they had foreigners in the top possitions of the companies, and wage discrimination against Mexicans, so labor could not benefit, and finally, the huge profits went abroad to the home countries of the owners.

During the post-revolutionary period, the Mexican state was in formation, and the economy was recovering from the war. Oil production was declining and its role in the economy was not as important as its role in politics. The attitude of the oil companies, the increasing demands from the workers, and the nationalistic trend in the government, lead to the expropiation in 1938. From then, oil has had an incresing role in the economy and politics of Mexico.

The recent economic history of Mexico falls into three clearly defined stages. The first of these, characterized by development with inflation, covers the period from the late 1930's until 1956, with annual price increases of 11%, government deficits financed with currency issues, foreign exchange instability -the peso was devaluated in 1948 and 1954- and a rapid agricultural development. In fact, agricultural output had a higher rate of growth than that of the gross national product (6.2 percent) and brought about a considerable expansion in agricultural exports and foreign

trade in general. In short, this was a period of externally-oriented growth. During this period Pemex had to face embargo of spares and equipment, and blocade of shipments. This situation was alleviated with WW II. Internally, it faced strugles from the union workers to get control of the new company, and to get the managerial and technical expertise that was lost with the departure of oil companies. From the experience gained from the nationalization of the rail roads, the government decided not to make the same mistake again, and manage to keep control of Pemex. Its role in the economy was limited to supply domestic demand, and a decreasing amount for exports. The director of Pemex during that period Antonio J. Bermudez, considered that Pemex should not get involve in the national politics, and kept the role of Pemex to fulfill its objectives: exploration, exploitation, refining, transportation, storage, distribution, and first hand sale of basic petrochemicals.

The second stage was inwardly-oriented, based on substitution for imports of manufactured goods, the proportion of which decreased from 8 percent of GNP in the first period to 5 percent in the second. Relative stagnation also became evident in the agricultural sector, the rate of growth of which fell below that of the gross national product, which remained 6.2 percent. The exchange rate of the peso was maintained at 12.50 to the dollar. Prices rose 1.9 percent per year on the average (less than in the United States, with which Mexico has 70 percent of its foreign trade).

As a result of the diminished vitality of the agricultural sector, the rate of increase of agricultural exports declined considerably, and in general receipts of foreign exchange increased at a slower rate than expenditures abroad. This produced a large deficit in the current account of the balance of payments and an increase in the foreign debt. The slowing down of investment in social overhead capital and in agricultural research and development, as well as the distortion of cost structure resulting from the effects of protectionism on the prices of industrial inputs, had an adverse effect on the competitive position of agricultural exports and constitute a factor in the slowdown in growth of merchandise exports. On the other hand, the parity prices for goods destined for domestic consumption rose in order to stimulate their output.

One characteristic of the period of price stability as the growth of domestic savings, which played an important role in the accelerated expansion of the banking system and, in fact, in a general financial boom of unusual magnitude, brougth about by factors such as transfers from the non-financial market to the institutional sector. The process facilitated the placement of government securities by the central bank among the financial intermediaries-especially the non-monetary ones- so that the government deficits no longer represented a mere creation money by the central bank, as they did in the first period.

During this period Pemex continued its solidification as company, it gained the technical expertice, to become self sufficient and proved to be a success of nationalization. It became an instrument of the government to encourage industrialization by supplying the increasing demand for hydrocarbons and to give subsidies through low prices. In 1958 it was granted a state monopoly on basic petrochemicals, becoming an active participant in the industrialization process by reducing imports and supplying feedstock for private manufacturing companies. Production of secondary petrochemicals was left to private companies whose share capital is at least 60% Mexican owned.

The third stage has been characterized by development with inflation and a higher deppendency on oil. This characteristics are a consequence of the problems of the second stage. The increasing deficits in foreign trade and government budget, plus the change in the stability in the international economy, created a sudden decline in GDP growth and in order to reactivate the domestic economy and to correct some of the deficiencies of the economic model, the government started a series of social and investment programs which were financed with money issues and borrowing. This generated high inflation rates and worsened the balance of trade, that eventually made it impossible to sustain the parity of 12.50 pesos per dollar and forced a major devaluation in 1976. This measure worsened the inflation and combined with expectations of oil revenues, made the government to follow a policy of rapid expantion and increasingly larger government budget deficits which lead to minidevaluations during 1980 and

1981, and a major one in 1982.

Through the 1960s and until 1971, the money supply was limited to an average annual growth of 10.4 percent, which, in conjunction with an annual real GDP growth rate of 6.8 percent and stable prices of imported goods, kept inflation at a 2.7 percent average annual rate. Since the end of 1972, however, Mexico has experienced a sharply higher inflation rate, mainly because of substantial increases in the money supply, the rapid growth of Government expenditures, the expansion of aggregate demand, bottlenecks inhibiting increased production and higher import prices. The removal of the fixed exchanged rate of the peso on August 31 of 1976, the subsequent decontrol of prices on many items and the adjustment of certain public utility and transport rates also contributed to high inflation. In addition, speculation concerning the imposition of the Value Added Tax on January 1 of 1980 contributed to the sharp increases in price levels during the begining of 1980.

With the discoveries of the huge hydrocarbon deposits of the Southeast of Mexico in the early 1970s, oil and Pemex changed its role in the economic arena. On the economic side, Pemex become the largest enterprise in Latin America and in Mexico. It is responsible on an exclusive basis for the operation and development of Mexico's oil, natural gas and basic petrochemical industries. It has total assets of 1,188,000 millions of pesos equivalent to $48,462 millions at December 31, 1981 and net sales of $ 461,000 millions of pesos equivalen to $18,806 millions (converted at 24.514 pesos per dollar which was the average exchange rate for 1981).

On the political side, the role has become more active because its actions generate strong debates, and from the retoric of the polititians that have built a lot of expectations from oil to the population.

In 1981, Pemex produced an average of 2,312,144 BPD of crude oil and condensate, 239,777 BPD of natural gas liquids and 4,060.8 million of cubic feet of natural gas per day. This represented an increase over 1976 production levels of 189%, 157%, and 92% respectively.

The continous rise in production has allowed Mexico to increase its exports of crude oil which started in 1974 with 15,902 BPD, and rose to

1,098,021 BPD in 1981. During 1980, exports amounted to $10,401.9 million and imports reached $765.9 million, resulting in a net surplus of $9,636 million. For 1981 it was expected that the total exports would reach $20,405.5 million and imports would be reduced to $552 million producing a net surplus of $19,853.5 million, a 106% increase over the previous year.

Due to the world surplus of oil, in the middle of 1981, there was a sudden fall of mexican oil exports to about half of the target, and up to the beginning of 1982, it has not been possible a full recovery despite of three reductions in price.

At December 31 of 1980 the export prices of Istmo crude oil was $38.50 per barrel and the export price of Maya crude oil was $34.50 per barrel. At the end of 1981 the prices were $35.00 and $28.50 per barrel respectively. In January of 1982 there was another price reduction of $2.00 to the Maya crude oil.

The shortage of export oil revenues made it necessary to increase foreign borrowing heavyly to a total of $16,234 million, paying $6,758 million, resulting in a net increase in debt of $9,476 million. This magnitude represents one fifth of the total public foreign debt outstanding at the end of 1981.

Domestic prices for Pemex's products are fixed by the Government with a view to generating sufficient revenues to cover operating costs, debt service and a portion of capital expenditures. The balance of capital expenditures is financed by borrowing and, when necessary, by capital contributions from the Government. Prices for products exported by Pemex are set by market supply and demand conditions.

As sole owner of Pemex, the Government is entitled to any distribution of profits. To date, no such distribution has been made.

Pemex is required to pay taxes based on total revenues at a rate of 15% for petrochemicals and 27% for all other products. Pemex's export sales of crude oil are subject to a 58% tax plus a 2% ad valorem tax.

The income by sales represented 55% and 45% was made by borrowing. The expenditure was:

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Federal Taxes	238,193	(28%)
Investment	230,773	(27%)
Payment on Debt	165,657	(19%)
Operation Expenses	134,217	(15%)
Interest of Debt	61,740	(7%)
Operaciones Ajenas	30,901	(4%)

The taxes were paid for the following concepts: 37,193 for internal sales, 200,117 export tax and 883 other taxes. This figures represented an increase of 47% over 1980.

In brief, the nation's economic development requires more money and more energy, and Pemex will be the source of both, as its sales and production increase. This implies that Pemex is destined to generate sufficient production to diminish imports, increase exports, and earn money abroad to balance necessary purchases. Then the continued expansion of Pemex will make it richer and more powerful.

The rebirth of the oil industry during the last decade, generated a series of debates, plans and policies regarding the uses, abuses, and implications of the new wealth. Who should benefit? To whom would the money go? What purposes would it eventually serve? To what extent?

After the discovery and confirmation of increasingly larger oil reserves in the Southeast of Mexico, there was also increasing concern and public discussion about the alternative policies that the Government should follow regarding oil exploitation and uses of oil revenue. For the first time in Mexico there were open discussions in all the arenas, at all levels, and from all political affiliations. So from several government agencies plans came out including the role of oil. Several organizations like the CTM proposed the creation of a National Fund for Employment (Fondo del Empleo), in which all oil revenue were to be allocated to create jobs. The main speackeman of the oposission in oil matters, Ing. Herberto Castillo, became very popular by its constant critics to the official programs, basically showing inconsistencies and political implications that were not always on the side of the government. For example in for the construction of the gaseoducto to the U.S. border, he talked against it on the grounds of higher dependency, and that the benefit of the natural resources were not for the Mexicans. Also he pointed out the big losses of burning the natural gas that come associated with the oil, and that Pemex should produce at a rate that could take advantage of all the resources, instead of loosing gas at the expense of high oil export growth.

The government retoric to sustain its policies and actions came from everyplace in the system. The most utopic of all was former director of Pemex, Diaz Serrano, which stated "Mexico's new oil wealth makes it possible to see in the future the chreation of a new country ...,permanently prosperous ...,a rich country where the right to work will be a reality, with a better style and quality of life in general...". There were other public officials that were more cautious in their statements, but that deffitelly took a clear position. Like the ministers of Patrimony, de la Pena and Oteyza, have consistently shown a nationalistic point of view and want to keep the oil for the Mexicans, while Diaz Serrano wants to sell it to the U.S.

Another point which was considered very important in the discussion was the amount of oil that should be produced, the so called the optimum rate of production. Due to the structural restrictions of the mexican economy, the amount of foreign revenue that it can absorb is limited, and above a certain point all the additional revenues are transformed into inflation. The basic cause is that the additional revenues are added into the monetary base, creating an increase in demand, but as the production is limited, the additional demand causes rise in prices.

Traditionally the main restrictions for economic growth in Mexico had been the lack of foreign resources to import capital goods, and the lack of domestic savings that limited the amount of internal resources to finance investment. With the sudden increment of oil resources, the new restrictions have switched to: lack of skilled labor force, lack of development and implementation of projects (lack of entrepreneurship), and the need for stability in peso exchange rate and inflation.

The objectives in economic policy then should be: to absorbe the growing labor force; and to guarrantee the transfer of oil wealth into permanent sources of income. The first objective requires high GDP growth and the second the need of even higher investment.

Eventually all those economic considerations and public debates, were transformed into concrete plans, that for the first time showed hints of intended productive uses of oil wealth, in a planned manner, and in some cases, looking into the long term perspective. The two more important plans are: the Global Development Plan (Plan Global de Desarrollo) and the National Energy Plan (Plan Nacional de Energia). The most relevant issues of these plans are:

Plan Global de Desarrollo.

Oil resources should be allocated in the following manner:

32% for Pemex investment

68% for investment in the prioritary sectors

25% agriculture

16% industry (excluding Pemex)

20% comunications and transports

24% social development

15% support to the states and municipalities

Oil resources are defined as Pemex current savings.

Plan de Energia.

-domestic energy prices should correspond to 70% of the international prices, and they should be adjusted during ten years to avoid strong inflationary impacts.

-25% of the investment in the electricity sector should be made with its own resources.

-The targets for exports of oil are 1.5 MMBD and 300 million cubic feet of natural gas. (There is a 10% margin to cover eventual needs).

-It will be encourage the development of nuclear energy. 20 nuclear power plants should be installed by the year 2000, that will generate 2000MW (25% of energy requirements)

-Encouragement of science and technology.

-Measures to enforce the rational use of resources.

The combination of both documents determine the official possition. The Global Plan has a very short term horizon 1980-1982, and concentrates on the allocation of oil resources. While the Energy Plan is long term strategy and focuses on the prices of energy, development of alternative sources, and conservation of oil.

SIMULATION MODEL: APPROACH AND METHODOLOGY

SYSTEM DYNAMICS METHODOLOGY.

This model was built using the System Dynamics approach, which has been developed by Jay Forrester at the Massachusetts Institute of Technology, since the 1950's.

System Dynamics is a technique for broad policy analysis of complex systems. It started as Industrial Dynamics, focusing on problems arising in the corporate setting. It was concerned with management problems like instabilities in production and employment, slack or inconsistent corporate growth, and declining market share. During the 1960's, it started to be applied to a broader class of problems and in different areas such as urban planning, and implications of population growth in a limited resource world. With these expansions in applicatons, the name was changed to System Dynamics.

Although System Dynamics has been applied in several fields, it is in social systems, which are characterised by: its complexity, the multiple-contradicting objectives, the imperfect knowledge of the variables and its relationships; that constitute the ideal field for applications of this approach.

The problem that one addresses from the perspective of System Dynamics have at least two features in common. First, they are dynamic: they involve quantities which change over time. Being the variables of the system and their interrelationships (the structure of the system) which determine the behavior. Second, they are feedback systems. The term feedback is used in engineering for servomechanisms and closed loop control systems, in psychology for homeostasis, in social science for vicious circles and self-fulfilling prophesies.

The System Dynamics approach applies to dynamic problems arising in feedback systems.

Feedback is the transmission and return of information. The emphasis, inherent in the word feedback itself, is on the return. A heating system produces heat to warm a room. A thermostat in the room, connected to the heating system, returns information about the room's temperature back to the heating system, turning it on and off and thereby controlling the room's temperature. A thermostat is a feedback device. Together with the furnace, pumps, and radiators or vents, it forms a feedback system.

Feedback systems characteristically form loops of interconnections-loops of causes and effects. Without resorting to the broad intrepretation of the word information implicit in the definition above: A feedback loop is a closed sequence of causes and effects, a closed path of action and information. An interconnected set of feedback loops is a feedback system. There is a growing awareness that biological environmental, industrial, economic, and societal systems are feedback systems. Understanding the dynamic behavior of such systems requires acknowledging the role of feedback.

Feedback loops form the central structures that control change in real systems. Likewise, they are the organizing structure around which system dynamics models are constructed. Although feedback has become a word in the public vocabulary, there is little appreciation of its full significance. The usual approach to problem solving is,as shown in figure #1: a problem is perceived; an action is proposed; a result is expected.

Information about problem ——→ Action ——→ Result

Figure #1

But the result often does not occur. The reason lies in the more realistic structure of figure #2, as extended to more complexity in figure #3. Symptom, action, and solution are not isolated in a linear cause-to-effect relationship, but exist in a nest of circular and interlocking structures wherein an action can induce not only correction but also fluctuation, counterpressures, and even accentuation of the forces that produced the original symptoms of distress.

All change takes place within the control of feedback loops. Growth, goal seeking, and oscillation are a consequence of feedback loop dynamics. Some loops tend to gennerate growth or decay, and others are self regulatory or goal seeking. The results are not always evident because the influence of one loop can vary when the rest of the variables in the system also change.

So many times the actions to solve problems in socioeconomic systems do not produce the intended results, not just due to lack of control in the implementation of the policy but as result of the so called counterintuitive behavior of dynamic systems, or the conflict between the short term and long term consequences of a policy change. A policy which produces improvement in the short run, within 5 to 10 years, is usually one which degrades the system in the long run, beyond 10 years. For example a policy to export oil and import food in order to improve food consumption and nutrition in the short run may create an apparent improvement, but it also may cause the stagnation of the agricultural sector, dependency on oil resources to alleviate the problem and higher imports of food. When the oil reserves are depleted, there is not enough food produced domestically and the food shortage and malnutrition in worse than original. Anyway, the short run is more visible and more compelling. Administrations in Mexico last six years. It speaks loudly for immediate attention. But a series of actions all aimed at short run improvement can eventually burden a system with long run depressants so severe that even heroic short run measures no longer suffice. With these concepts in mind there was a concern to build a model that show the main variables of the Mexican economy, their interrelationship and their implications.

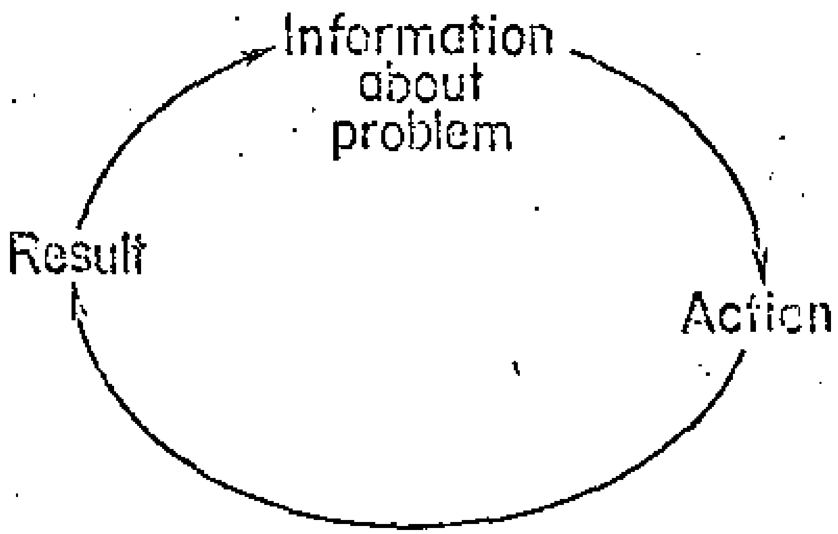


Figure 2 Basic loop structure within which all policies exist.

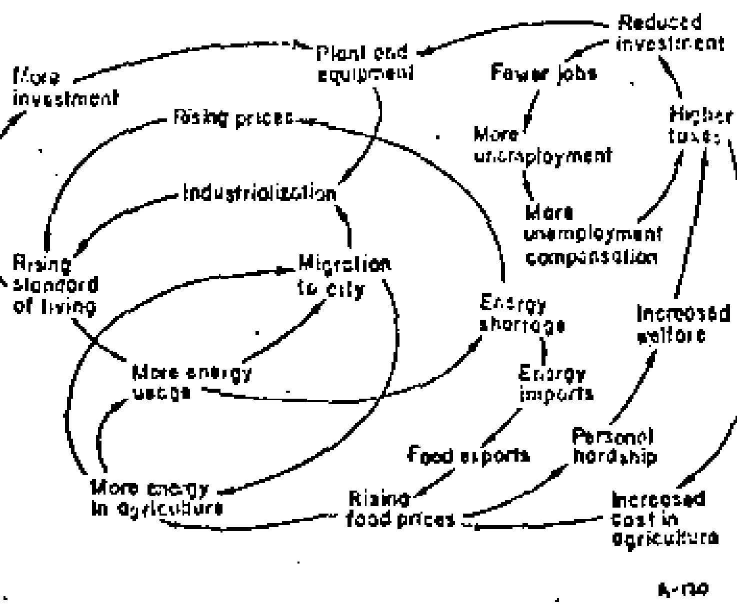


Figure 3. Interconnected loops produce growth, instability and goal-seeking as policies interact.

Models have become idealy accepted as a means for studying complex phenomena. A model is a substitute for real equipment or system. The value of the model arises from its improving our understanding of obscure behavior characteristics more effectively than could be done by observing the real system. A model compared to the real system it represents, can yield information at lower cost. Knowledge can be obtained more quickly and for conditions not observable in real life.

Perhaps the most feasible feature of the system dynamics approach is its use of formal, quantitative computer models. The term model stands for representation, essentially a simplification, of some slice of reality. A a system dynamics model is a laboratory tool. It allows repeated experimentation with the system, testing assumptions or altering management policies. The purpose is to gain understanding, so that the problem to which the model is addressed may be solved or minimized.

A formal model has two advantages over the informal so-called mental models on which most human decisions are based. First, formal models are more explicit and communicable. A system dynamics model exposes its assumptions about a problem for criticisms, experimentation, and reformulation. A mental model, on the other hand, is fuzzy and implicit. Its fuzziness is a result of its rich intuitive detail and is a source of its range and adaptability. The implicit nature of mental models, however, is the cause of occasional misunderstanding, miscommunication, and misapplication. Second, a formal model handles complexity more easily. Unlike a mental model, a system dynamics computer model can reliably trace through time the implications of any messy maze of assumptions and interactions, without stumbling over phraseology, emotional bias, or gaps in intuition. Computer models have these two advantages not because computers are so smart but, in a sense, because they are so dumb: they love the boring, repetitive computations involved in tracing a model through time, and they require absolutely every assumption to be spelled out in computer code, explicitly.

It is attractive, indeed, to think that experimentation with appropiate computer models might lead to the understandings we require to solve or minimize the host of complex problems we face. But the history of the application of formal models to policy problems does not produce great confidence.

In contrast to traditional approaches, this model emphasizes:

-a long time horizon, not limited to the conventional planning horizon in government of less than six years, but long enough to encompass the period influenced by current decisions and to anticipate future undesired effects in time to avoid them

- a wide perspective, not limited to one sector or one discipline, but including all the variables and social mechanisms bearing on the problem; and

- a flexible conceptual framework, not unnecessary limited to traditional variables, but based on open-minded observation of the real world and on the willingness to define new concepts to avoid excessive emphasis on what is already measured or easy to measure.

MODEL DESCRIPTION.

Figure #4 overviews the principal interactions between the various model sectors. At the top, the production sectors are linked to each other through orders and payments for factors of production. Also, the production sectors are connected to the financial sector through various channels, including domestic and foreign borrowing, payment of interest on debt, and holdings of money. The production sectors are tied to the foreign trade sector through imports and exports of various goods and services, including an explicit representation of the competitiveness of Mexican non-oil exports. The production sectors pay wages and dividends to the household sector and generate a demand for labor from the household; in the opposite direction, the household demands food, goods, housing, and energy from the production sectors, make payments for these factors of utility and offers a

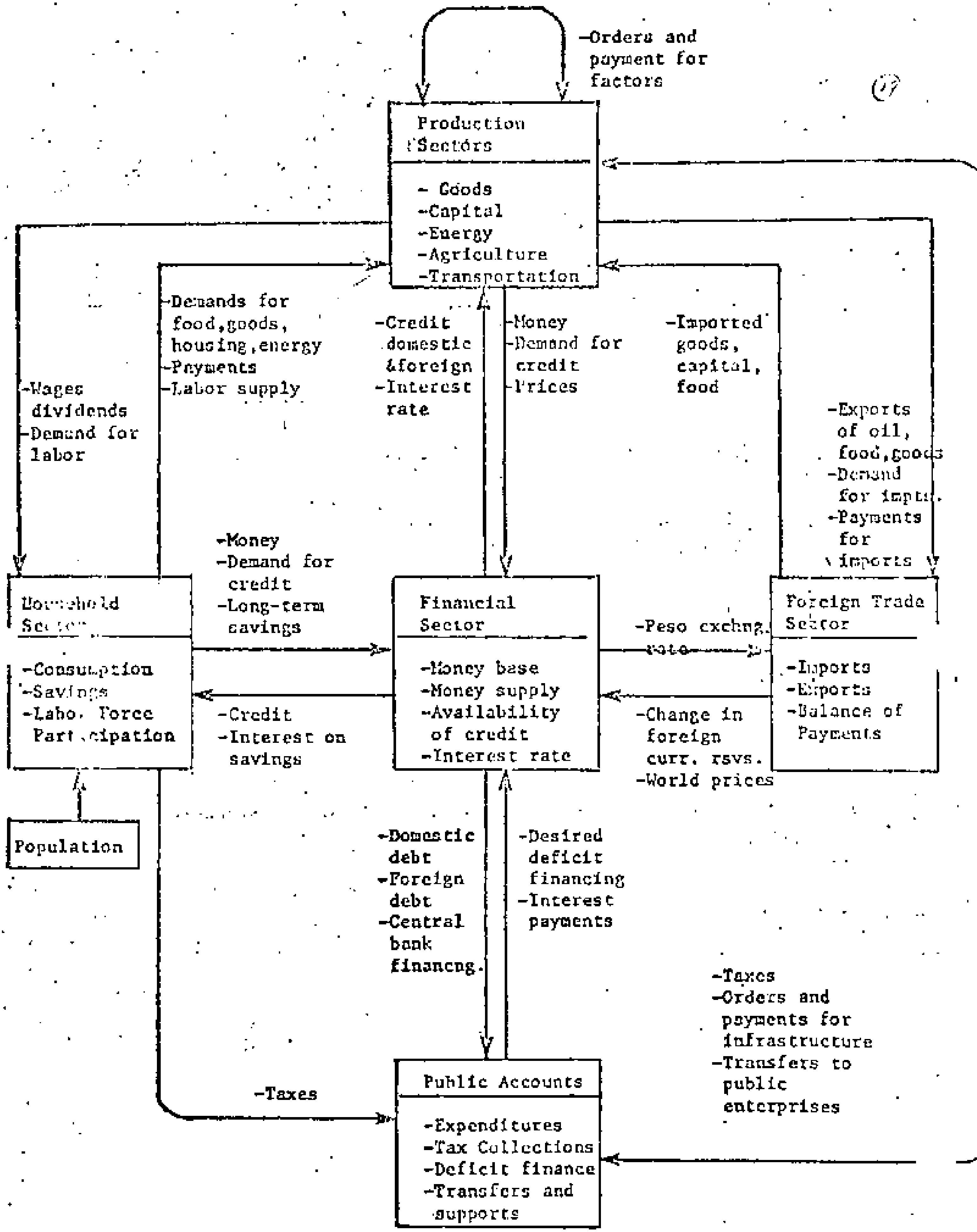


Figure 4.

OVERVIEW OF INTERACTIONS BETWEEN MODEL SECTORS supply of labor. Also, the production sectors are linked to the public sector through tax collections, production of infraestructure, and net revenues and transfers between the public sector and those public enterprises that reside within each aggregate production sector.

At the left of the figure #4, the household sector interacts with the production sectors as described earlier, with the financial sector through borrowing, savings, and interest payments, and with the public sector through income tax payments and receipt of and payment for social services (such as health, and social security). Population is an exogenous input to labor supply within the household sector, although the actual labor supply is affected both by population and by relative wage rates and employment opportunities; the model can also incorporate various assmptions about future population growth.

In the center of the figure #4, the financial sector portrays explicitly the main components of the monetary base such as foreign currency holdings and the Treasury debt held by the Central Bank. The financial sector also represents the supply of money and liquidity, and the availability and cost of credit. The financial sector interacts with the production, household, and public sectors through flows of money and credit. Additionally, the financial sector interacts with the foreign trade sector through determining the peso exchange rate that affects the competitiveness of Mexican exports as well as incentives to import, and through changes in the foreign currency reserves that affect the monetary base.

Because the major focus of the model is energy policies, it incorporates a number of different policy options in the area of domesting pricing of oil and gas, export levels, and allocation of oil revenues, the model incorporates a number of different policy options in each of these areas. For example, domestic oil prices can be set in any relationship to the world oil price, including the possibility of increasing domestic energy price up to levels near the world energy price over some time span, as called for the in the National Energy Plan. Finally, the model includes a policy variable representing the fraction of Pemex current savings which goes as export taxes to the government and the remaining fraction which is retained by Pemex for its own internal expansion. That tax rate on oil exports can be changed in the model to show the impact of different tax rates on the general disposition of Federal revenues, and on the financial structure and availability of liquidity to Pemex.

The model was also designed to represent a variety of different allocations on earmarkings of the government share of oil export revenues. The major possibilities incorporated in the model are, imports of food, imports of capital goods and technology, reduction of government deficit, increase of social expenditures, stimulus of particular production sectors, and so on. The model can incorporate any desired distributions of the government's share of oil export revenues between these uses in order to examine their impacts on sectoral output levels and on overall macroeconomic indicators such as inflation, unemployment, and the federal deficit.

The model is based on an energy-economy model for the United States, and it was addapted to represent the mexican case. The approach was to replicate the decision making processes and the physical and technical relationships of a single firm and generalize them to represent a sector of the economy. In other words, there is a generalitation of the microeconomic behavior into the macroeconomy. There were simplifications, being the most important, the representation of the agricultural sector, but in the real Mexico there are two sub-sectors: one that behaves according to the economic theory, and second, the traditional agriculture, that does not. The energy and public sectors in the model were changed to represent the Mexican case, in which the energy is concentrated into two government agencies, and the public sector that is much larger than its American counterpart.

The model represents both the physical structure of the national economy (people, capital, goods, money) and the decision-making structure of the various actors in the system (the decision rules and the information sources for decisions).

There are five major sectors: production, household, financial, government, and foreign trade.

The production sector.

The production sector actually consists on five distinct production sectors: the goods sector, representing consumer goods and services; the capital sector, representing capital plant and equipment and housing; the agriculture sector, representing all the food industry; the transport sector; the energy sector, which is divided into Pemex and the electricity sector consisting of the Comision Federal de Electricidad and of the Compania de Luz y Fuerza.

Each of the five production sectors in the model represents many firms producing similar types of output. The five sectors all have the same structure which constitutes a dynamic behavioral theory of the firm. Investment and capacity aquisition, labor management and wage bargaining, pricing, production scheduling, and financial management are all represented explicitly.

Each sector is composed of ten major subsectors. The subsectors are divided into those concerned with the physical or real aspects of production (the determination of output, factor use, and flow of materials, people, and energy) and those responsible for financial management (wage, prices, and the balance sheet and income statement).

The household sector.

The household sector supplies labor to the production sectors, and in turn receives wages which are used to purchase goods, housing, food, and energy. The household also supplies savings, through the financial sector, to the production sectors, and receives the profits of the production sectors in return. It also pays taxes to the Government Sector. Though the household does not sell physical output or set a price, it must make many of the decisions faced by production sectors: housing, goods, and energy must be ordered in the proper proportions; labor utilized; revenues and expenditures must be balanced, taxes paid, and debt managed. These decisions are, to a large degree, modeled in a manner analogous to their treatment in the production sectors. The basic difference from the production sector is that it maximizes utility instead of profit and labor represents leisure time and household employment.

The financial sector.

The financial sector represents the monetary and financial linkage between all model sectors, including the Government Sector and the Foreign Trade Sector. This sector represents the operations of financial institutions by setting interest rates and directing the flow of funds between lenders and borrowers. The financial sector is considered an intermediary, allocating savings among competing demands for credit and channeling interest payments, dividends, and capital gains among the various savers. The financial sector does not accumulate funds or employ factors of production. It also represents the Central Bank operations and policies regarding legal deposits, passive interest rates and the Peso exchange rate.

The government sector.

The Government Sector reperesents the expenditures and receipts of the Federal Government as it relates to public enterprises, households, and private producers. The receipts included in the model are:

Tax collections

- personal income
- corporate income
- excise
- value added

export

Revenue from social expenditures

Domestic Borrowing

Foreign Borrowing

Financing from Central Bank

The expenditures are:

Social Expenditures

Investment in Infraestructure

Administrative Expense

Net Transfers to public enterprises

Repayment of domestic debt

Repayment of foreign debt

Interest on domestic debt

Interest on foreign debt

Imports of food, capital, goods

The government role is to collect taxes and to spend the money according to certain goals or plans. Then the major expenditures of the government code from trying to accomplish those goals, for example: one goal may be to increase the social government expenditure per capita at 4 % per year, meaning more education and health for the population, or a similar goal for investment in infraestructure, meaning more roads, drainage and water supply per capita. Then the government sets the budget trying to accomplish the goals, but this generates a deficit that has to be financed from any of the following sources:

Financing from the Banco de Mexico

Foreign Borrowing

Domestic Borrowing

Accounts Payable (representing a delay between the time government is billed for services and its actual subsequent payment; these payables correspond approximately to ADEFAS)

The formulation of the domestic borrowing assumes that the Federal government attempts to avoid excessive loads on domestic capital markets, and that borrowing request from domestic banks will therefore be deliberately limited somewhat if credit is in short supply. Foreign borrowing provides a substancial net source of government funds. The model assumes that if government debt and interest obligations are high in relation to tax collections, expenditures will need to be limited as a consuquence of diminished access to new financing. Government expenditures may also be limited on the base of total public sector debt relative to GIP as a policy option. Treasury financing from the Central Bank makes up the residual of financing requirements that cannot be met by boorowing or delaying payments.

Government social expenditures (health, education, social security, etc.) and expenditures for infraestructure (dams, roads, public buildings, etc.) have a similar formulation in the model. Target real social expenditures per capita and target infraestructure per capita are translated into nominal spending amounts by adjusting for the price level. Change in the targets from year to year can be represented (1) through an exogenous growth rate in nominal spending, (2) through an exogenous target real growth in expenditures per capita, or (3) by endogenously linking real expenditures to average growth in real GDP.

Real social expenditures contribute to labor productivity and therefore to growth in overall GDP, representing effects of expenditures for health and education; a delay exists in achieving the full productivity benefits of higher expenditures. Analogously, infraestructure development contributes to national productivity through allocating a portion of the infraestructure to the agricultural and transportation sectors to supplement their capital stocks; in turn, higher capital productivity will stimulate more employment help to lower production costs. The remainder of public infraestructure represents public buildings, schools, and other governmental facilities. Administrative expenses are linked to the overall volume of government activity.

Transfers to public enterprises are the final major category of Federal government expense in the model. The transfers represent an additional source of income to each recipient production sector besides revenues from product sales. Depending on the receiving sector's need for liquidity, transfers to public enterprises will have a mixture of two effects: direct stimulus of investment and output, and price reduction.

Thus, for example, transfers to the Federal Electricity Commission and to the agricultural sector through Conasupo allow sale prices to consumers to be lower than otherwise, and elicit more investment than would otherwise be called for by a given output price. In the model, transfers can either be specified as covering a given fraction of a sectors production costs, or generated endogenously to provide transfers when a given sector is falling short of meeting output demand. The model thus attempts to capture the shifting investment priorities of the government depending on individual sectoral conditions.

SIMULATION OF POLICIES

The model is strategically oriented, and is designed to span a time horizon of 50 years, beginning with the significant initial exploitation of Mexican oil reserves around 1977. The purpose of the 50 year time horizon of the model is twofold: first, a long time horizon is required to evaluate both short term (5 to 10 year) and long term consequences of energy policies such as accelerated development of alternative energy sources, whose implementation will take a long amount of time due to long development and start-up lead times and whose effects will be felt even long after initial policy implementation. Second, a relative long time frame is also needed to span the full life cycle of Mexico's oil and gas reserves, given a range of estimates for potential production. For example, current estimates of likely potentially recoverable reserves from oil and gas in Mexico amount to 250,000 million barrels. During 1978, production of oil and gas for domestic use amounted to over one million barrels per day, and domestic consumption was growing at over 10% annually in real terms. At this rate of growth, even without any exports, Mexico's oil reserves would be depleted within 40 years. The model has not being designed to answer operational questions or to generate short term forecasting over less than 10 years.

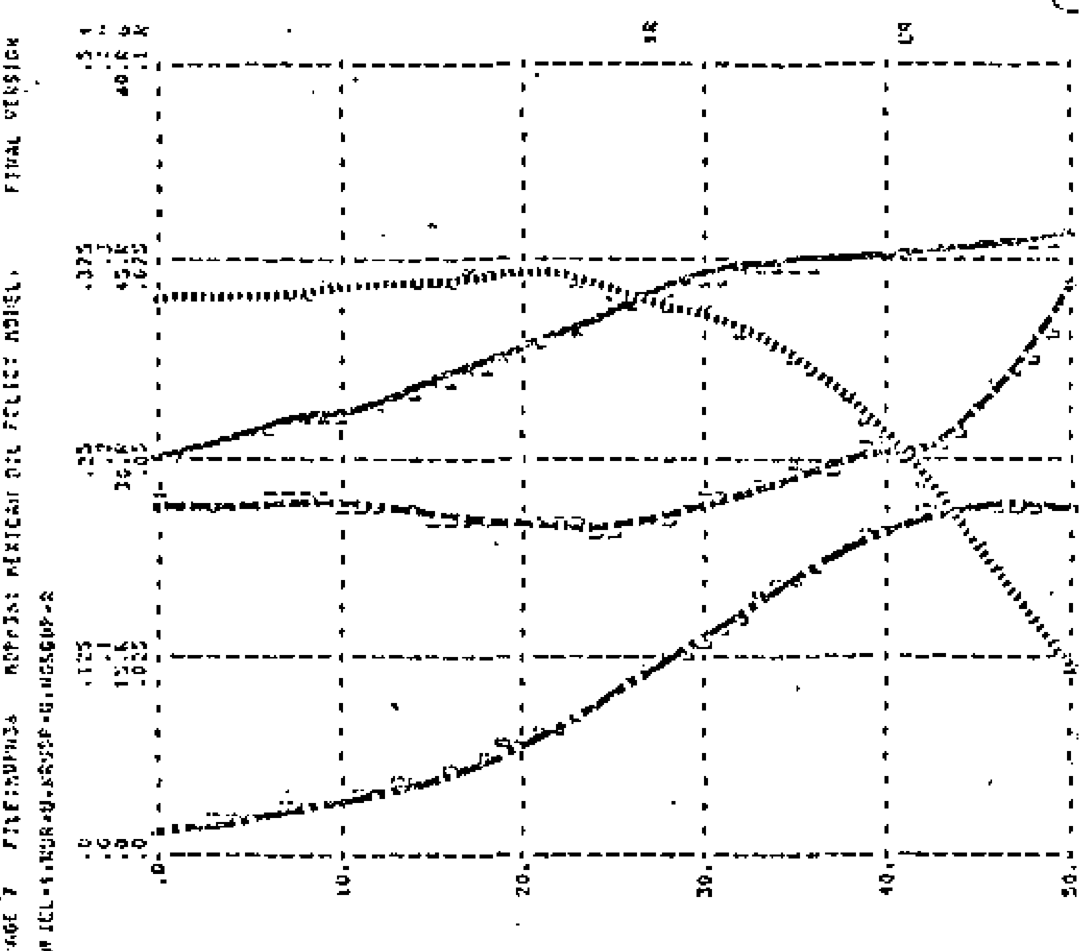
In order to analize the impact of alternative oil policies, it is necesary to define one alternative as point of departure. For this purpose the case of low exports of oil was taken. With that reference, the policies of the National Energy Plan and the Global Plan are analized. To finalize, an alternative policy is included, that seems to have a positive effect in the economy. This is just a limited set of alternatives that are possible to simulate with the model, but is enough to give an idea of the possibilities and the effects of the official policies.

test # 1: low oil exports and continuation of energy subsidy.

This level of exports was achieved during 1978, and this simulation

Figure 2-1: Sustained Low Oil Exports

(27)



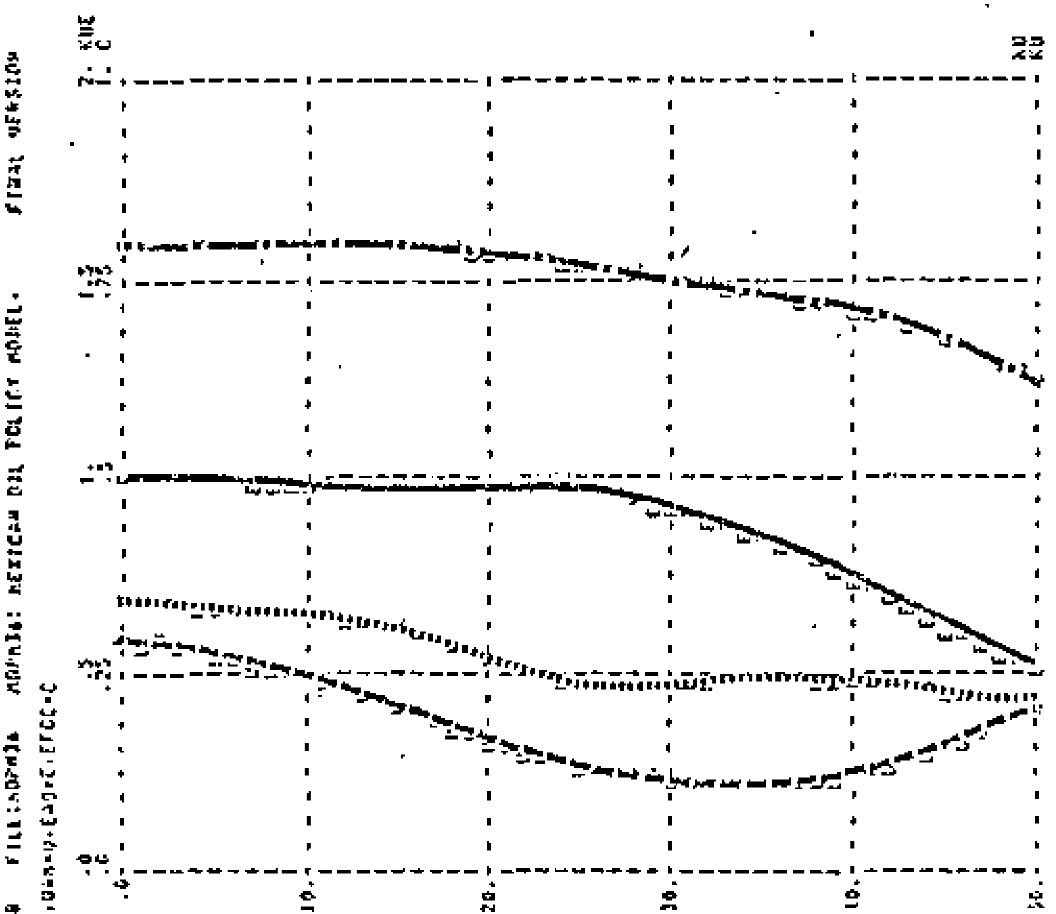
Inflation

Unemployment

Real GDP

Real GDP growth

Figure 2-1a



Capital sector liquidity

Unconventional sector liquidity

Energy adequacy

Pemex fraction of energy demand

Figure 2-1b

Figure 2-1: Sustained Low Oil Exports

(30)

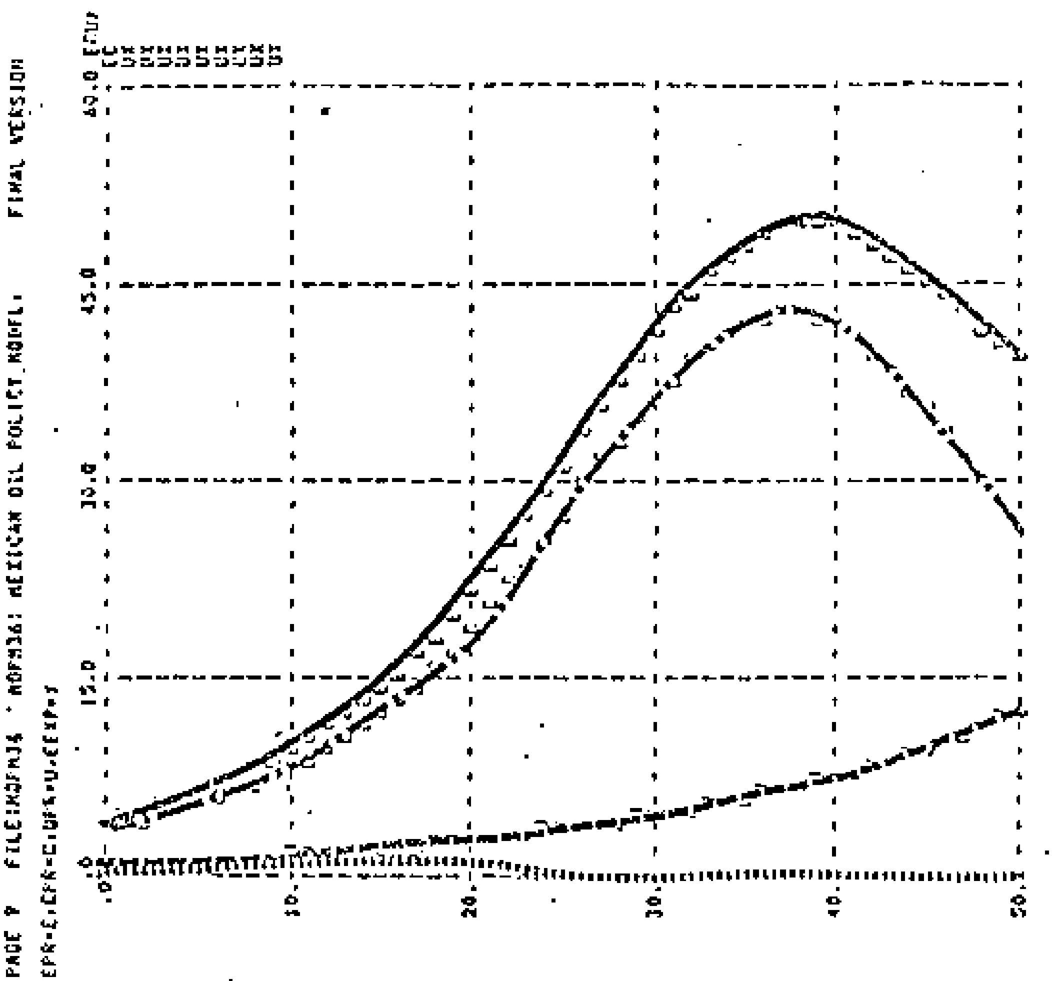


Figure 2-1c

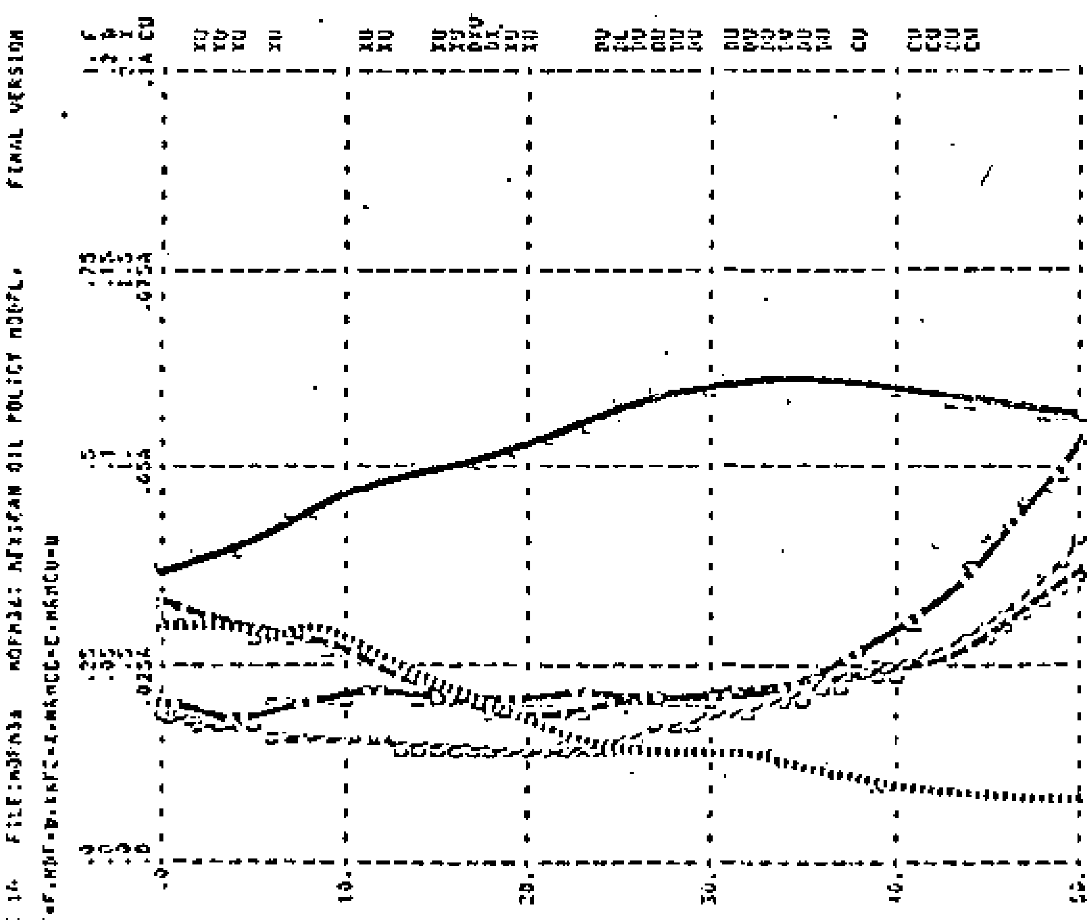


Figure 2-1d

unconventional energy. Despite a high subsidy from the Federal government of more than 30% of its production costs, the unconventional energy sector (representing production of electricity by the CFE and production of energy from alternatives to hydrocarbons, such as nuclear or solar) is suffering a severe liquidity shortage. Adequacy of liquidity in the unconventional sector starts at about 60% and declines to below 30% by year 30, during which time unconventional production is being called upon to supplant depleting hydrocarbons. The low liquidity, and consequent high debt loads and weakened financial position of the unconventional energy sector, are the consequence of two forces: first, a rapid attempted rate of expansion of conventional energy, with long lead times and consequent high cost of capital projects in the construction phase; and second, increasing general inflation that raises both nominal interest rates and nominal financing requirements of the unconventional energy sector. Although not shown, there is a weakening financial position of Pemex as a consequence of rising marginal cost of producing energy in the face of resource depletion (figure 2-1d). In other words, increasing amounts of labor and capital and progressively deeper wells are necesary to continue producing oil and gas.

Figure 2-1b shows that adequacy of energy supply falls off sharply between years 30 and 50, indicating that Mexico suffers from a general shortage of energy relative to domestic demands. Such energy shortages early in the next century would most likely have to be met through substancial imports of energy by the government at high real energy prices due to worl wide depletion of oil and gas resources (although such imports are not explicitly represented in the model). Declining rates of real GDP growth seen in figure 2-1a between years 30 to 50 are a consequence of weakening liquidity positions through the economy due to mounting inflation, compounded by the emerging energy shortage. For example, figure 2-1b shows declining adequacy of liquidity in the capital goods producing sector, thereby retarding production of capital goods and contributing to capital shortages throghout the Mexican economy. Moreover, significant development of unconventional energy is being delayed due to relatively lower prices of conventional oil and gas, and consequent high consumer and industry demands for energy end uses that are most suitable met by conventional production by Pemex.

Inflation is a consequence of several self reinforcing processes (possitive feedback) as shown in the figure 2-2. For example considering the inner loops of this figure . Both loops originate with a higher inflation that leads to additional (nominal) spending by the federal government in order to accomplish the government's real development objectives for social programs and infraestructure. More government spending leads to higher deficits, which in turn, tend to be financed primarly through a mix of foreign borrowing and treasury financing from the central bank. Both sources add to the monetary base, which eventually results in higher rates of inflation through expanded liquidity and credit availability. In the middle loop in figure 2-2, high inflation also supplements demand for credit, both by increasing nominal transaction requirements, as well as by lowering the real interest on debt. In other words, in the face of higher inflation, the real cost of debt is reduced since debt can be repaid at time of maturity in depreciating currency. Increased credit demand reduces the relative availability of domestic credit from commercial banks and other financial institutions and intermediaries. In turn, lower domestic credit availability induces corporations and public enterprises to take on additional foreign debt,thereby increasing the monetary base and adding to total liquidity and consequent pressure on prices. Finally, in the outer loop of the figure, higher inflation reduces the incentive for household savings, which reduces domestic credit supply, leading to more foreign borrowing, greater increase in foreign currency holdings from external debt, and compounding pressures for more inflation. Accompanying the trend toward greater inflation, figure 2-1d shows the increasing dependence on foreign debt, which provides more than 50% of total financing by the turn of the century.

Figure 2-1d also shows a rising government deficit as a fraction of GDP. The deficit fraction rises slowly during the first 30 years of the simulation, generally remaining near 4%, but then more than doubles between years 30 and 50. During this time, slowing GDP growth due to rising energy prices, diminishing liquidity, and energy shortages, reduce the growth rate of the economy and hence lower growth in tax collections. In the model, the government is assumed to adjust its expenditure patterns over time so as to avoid excessive drains on the real output capabilities of the economy. In other words, during a period of declining real growth rates, real growth in government expenditures is eventually lowered as well, but with a perception and reaction delay for several years during which time deficit spending is exercised in an effort to stimulate growth. Thus, for a significant period of time, real government expenditures are increasing more rapidly than tax collections, leading to accelerating deficits and still higher inflation.

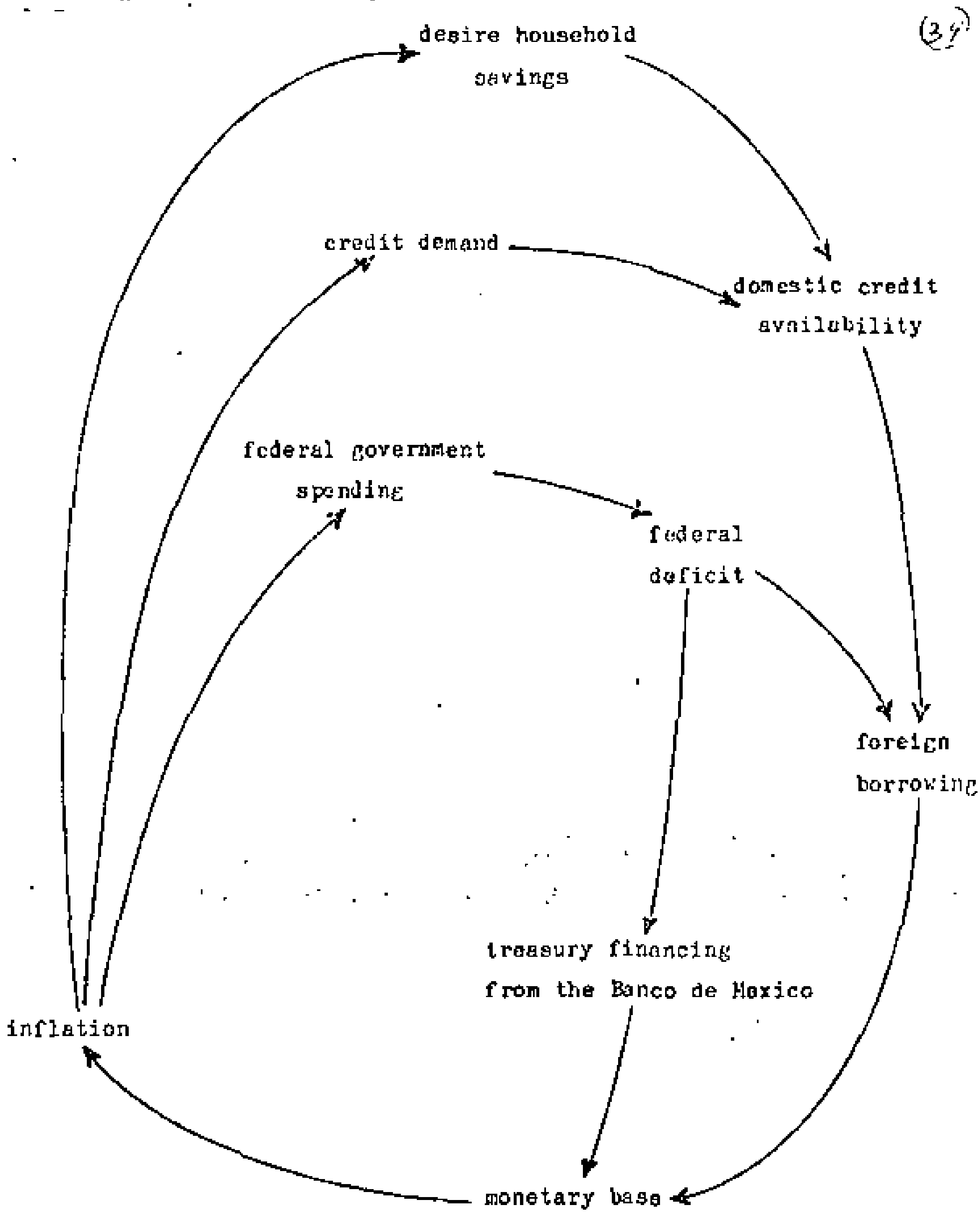


Figure 2-2

test #2: low oil exports and reduction of pricing subsidy. (65)

This simulation represents a policy change in addition to the low export scenario depicted in test #1. Here, domestic price of oil is raised to 70% of the world price in a graduated manner between 1982 and 1992, as proposed in the National Energy Plan.

Figure 2-3a shows slowly rising inflation, from 26% to 29%, from years 0 to 15. Thereafter, inflation slowly declines to about 18% per year at year 50. The dominant reason for the reduction in long term inflation is the stable ratio of federal deficit to GDP (at below 5%) as seen in figure 2-3d, in contrast to the more than doubling in the deficit ratio in figures 2-1 without the relative increase in domestic oil price. In turn, a major source of the deficit reduction lies in the revenue feedback deriving from increased taxes paid by Pemex due to higher revenues. As noted earlier, in the low export case with a continued pricing subsidy for domestic use of oil and gas, the financial structure of Pemex deteriorates along several dimensions, including diminishing relative liquidity and increasing debt ratio. In contrast, with a higher domestic price for oil and gas products, Pemex current savings improve dramatically, enabling a relative reduction in debt and a removal of liquidity induced constraints on capacity expansion. Consequently, taxes paid by Pemex based on current savings become a significant fraction of total government tax collections, even without substancial oil export revenues. For example, in the yest underlying figure 2-3, tax on Pemex based on current savings becomes more than 20% of total government tax collections by year 15. The higher tax collections are alloted to the uses described in the Plan Global. Hence, there is no immediate reduction in the government deficit as a result of Pemex's increased tax contribution since the tax stream is fully recirculated to expenditures and investments. However, the additional transfers to the agricultural, industrial, and transportation sectors are retained within those sectors for investment to a significant extent. Expansion in activity of those sectors yields an indirect revenue feedback to the government. Moreover, improved adequacy of output due to allocation

of tax revenues derived from Pemex production reduces the pressures for transfers to public enterprises, and thereby diminishes the need for federal deficits to subsidize production in public enterprises. Low deficits also slow growth in the money supply and in inflation. In turn, lower inflation tends to improve liquidity in all production sectors, including public enterprises, thereby further rising adequacy of output and diminishing the ongoing need for transfers from the government. A long term process of relative deficit stabilization is thereby set in motion, with significant benefits in the form of lower inflation.

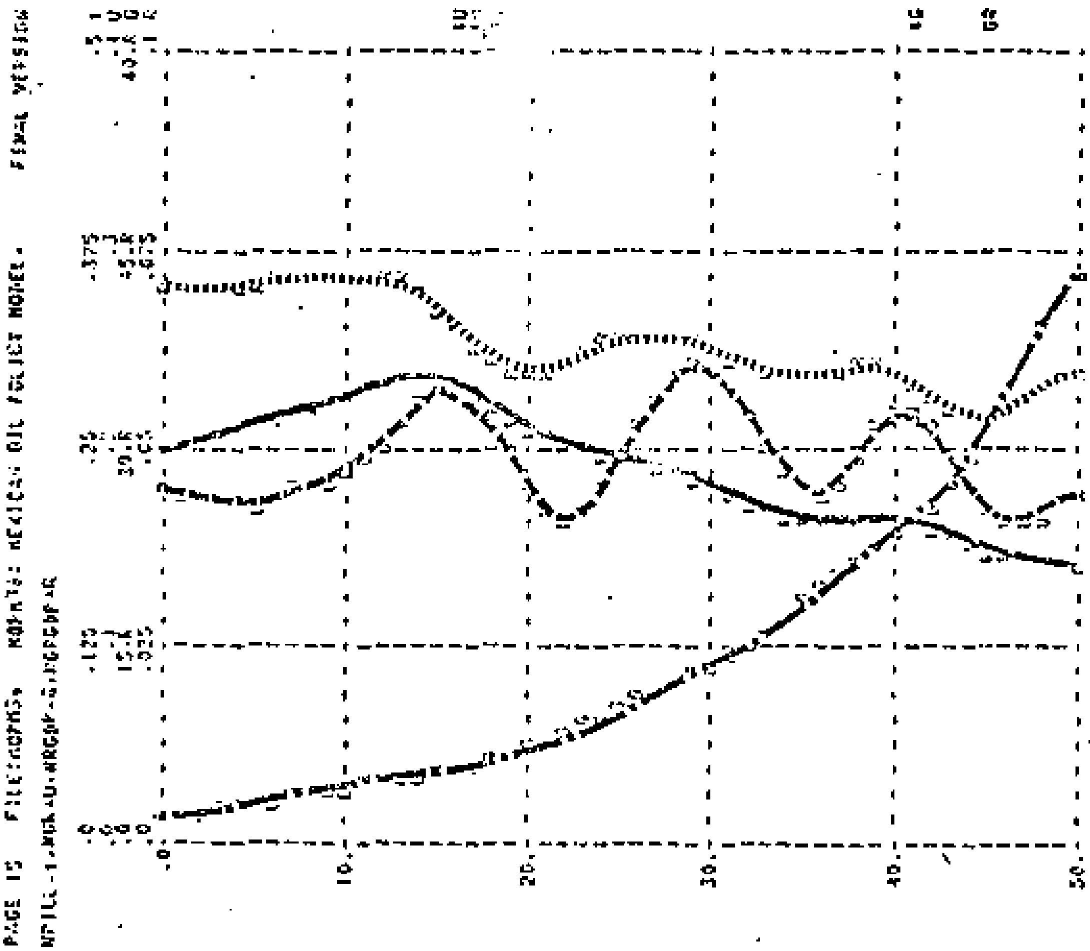
Figure 2-3a shows a reduction in real GDP growth in the early years as a consequence of higher oil price. For example, in figure 2-1a, growth rate in GDP declines from 7.5% to 6% per year between years 10 and 20 (1987-97), and real growth thereafter remains stable at an average of about 6% per year. Figure 2-1a showed continued growth in the range of 7.5% per year for the first 30 years. As a consequence of real higher energy price, real GDP is lower for the first 40 years with the relative increase in oil price. But this policy shows a smoother long term growth and does not exhibit the substancial reduction in the real growth rate as a consequence of emerging energy shortages and strained general liquidity. In fact, by year 50, real GDP is significantly above its corresponding value in the previous simulation.

The long term improvement in the real economic growth results from the longer lasting of oil reserves as a consequences of lower consumption due to higher price. Following an adjustment period in which energy intensities and energy growth rate of the economy must be brought into line with a higher real price of energy, improved adequacy of energy enables sustains long term GDP growth without the problem of rapid depletion of domestic reserves and consequent dependence on imported energy. There is also an improvement in relative liquidity, as a consequence of lower inflation, which reduces nominal financing charges on debt, and more importantly, lowers the interest cost of capital under construction as a fraction of sales revenues.

The results of this simulation suggest significant long term benefits from increasing the real domestic oil price, including eventually higher GDP and lowered inflation. However, there are some short term costs, particullarly in terms of diminished GDP growth during the 1980s and short

Figure 2-3: ... Oil Exports and 70% Domestic Price Parity

(37)



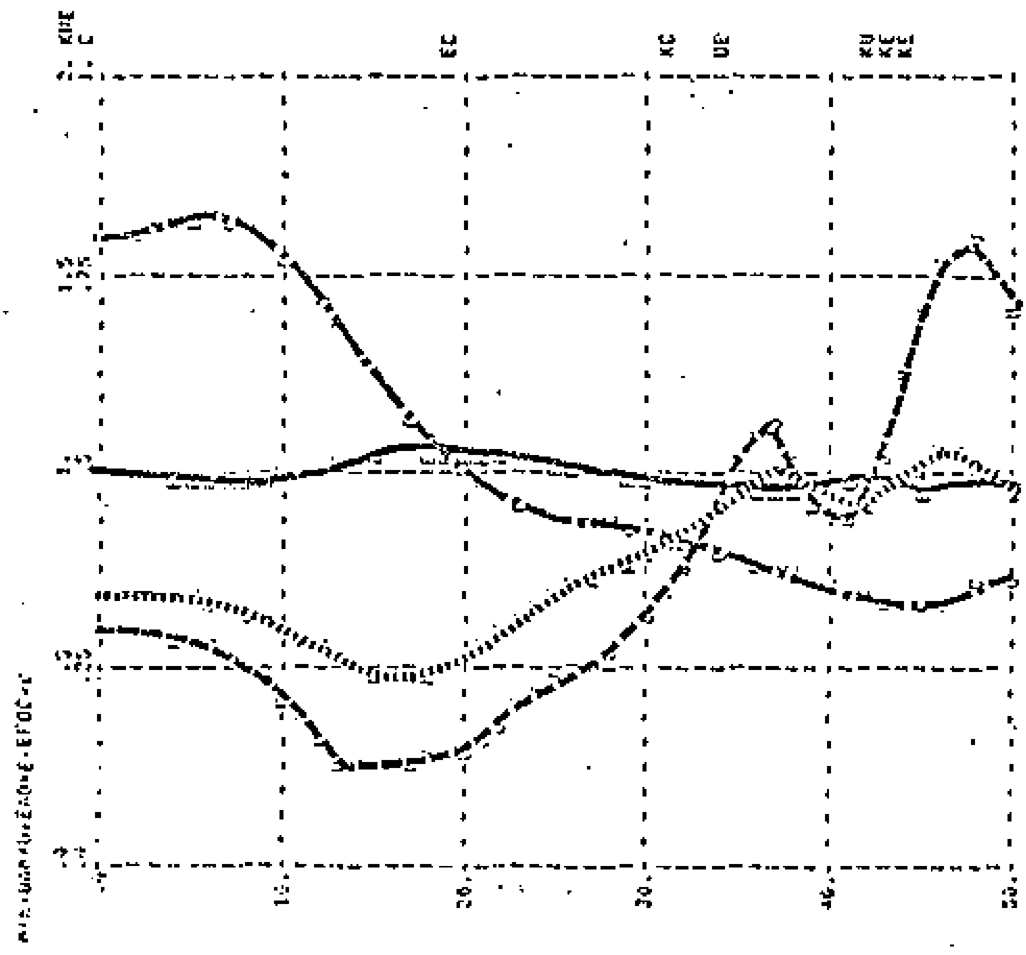
Inflation

Unemployment

Real GDP

Real GDP growth

Figure 2-3a



Capital sector liquidity

Unconventional sector liquidity

Energy adequacy

Power fraction of energy demand

Figure 2-3b

Figure 2-3: Low Oil Exports and 70% Domestic Price Policy

(38)

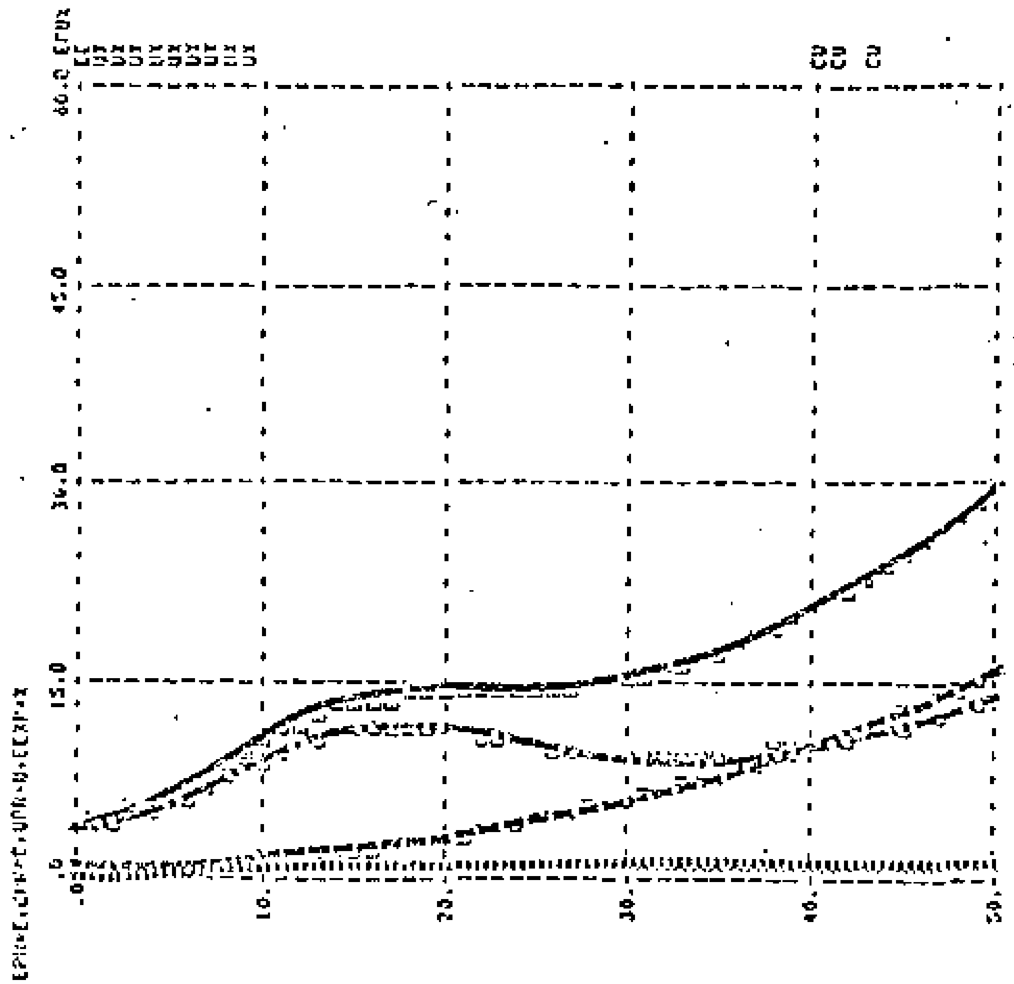


Figure 2-3c

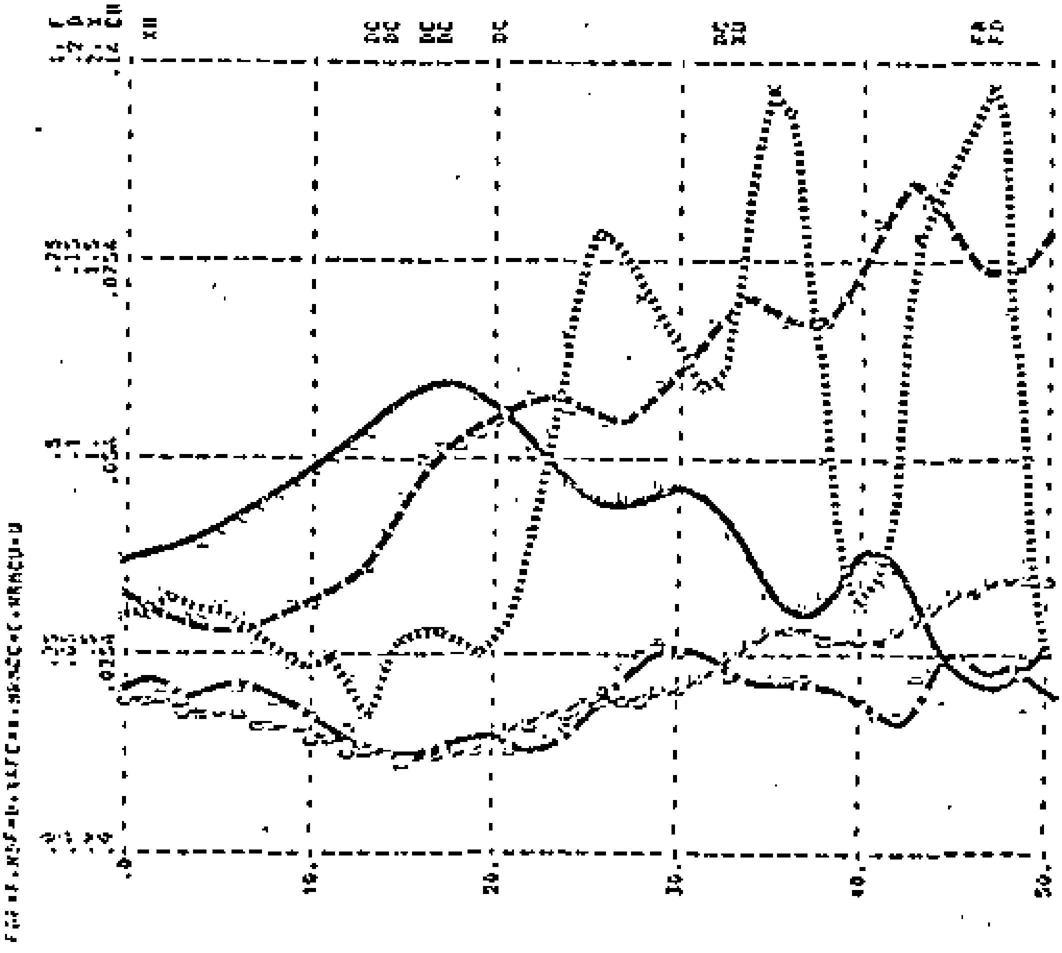


Figure 2-3d

period of oil exports is that it enables more imports of capital and consumer goods. High rates of growth generate large demand, while high interest rates and inflation limit the capacity of domestic capital producers to keep up with demand.

At a generic level of policy perspectives, the above results suggest that to the extent that oil exports are used to import food, consumer goods, capital goods, or other items that could be domestically-produced, there is less impetus for domestic producing sectors to evolve to satisfy demand. Such effect may be difficult to discern, especially in the face of rapid general economic growth such as has occurred in Mexico in recent years. In other words, when economic sectors are growing it is hard to know what their potential really is. But the experience of petrolization in countries such as Venezuela seems consistent with the idea that substancial imports financed by oil exports can stultify internal sectoral and macroeconomic development and rise external dependence. It is important to note that the stimulus of capital imports due to improved adequacy of foreign exchange exhibited in figure 3-1 was not part of a deliberate attempt to import capital goods using oil export revenues, but a consequence of the improved foreign exchange position and greater supply of foreign currency to enable imports. The foreign exchange earnings derived from oil exports accumulate in foreign currency holdings and therefore in the monetary base. If these currency holdings were to remain in the domestic economy, they could have an inflationary effect. But the diversion of foreign currency earnings to pay for capital goods imports means that a significant portion of the increase in foreign exchange from oil export revenues is being quickly recirculated into imports that retain growth in foreign currency holdings. Improved adequacy of output due to higher transfers and more capital imports tends to have a reinforcing effect towards restoring inflation over time: greater adequacy of output reduces pressures for inflationary government finance due to supply shortages and bottlenecks, thereby yielding lower inflation, improved relative liquidity and lower interest rates, and consequently still further improved adequacy of output.

Figure 3-1: Effects of Target Oil Exports

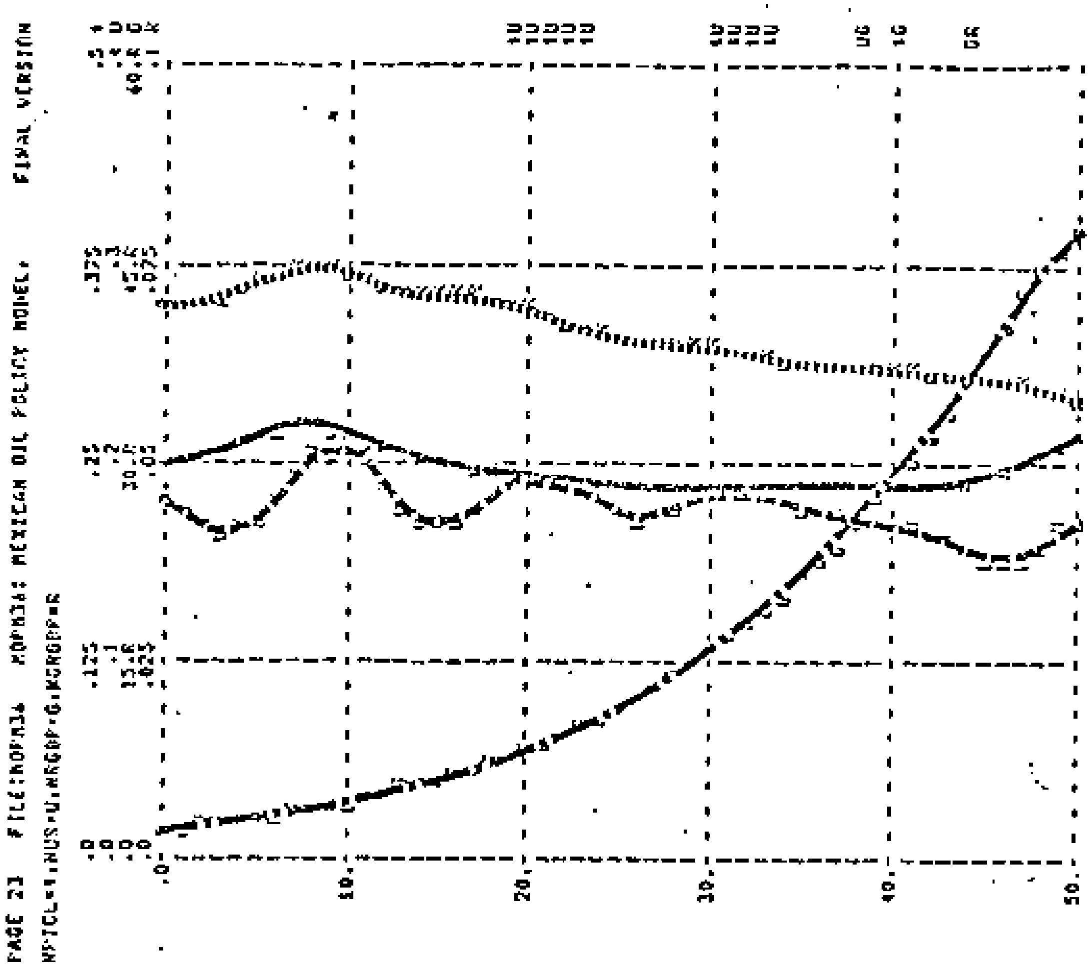


Figure 3-1a

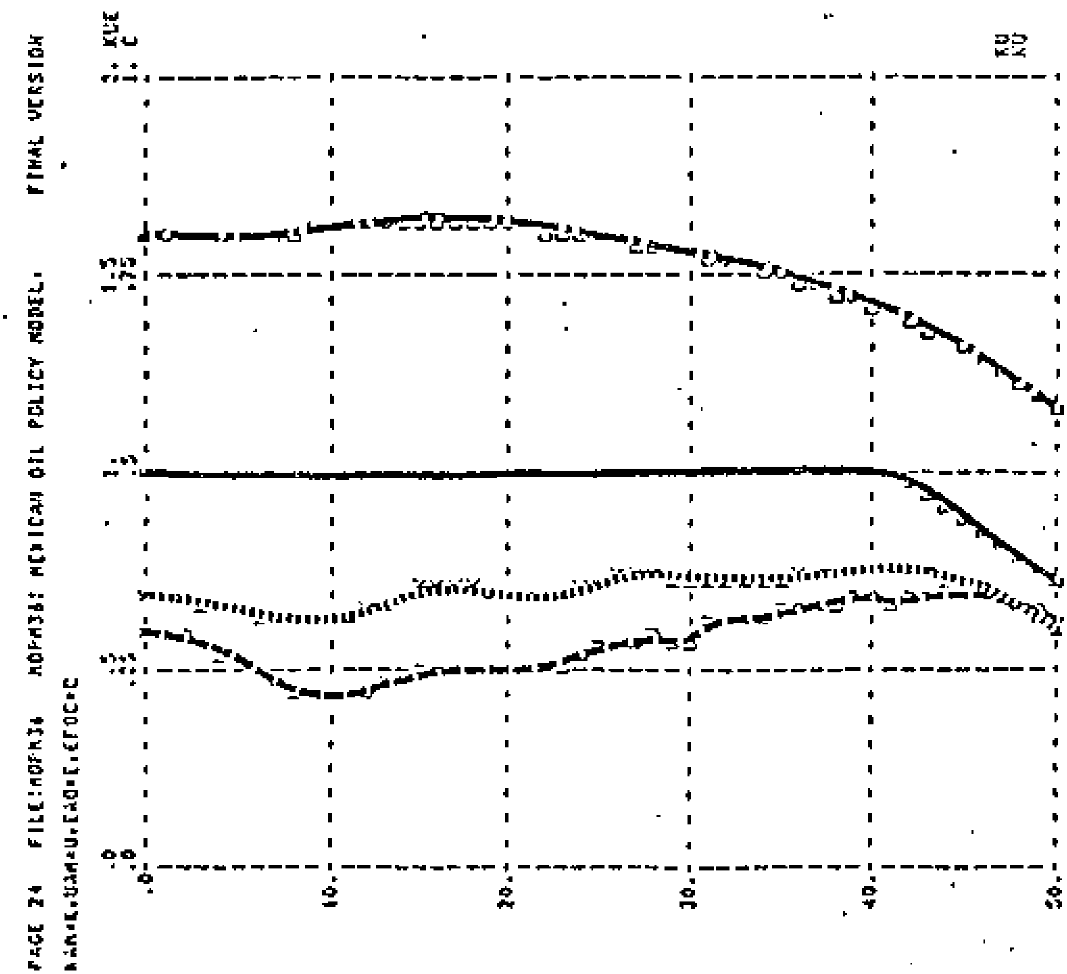


Figure 3-1b

(112)

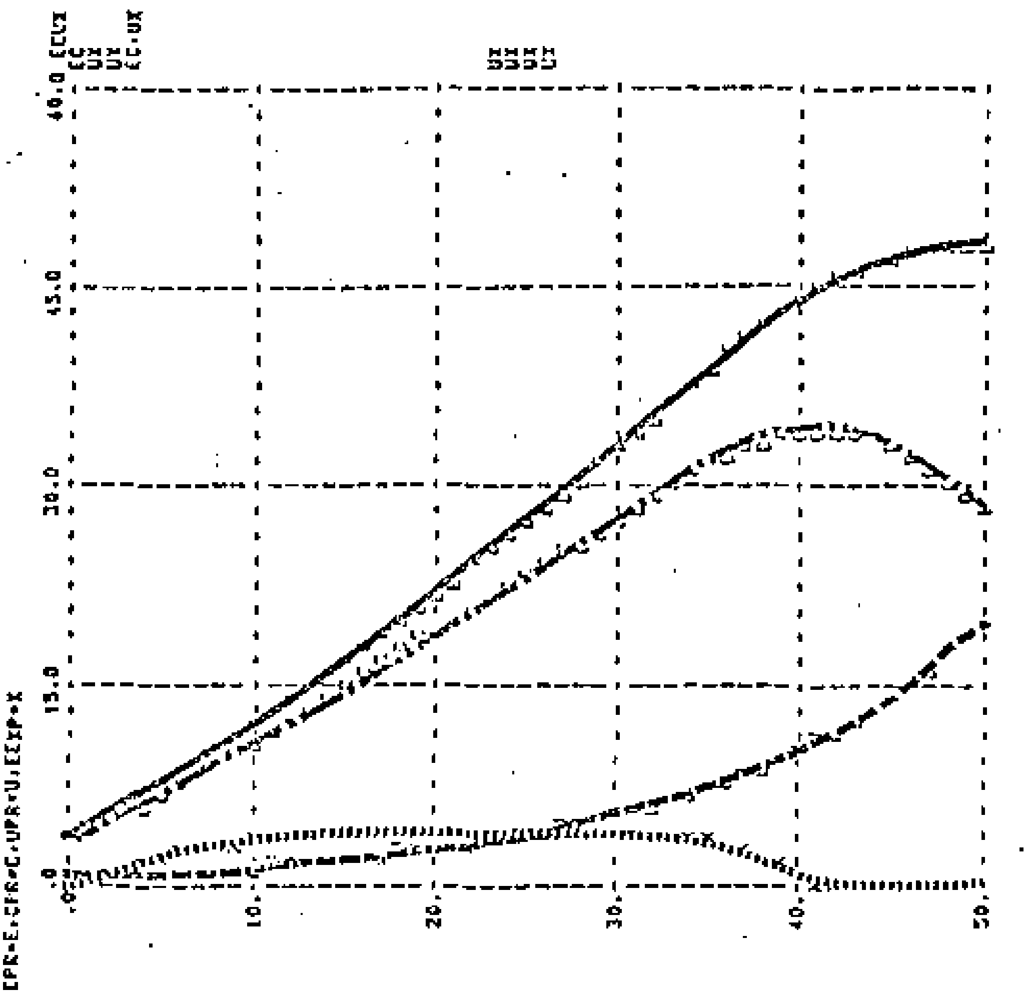


Figure 3-1c

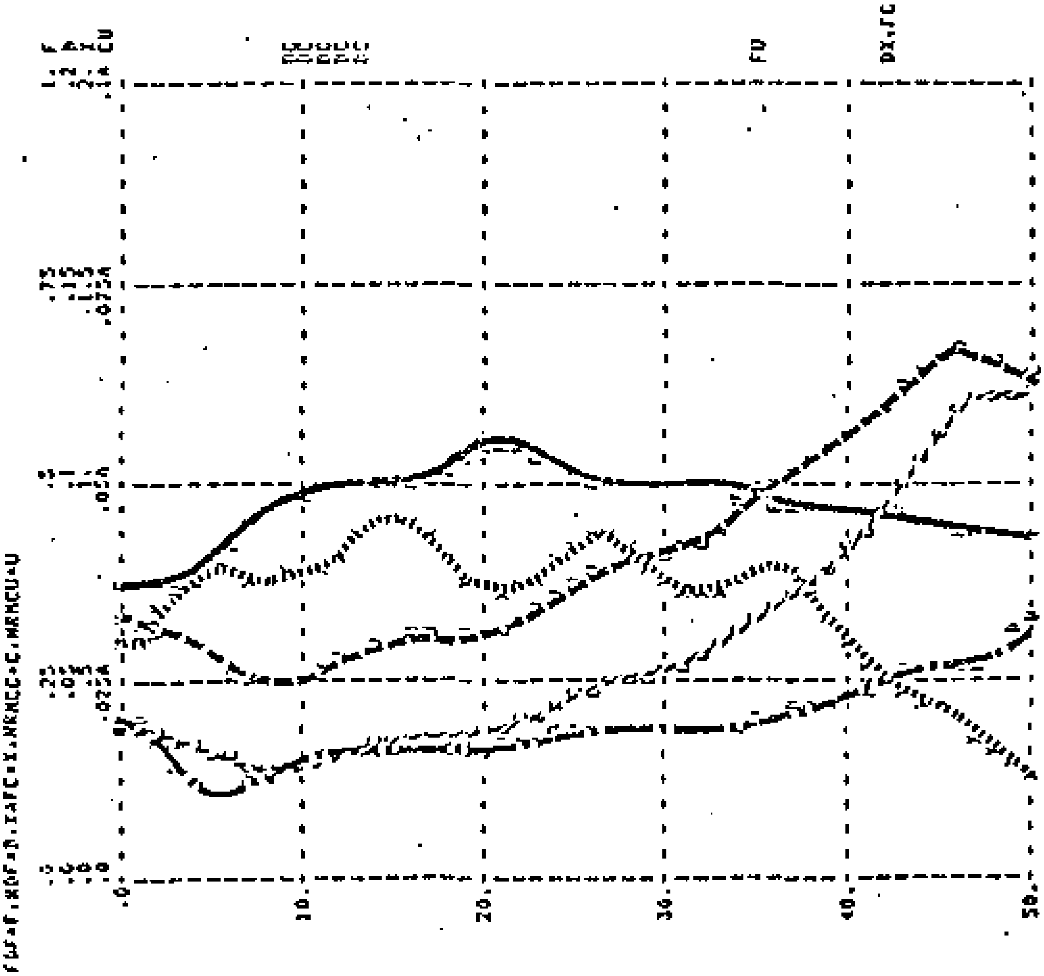


Figure 3-1d

test #4: oil exports of 1.5 MMBD and reduction of pricing subsidy.

This test is a combination of tests #2 and #3. Domestic price for oil is raised to 70% of the world oil price, and the target for oil exports is implemented.

Figure 3-2 shows that growth in total energy use is slowed dramatically by the relative increase in domestic energy prices. In figure 3-2c, between years 10 and 30, domestic energy use by households and production sectors is actually lower than the real growth rate of GDP. Due to a higher price of conventional oil and gas, production of energy from alternative sources is accelerated. Unconventional energy production rises by 35% of total energy supply by year 30, compared with 15% in figure 3-1. Figure 3-2c also shows that exports of oil and gas sustained at target levels for the full 50 years, instead of 35, due to the greater longevity of energy resources resulting from diminished domestic energy growth and consequent reduced competition for energy sources between domestic and export uses. Energy shortages are avoided compared with the previous case.

In summary, figure 3-2 indicates the same relative benefits and trade-offs from reduction of the existing pricing subsidy for domestic energy use as analyzed previously: intermediate term real GDP growth is lower with slightly higher unemployment; but inflation is continually lowered by up to 15 points, liquidity is improved and general interests rates are lowered, long term economic growth is enhanced due to greater longevity of energy supplies, Pemex exports are stabilized for at least an additional 15 years, and long term dependence on oil exports, external energy supplies, and foreign debt is reduced.

test #5: 1.5 MMBD exports, low subsidies and development of alternatives sources of energy.

In addition to the attainment of 70% price parity for domestic oil prices versus world oil prices, the national Energy Plan also calls for accelerated development of unconventional energy. Nuclear electric generating capacity is expected to grow to 2,500MW by 1990 and to 20,000MW by the end of the century.

Figure 3-2: Target Oil Exports and 30% Domestic Pricing Parity

(44)

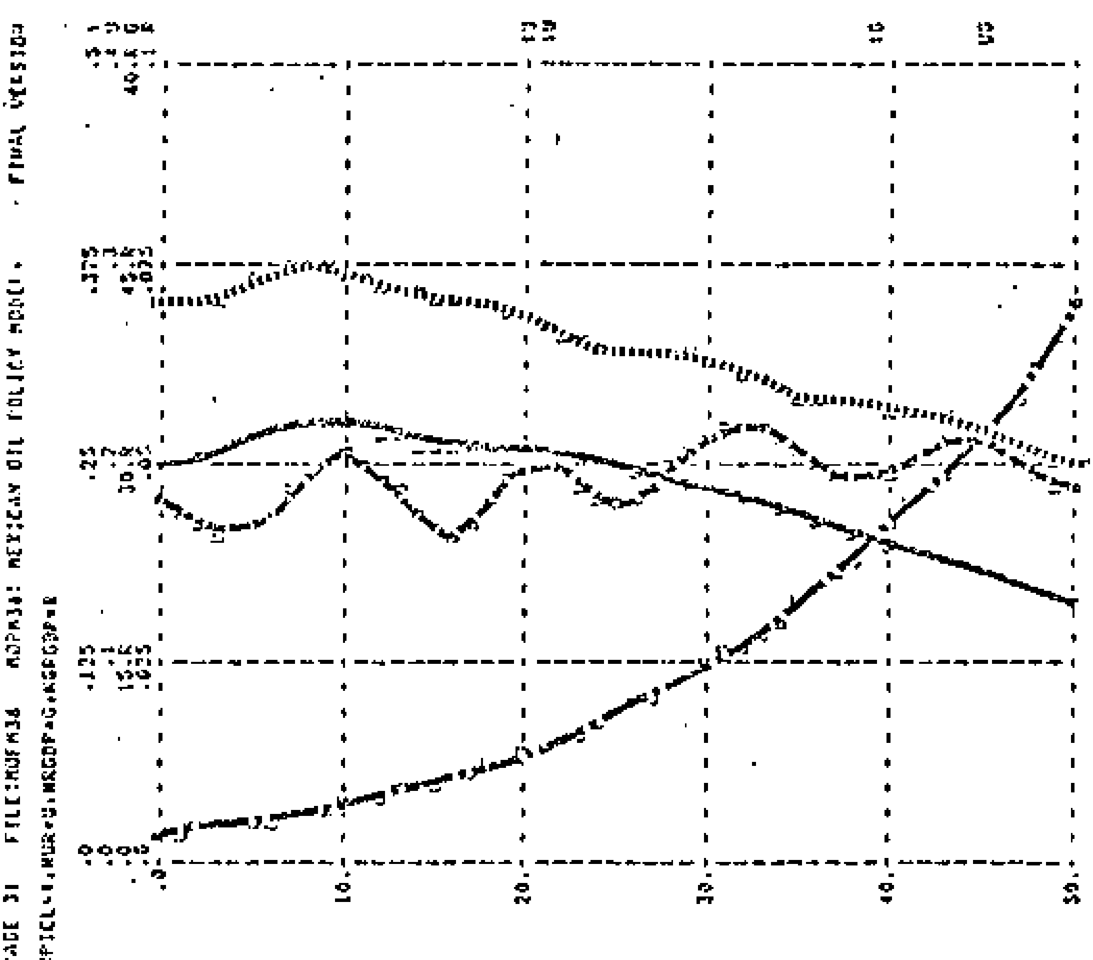


Figure 3-2a

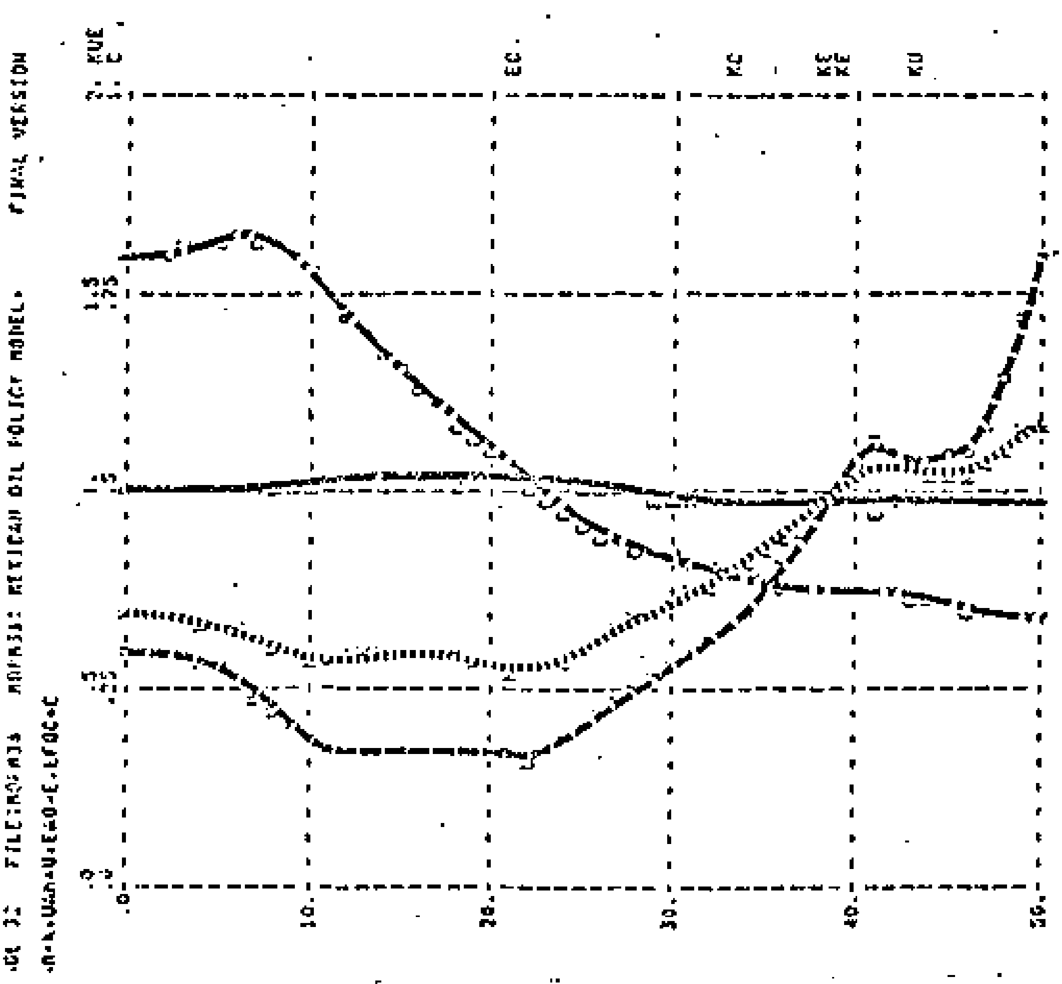
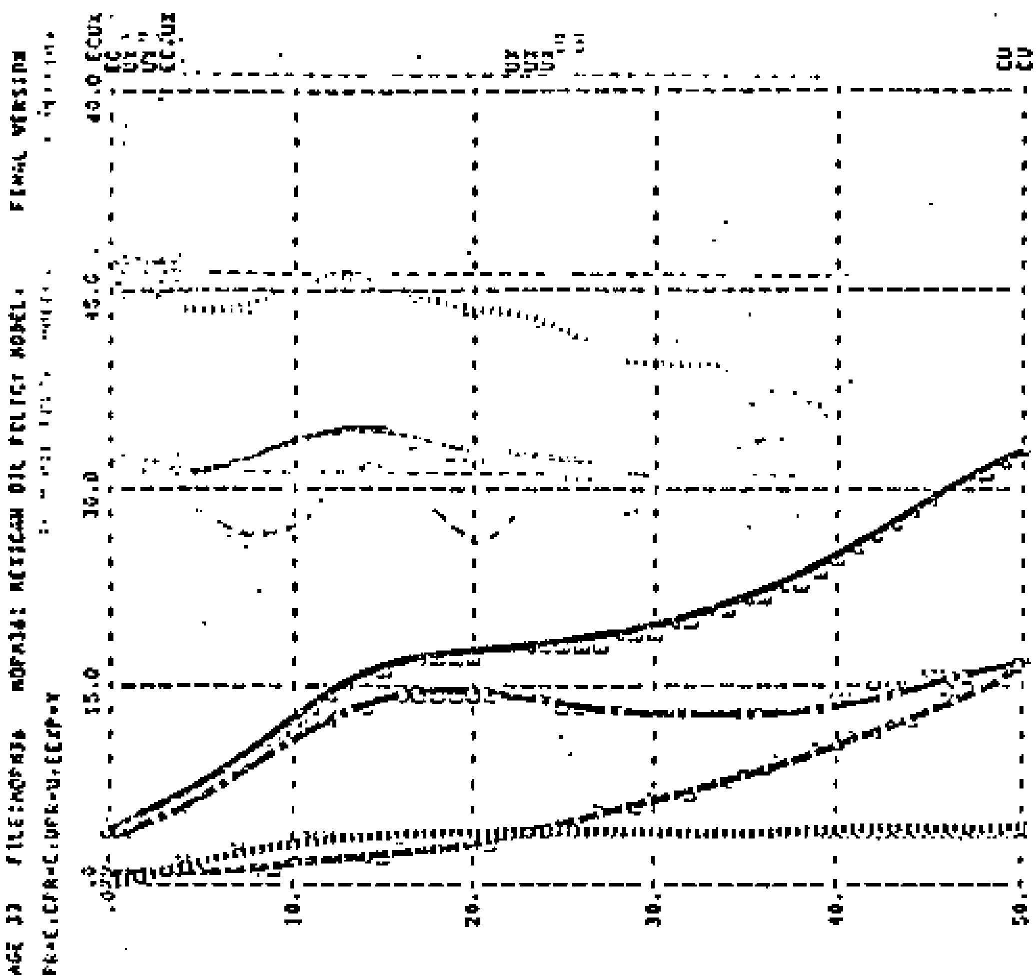


Figure 3-2b

(45)



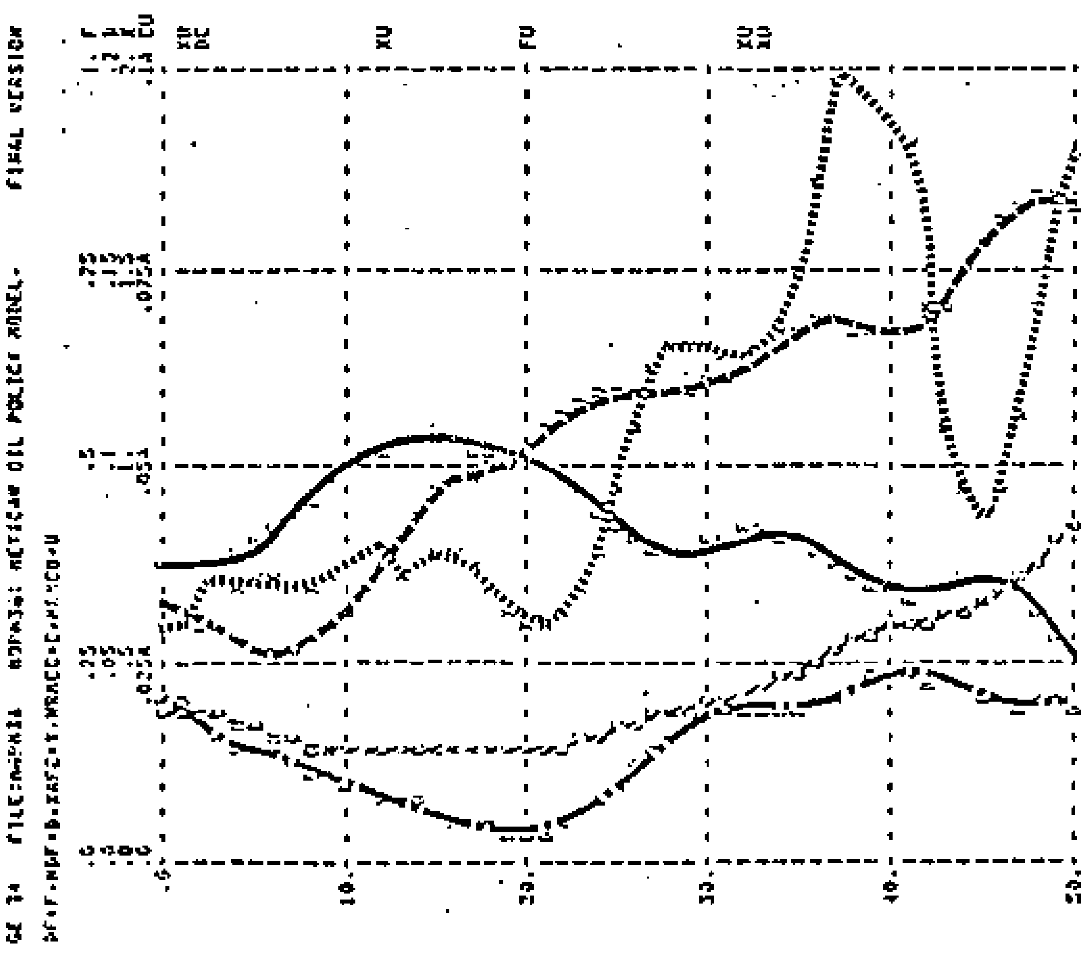
Energy production

Pemex production

Unconventional production

Energy exports

Figure 3-2c



Foreign debt fraction

Deficit fraction

Adequacy of foreign currency

Real Pemex marginal cost

Real unconventional marginal cost

Figure 3-2d

Overall, the results of the policy tests embodied in this section suggest that stimulus of unconventional energy production can have a significant benefit within the energy sector toward increasing stability of Pemex exports and diminishing the possibility of eventual dependence on external energy sources when domestic oil and gas reserves within Mexico become more costly to exploit. On the other side, general macroeconomic effects tend to be small, with the impacts on real growth and inflation depending on how the encouragement of unconventional production is financed from a governmental and federal deficit point of view.

The results are shown in figure 3-3.

Figure 3-3: Allocating Oil Revenues to Develop Alternative Energy

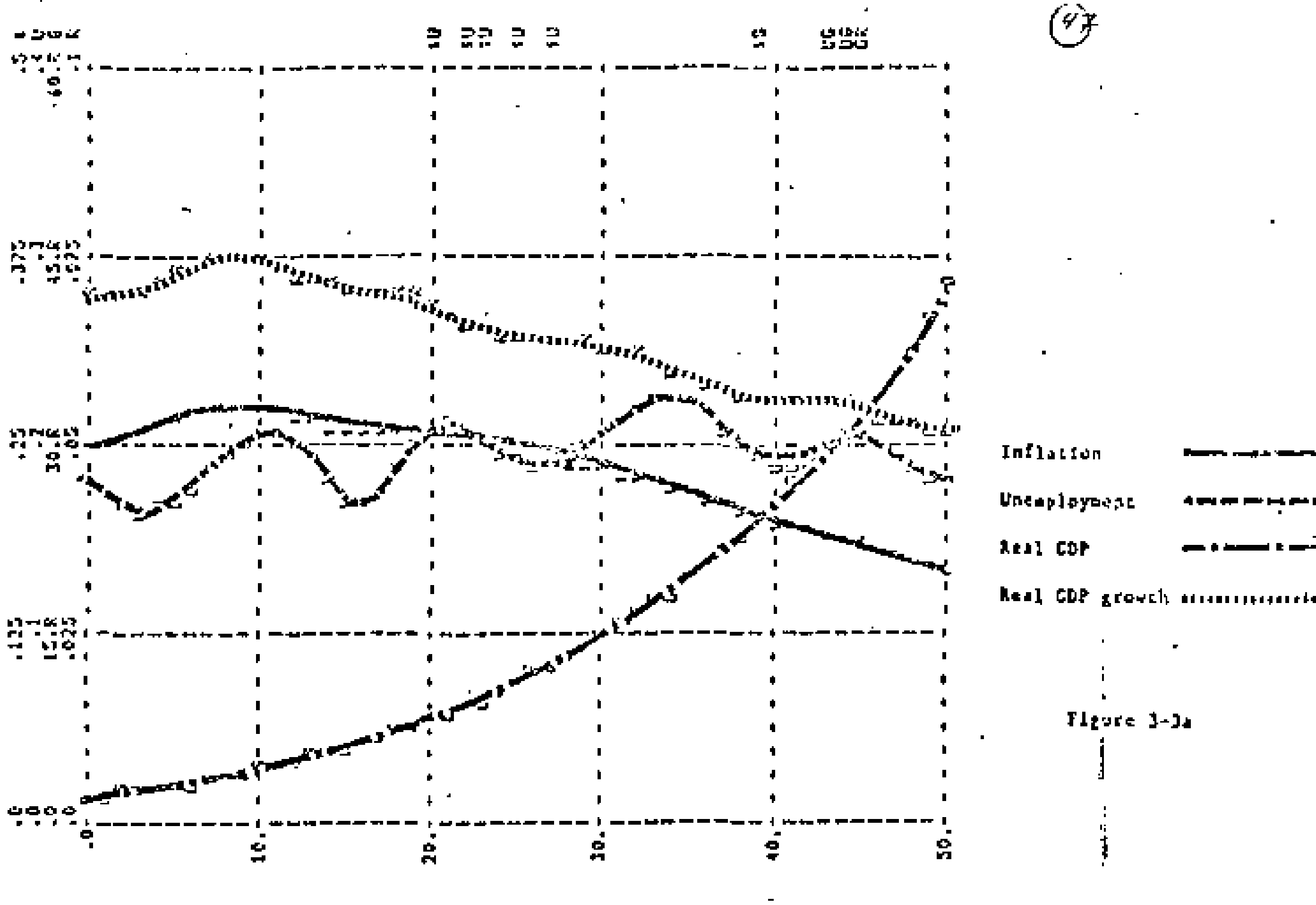


Figure 3-3a

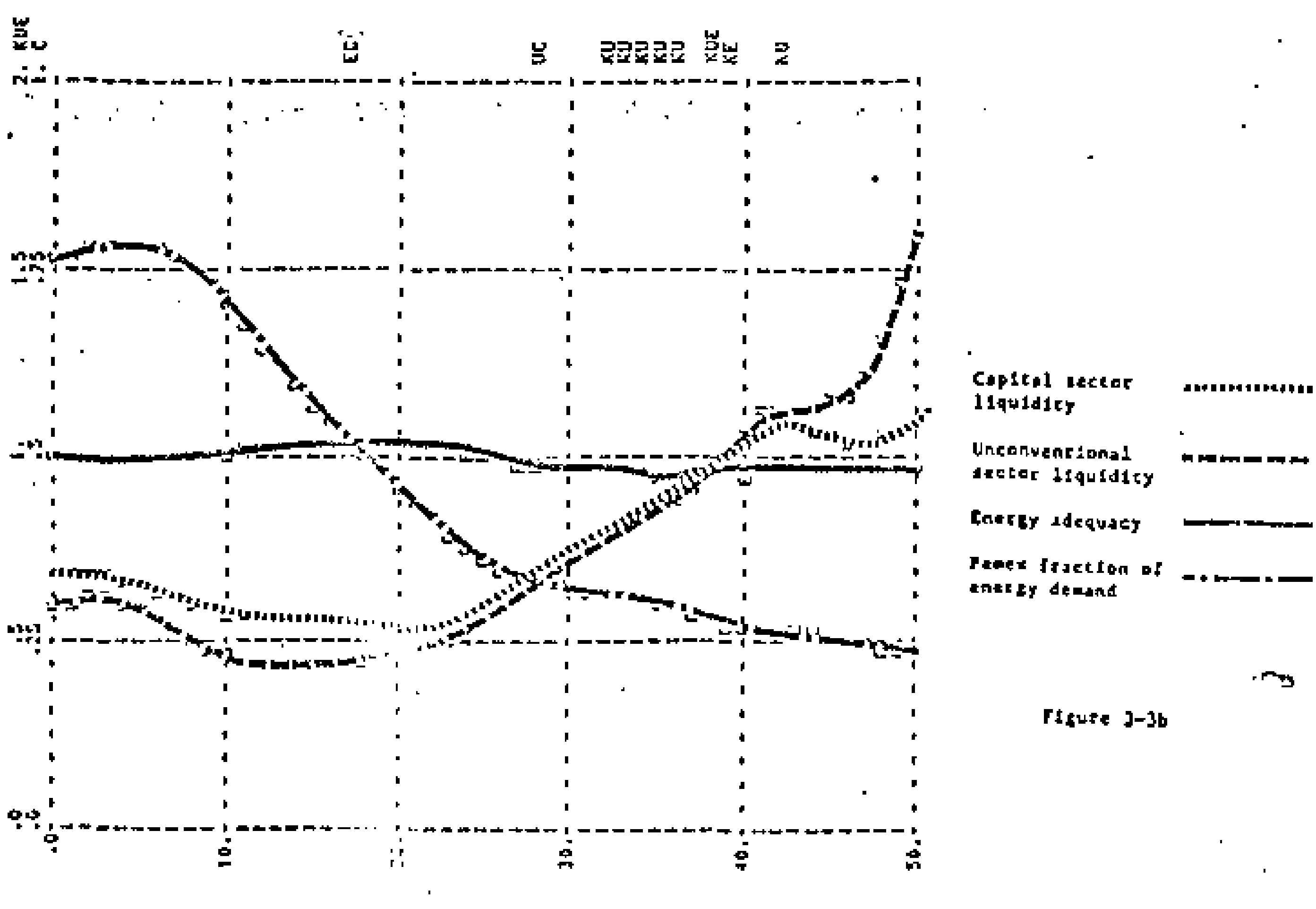


Figure 3-3b

Figure 3-3: Allocating Oil Revenues to Develop Alternative Energy

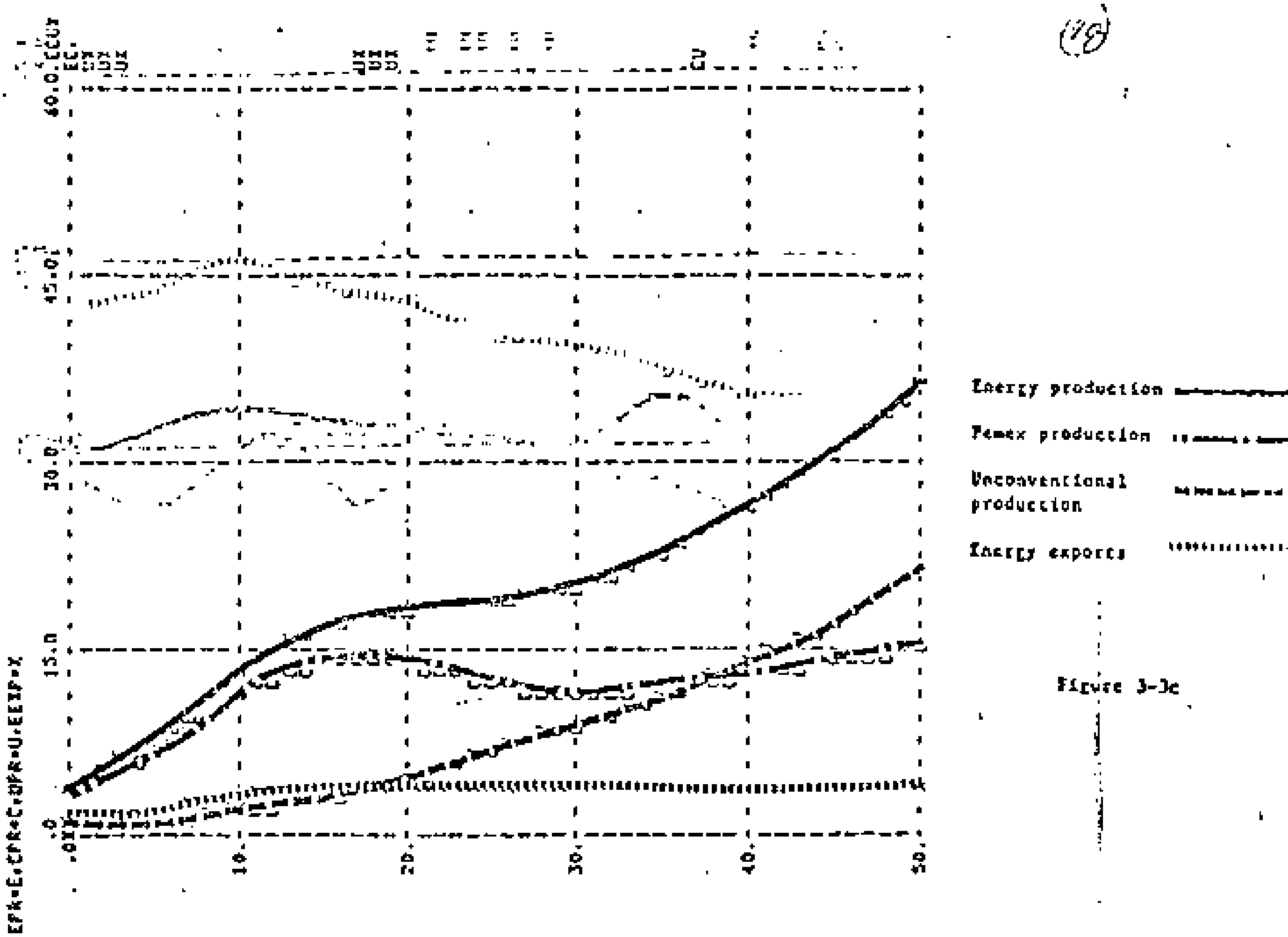


Figure 3-3c

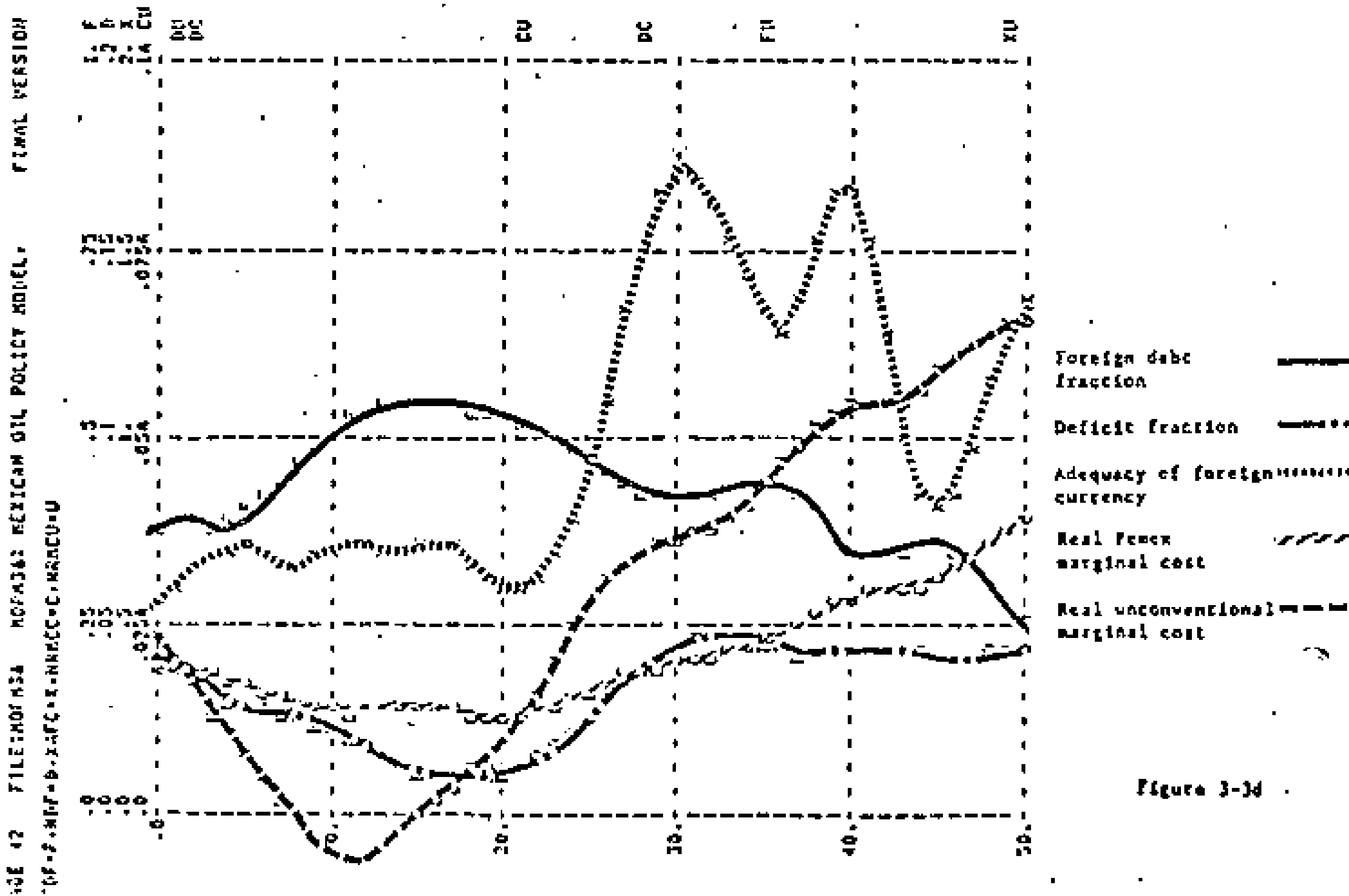


Figure 3-3d

ADDITIONAL DIRECTIONS FOR NATIONAL ENERGY POLICY

The preceding analysis has shown that the major elements of the National Energy Plan and Global Development Plan within the energy arena achieve a number of benefits. Rising the domestic price of oil and gas to 70% parity with world prices tends to lower inflatio by several points and to conserve long term energy supplies, although at the cost of some real growth due to higher average costs and relatively lower labor productivity. Accelerated development of alternative energy sources to supplement, and eventually replace, Pemex conventional production of oil and gas also helps to maintain long term energy supplies, diminish vulnerability to potential energy shortages, yet has a relatively minor impact on inflation.

On the other hand, the analysis also suggests that the real economic benefits of energy export may not be as substancial as expected by some analysts and policy makers. For example, model results suggest that a policy of raising Pemex exports up to a level of 1.5 MMBD of crude oil and some additional exports of petrochemicals and refined products, coupled with reduction in the subsidy for domestic use and uncouragement of alternative energy sources, tends to raise real GDP by a total of 10-12% by the end of the century, implying an annual growth increment of less than 0.5% per year compared with a policy of sustained low oil exports and 70% domestic price parity to international prices. Another important mechanism that tends to lower growth is the imports of capital goods, because although they add to the national productive capacity and thus enhance productivity, but at the same time they reduce the pressures to develop a strong domestic capital goods sector within Mexico. Basing economic development on a substancial fraction of imported consumer goods and capital goods financed by oil exports may be a necessary short term strategy, but posses long term risks in terms of external dependence and slower development of internal production capacity and techniques than is possible given Mexico's substancial oil wealth. One important complication from a policy stand point is that even if imports of consumer and producer goods were to be limited, the additional accumulation of money within Mexico before real production capacity can catch up with nominal purchasing power will yield additional inflation. From this perspective, the conversion of oil revenues into imports that diminish foreign currency holdings tends to restrain the inflationary thrust of buildup of foreign exchange from oil export.

The policy examined here incorporates the target export levels set in the National Energy Plan, the increase in relative domestic oil prices, and the stimulus to production of alternative energy sources. It also includes:

-In order to stimulate internal development of capital production capacity within Mexico and to lower dependence on external sources of capital goods from a long term standpoint, the policy limits imported capital goods to 75% of desired levels based on the shortfall of domestic production capacity compared with desired capital investment rate.

-In order to limit the inflationary impact from retention of a higher percentage of oil revenues within foreign currency reserves and domestic money supply, the policy also shifts the allocation of oil export revenues compared with that laid out in the Global Plan: 50% of oil export taxes go to economic development, and the remaining 50% go to reduce the government deficit and therefore lower foreign debt and money creation by financing through the central bank.

Figure 4-1 shows the impacts of the policy on real growth and other macroeconomic indicators. There is a significant stimulus to real economic growth from the policy. The major source of the increase is due to the substitution of domestic capital production for imported capital goods.

Unemployment tends to be less during the first 10 years of the policy as a consequence of pressures to subtitute labor for capital goods in the face of higher real GDP. Over the long term, unemployment tends to held down by higher real GDP growth surrounding the multiplier effect from development of domestic capital production.

Regarding inflation none of the tests examined indicate a significant improvement in reducing price increases. These results may suggest that energy policies will need to be complemented by monetary and fiscal policies that lower federal deficits and rates of monetary growth in order to control inflation.

Figure 4-1: Limited Capital Imports and Deficit Reduction

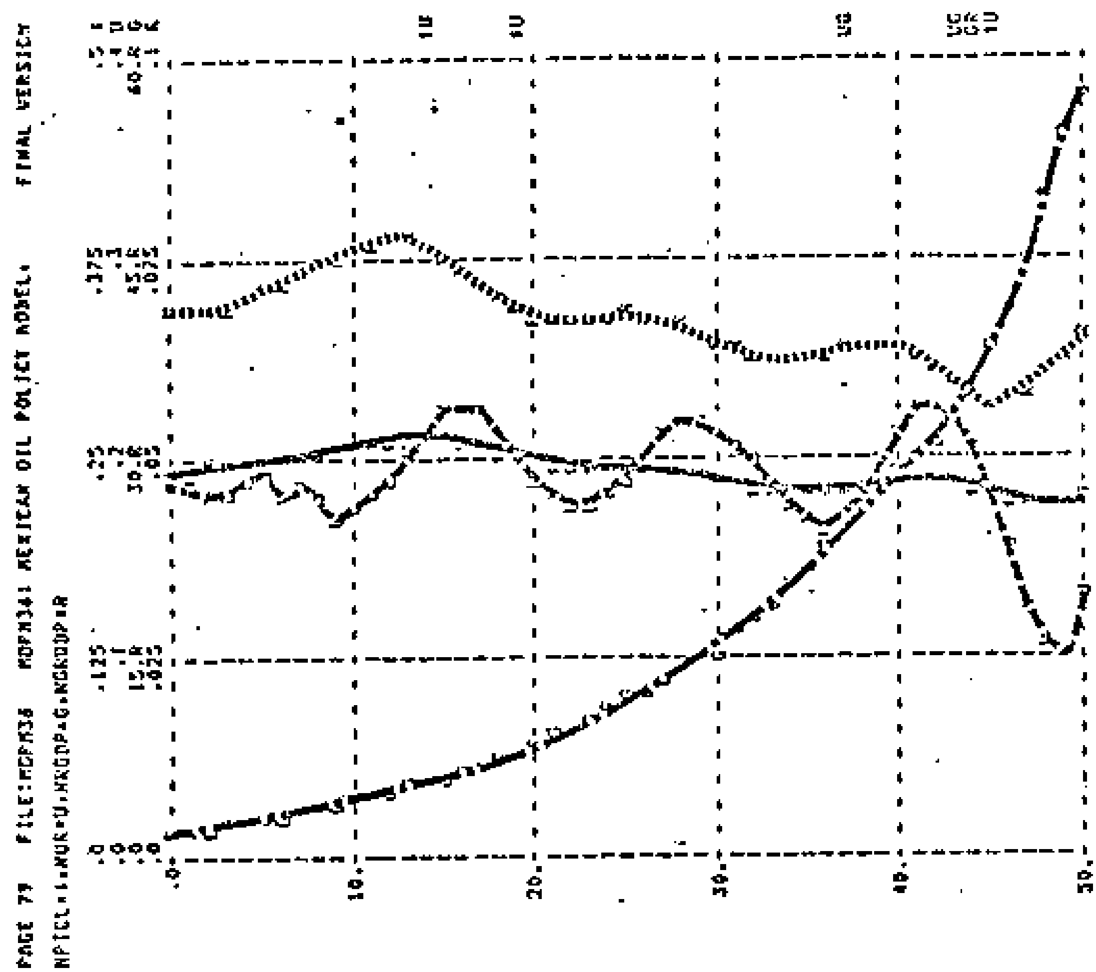


Figure 4-1a

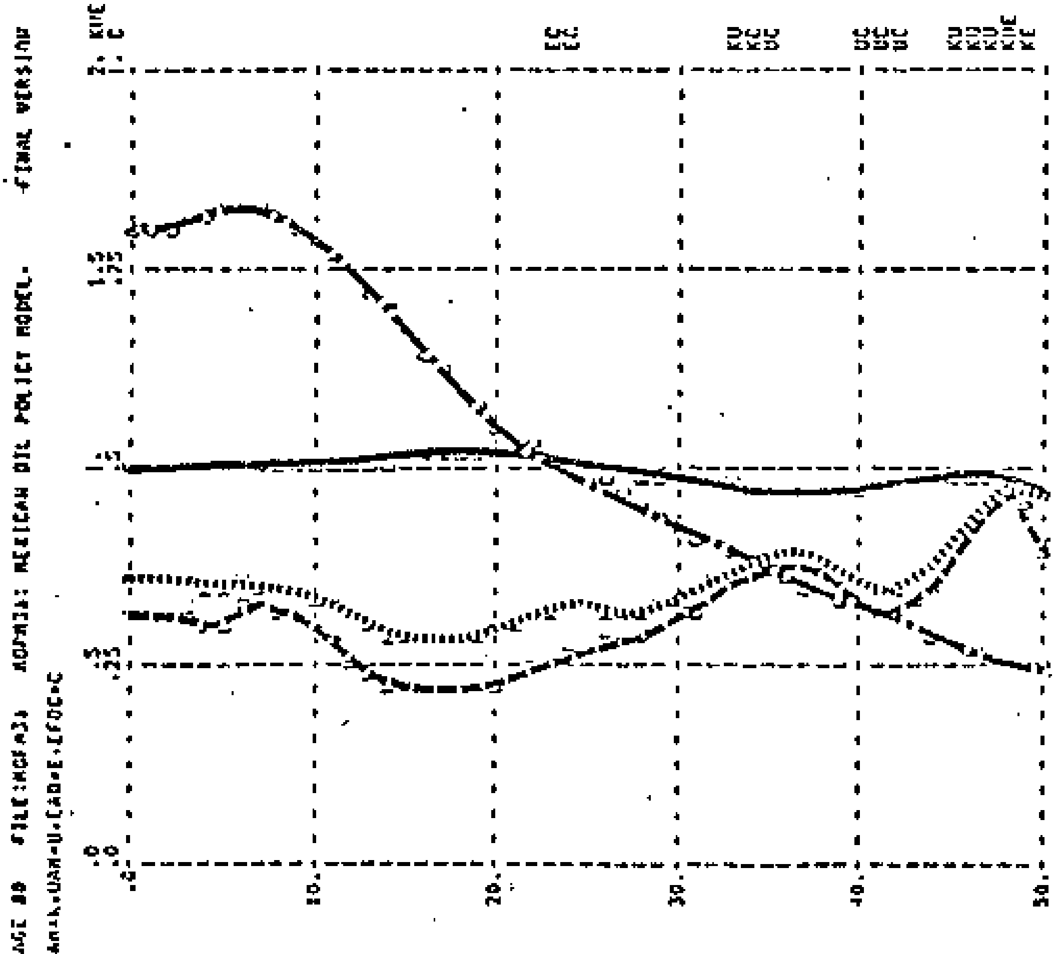


Figure 4-1b

Figure 4-1: Limited Capital Imports and Deficit Reduction

(52)

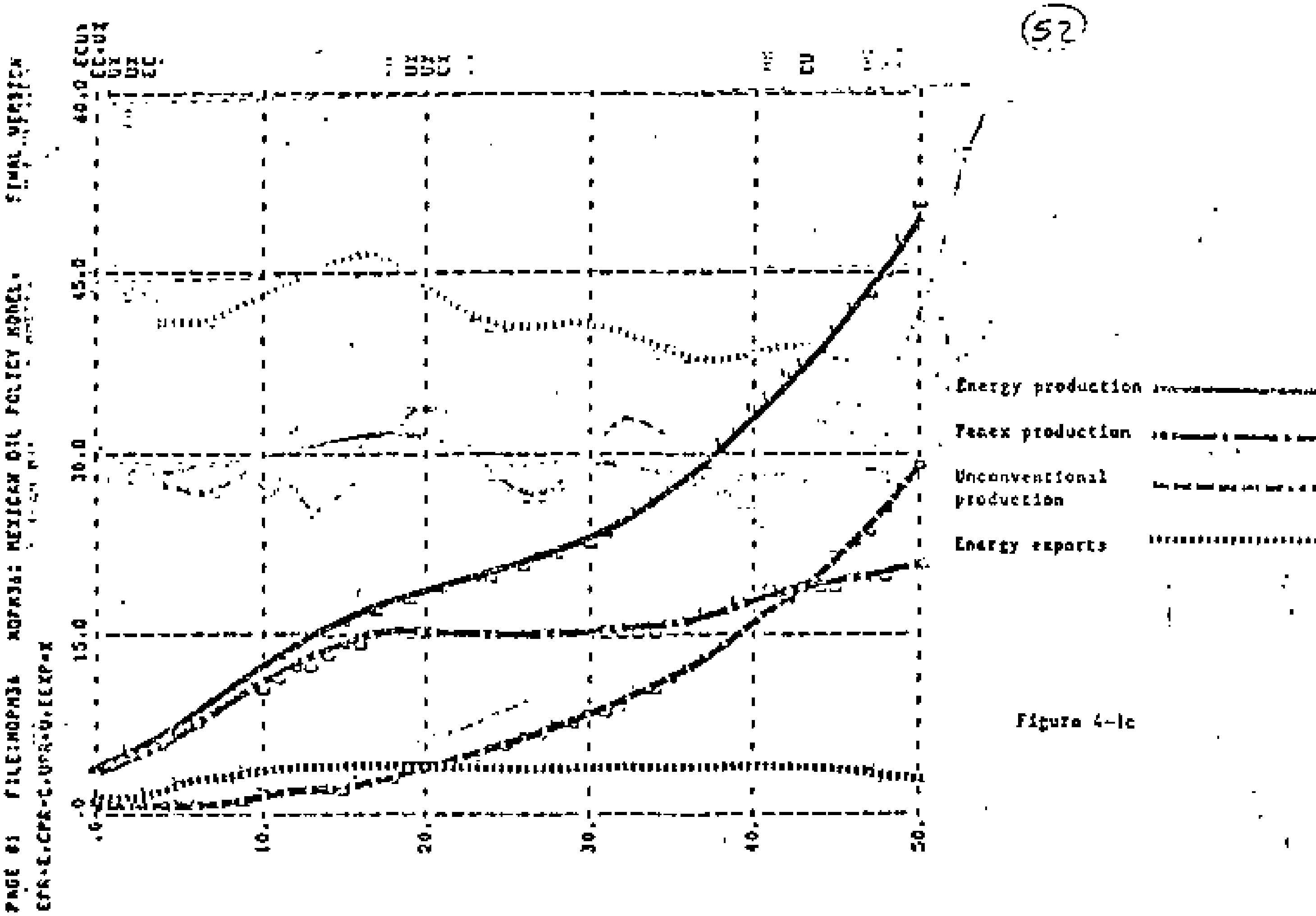


Figure 4-1c

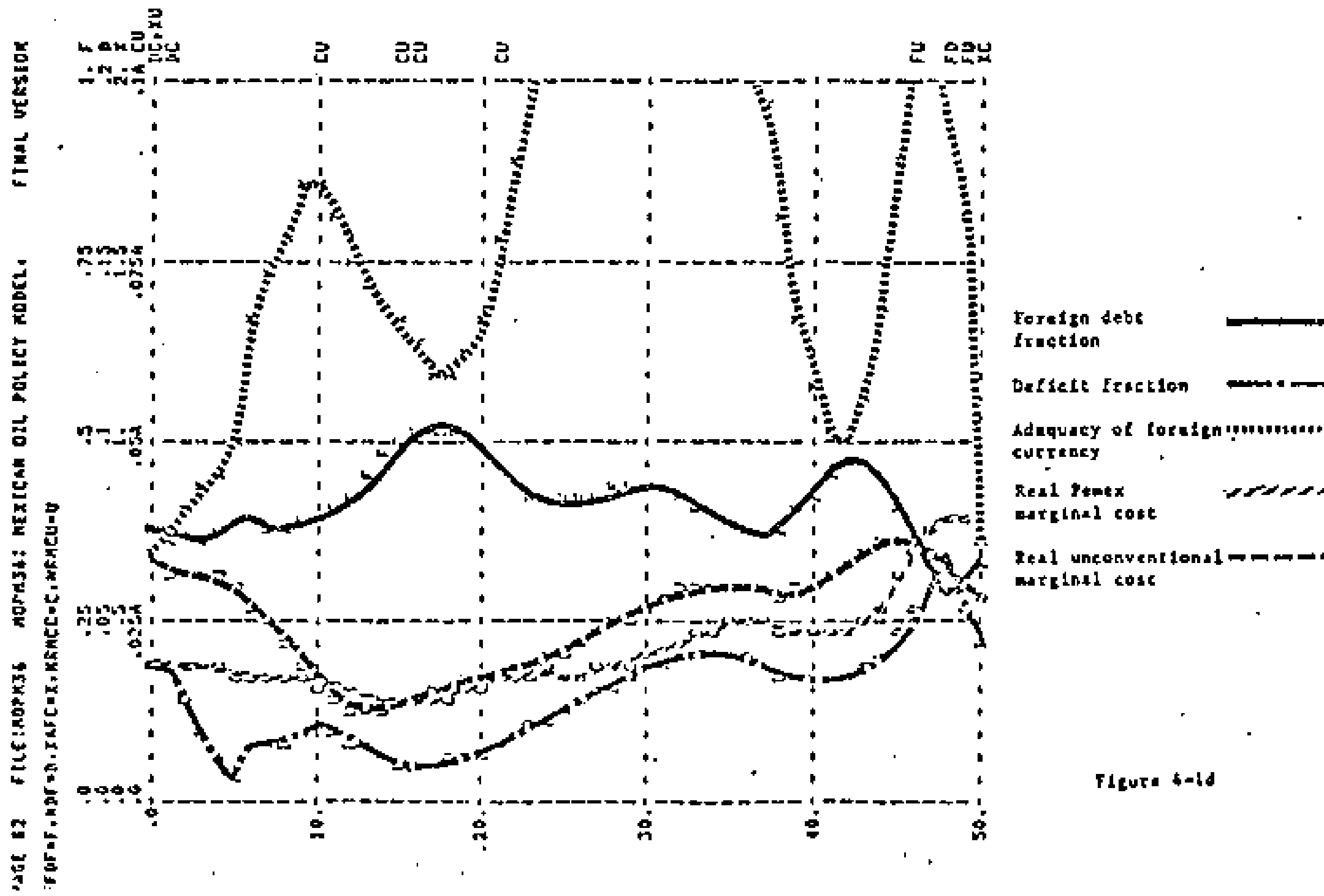


Figure 4-1d

FINAL REPORT:
HONEYWELL CUSTOMER SERVICES DIVISION
SYSTEM DYNAMICS MODELING PROJECT

by

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Luis Leon
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FINAL REPORT:
HONEYWELL CUSTOMER SERVICE DIVISION
SYSTEM DYNAMICS MODELING PROJECT

CONTENTS

Outline, Documentation, and Model Description

APPENDIX 1: Presentation Outline

APPENDIX 2: Policy Structure Diagrams

APPENDIX 3: Documented Model Listing

APPENDIX 4: Model Equations with Reruns

1. INTRODUCTION

1.1 Purpose of Pilot Project in System Dynamics

The System Dynamics approach is a technique to further the understanding of complex systems through policy structure analysis. This formalzed approach uses dynamic simulation models. The ultimate objective is an incresed insight into the dynamics of the system at hand. Much knowledge is obtained in going through the exercise of building the model. In some aspects the modeling process is more valuable of an asset to the parties involved than the actual model itself! -- for building a model requires hard and clear thinking. It requires that all assumptions be rigorously justified. It is quite an intellectual challenge with definite practical applications. The lessons learned and the information uncovered in the process of conceptualizing and reconceptualizing a system's dynamic structure are well worth the work it demands.

This project has attempted to expand and clarify ideas about modeling the relationships between the Honeywell Customer Service Division and the Market. A picture of the organization is developed in terms of decision making processes. That picture of organizational structure is then translated into a set of precise mathematical equations to be used as a simulation model.

Once enough confidence is built up in the model, it is possible to develop many new insights into the system as well as confirm prior knowledge. This System Dynamics model can be used to explore the short- and long-term consequences of policy changes in the Customer Service Division. It can also be very valuable as a policy and strategy tool in the analysis of current bsiness problems.

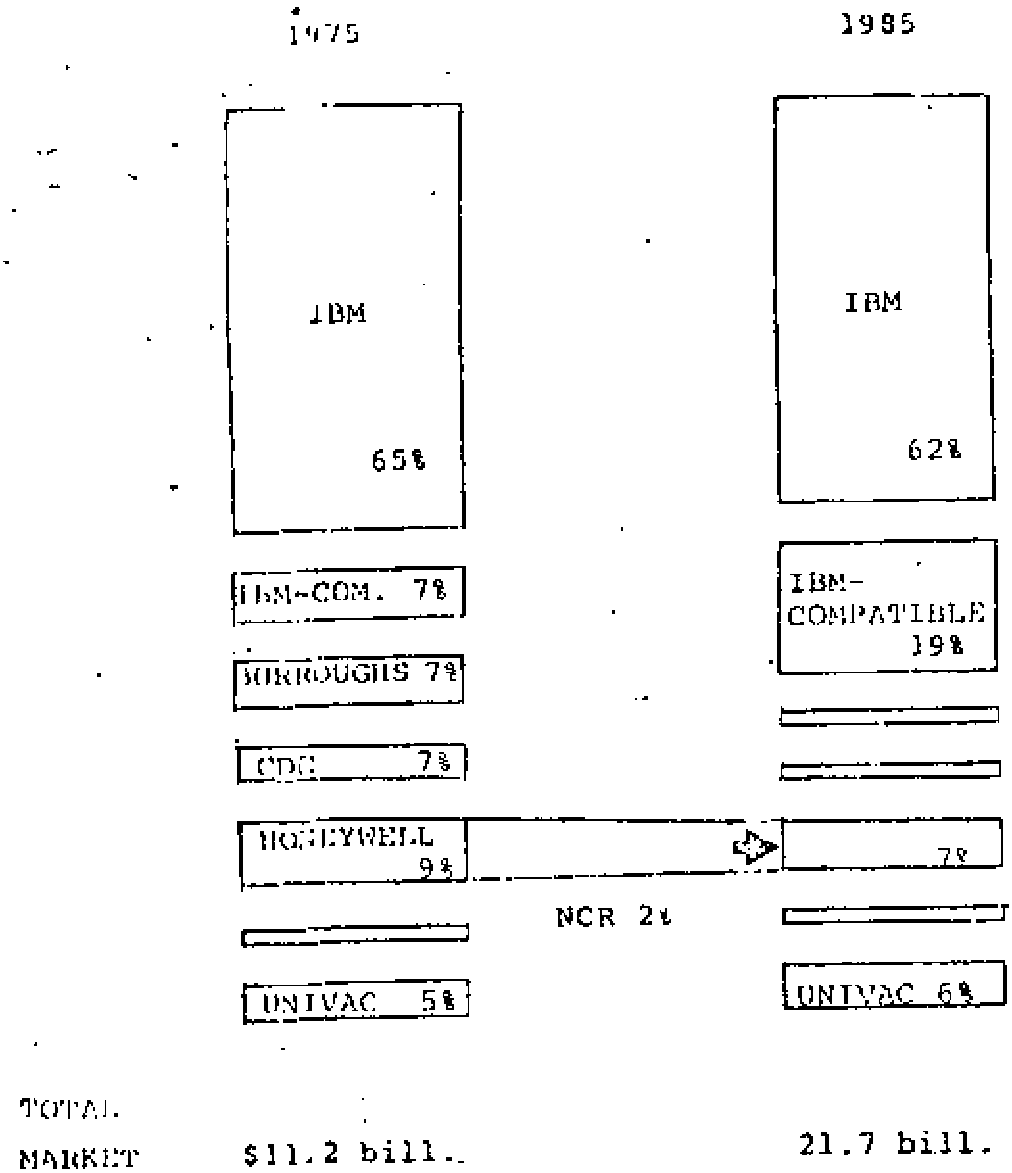
System Dynamics seecks qualitative conclusions about the potential impacts of policy and decision-making upon a system. We aim to understand the structural underpinnings of a complex system and consequentially establish the relationships by which the actual system behavior is finally influenced. System Dynamics does not attempt to predict anything. It is merely a very powerful and unique tool by which to facilitate understanding of phenomena which are not readily comprehensible.

1.2 Review of Problem Area

Upon initial inspection there did not exist one clearly distinct "problem" for us to "solve" within the Customer Service Division. Honeywell has definately been experiencing a loss of market share in relation to its competitors (see Figure #1). The current situation cannot simply be broken down into a "problem and answer" scenario. It is our view that what is going on within Honeywell, and in fact within the whole information processing industry at this time, is an acute transformation. There is a tremendous market opening up for relatively low cost, small scale computers such as Honeywell's Level 6, as opposed to the large scale mainframe computers.

FIGURE #1

HONEYWELL MARKET SHARE



As illustrated in Figure #2, the trend is clear. Whereas in 1975 mainframe computer sales occupied an overwhelming 83 per-cent of the overall computer market ($13 billion), in 1985 that figure is projected to decrease by more than one-half to 36 per-cent of a total computer market which will increase five fold to $63 billion. In contrast, mini-computer sales as a percentage of the market are projected to increase by one and one-half times between 1975 and 1985, from 9.5 per-cent to 13 per-cent. We expect to see mini-computer sales for the entire computer industry to increase by eight times their 1975 level to $8 billion by 1985. Indications are that this will be only the beginning of a long period of exponential growth in the mini-computer market.

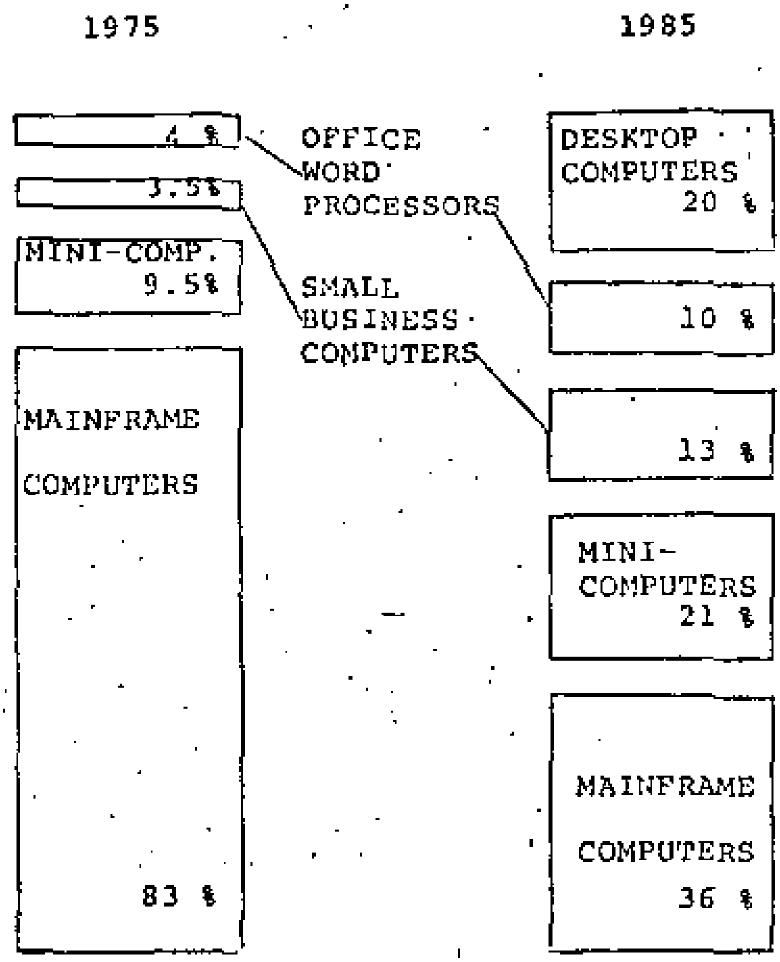
When the above observations are put more in the perspective of Honeywell, it means that mini-computer sales will double to fifty percent of overall service revenue. It is in just this particular case that the numbers can be quite deceiving (see Figure #3). Mini-computer sales which were $210 million in 1980 will more than quadruple to a projected $925 million in 1985 because the overall market is growing so fast. This type of growth characteristic, the phenomenon of exponential growth, has the capability of producing unexpected and unintuitive behavior within an organization.

1.3 Discussion of Alternative Policies

Unprecedented increases in the sales of mini-computers during the next five to ten years will necessitate new ways of thinking about

FIGURE # 2

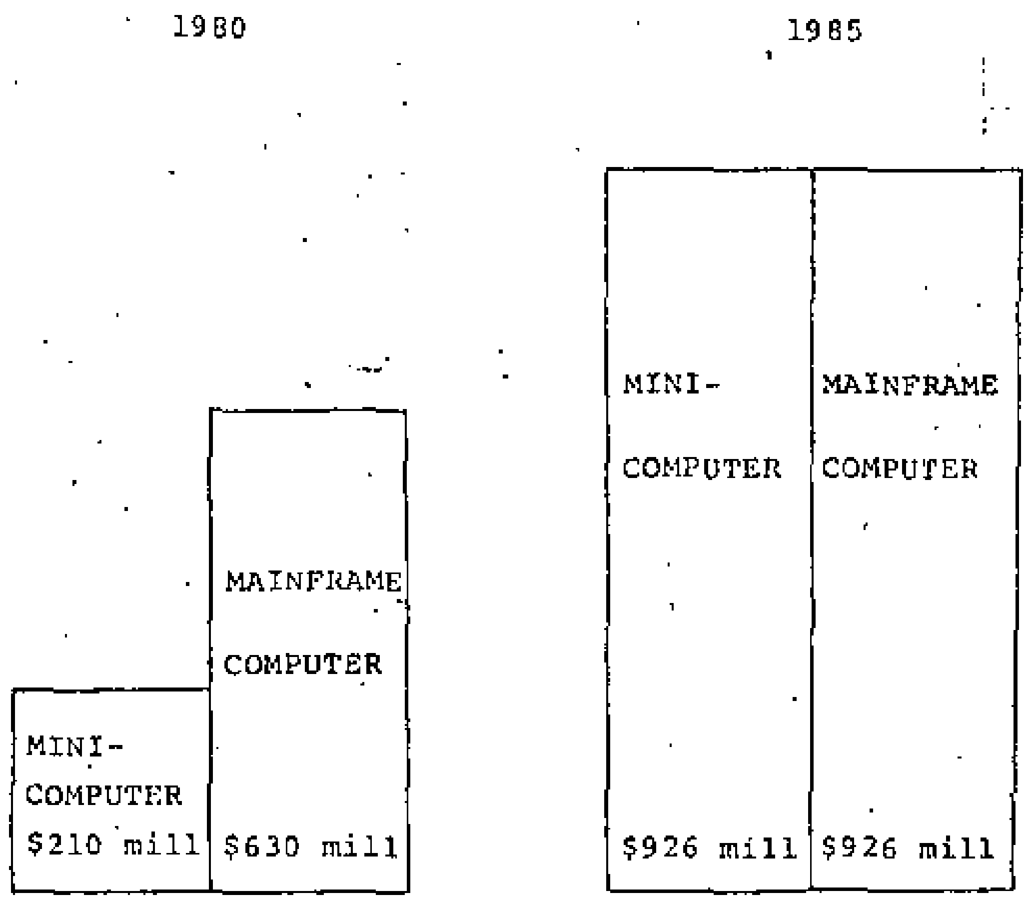
MAINFRAME COMPUTER MARKET SHARE



TOTAL MARKETS $12.83 billions $63.31 billions

FIGURE # 3

HONEYWELL REVENUE



and providing service. In the past Honeywell has refrained extensively from obligating itself to maintain Honeywell mini-computers sold by resellers. There is a different cost and profit structure associated with servicing minis as opposed to mainframes. The profit margin per mini installation, at least initially, is much less than large scale computers. Replacement parts, spares, and circuit boards for new mini equipment are very capital intensive.

In light of these financial considerations, there is uncertainty as to encouraging further reseller and third party maintenance of Honeyell equipment. Price discounts on service contracts for resellers are one means of inciting growth, but such measures might tend to reduce profit even further. Non-traditional maintenance policies such as the man-in-the-van program would seem to cut down on costs by making more effective use of existing assets and labor, but its ultimate effect is not quite known.

Honeywell is looking to increase market share in the coming years with the influx of mini and micro products. Therefore, high service quality is also a topic of concern. It is important to assess the impact of the above policies upon service quality and the market, while keeping in mind the new financial structure associated with mini-computers. Leverage points can be found within the Honeywell Service organization through which policy decisions will have the greatest effect upon the organization while generating the least amount of internal resistance.

2. OVERVIEW OF MODEL

This study involves Honeywell Customer Service Division and its relationships to a changing market. HCSD has to provide service to two different types of equipment: minicomputers and large scale systems. Traditionally it has been providing service to the latter, but there has been a change in the computer market, due to the maturation of large scale systems and fast growth in minicomputers. This creates a problem because the requirements, costs, and prices of mini service are different, so there is the need to look for new methodologies.

2.1 Honeywell Customer Service Division

The Honeywell Customer Service Division can be thought of as having two primary and sometimes conflicting goals: to provide service and also to make a profit. We have represented the CSD by the Service Subsystem, which is composed of a Service Sector and a Financial Sector, in order to capture these two distinct goals and the processes associated with them.

The Service Sector provides service by aquiring the necessary resources, namely Labor and Assets. The desired levels of these resources are calculated by forecasting expected service requirements. Labor is especially more intricate than Assets in that Average Experience of Labor and Overtime Policies are also necessary to be taken into consideration. Backlog of service calls is generated by the number of installations serviced by Honeywell. These calls then must be answered using the available resources. If the required Assets and/or Labor are not available, then Backlog will build up and Honeywell Service Quality consequently will decline.

The Financial Sector is a mechanism for keeping track of the cost and revenue of the Service Division. Based upon these figures, Service Profit Margin can be calculated. When Profit Margin differs from its historically expected target, then financial constraints will be imposed upon the Service Division in order to reduce costs and increase profit. These are simplified budgetary processes. As a result, Asset and Labor aquisition will decrease which will then leave the Service Sector short of resources. The two sectors are truly conflicting.

2.2 The Marketplace

The Marketplace can be thought of as two distinct sectors: the Sales Market and the Service Market.

Honeywell and Reseller Sales are both represented in the Sales Market. Each grows at a rate proportional to its own size; as they get bigger, then they grow at faster rates. Price and Service Quality are the two main factors which influence rate of growth in the market. Therefore, Service Subsystem performance in terms of Service Quality will influence market growth. The market will then feed back and influence Service once again.

The Service Market is meant to differentiate between those Honeywell installations which are serviced by Honeywell and those which ar serviced by Third Party Maintainers. When Honeywell Service Quality declines in relation to TPM Service quality, then Third party Maintainers are liable to receive more service contracts. Conversely, when Honeywell Service Quality increases, then they are likely to get more business.

The Market and the Service Division interact in a unique way. The two feed back to one another. If Honeywell Service Quality were to decline, then market growth would also slow down. A decrease in sales would increase the installations which need to be serviced, and so Service Quality would eventually rise back up. This increase would cause growth which in turn would decrease Service Quality and start the whole cycle all over again. (See Figures #4, #5, #6, #7)

3. SIMULATION ANALYSIS

3.1 Simulation #1: Mainframe Growth

Our first major concern when testing the model was that it correctly portray the behavioral characteristics of normal mainframe growth. We have assumed for this purpose a maturing linear growth of large scale installations beginning at 12,500 in 1978 and increasing to 25,000 over a period of ten years. The simulation is begun in equilibrium; it therefore requires almost a 24 month period for the transient effects of growth to die away. The same will be true of all subsequent simulations.

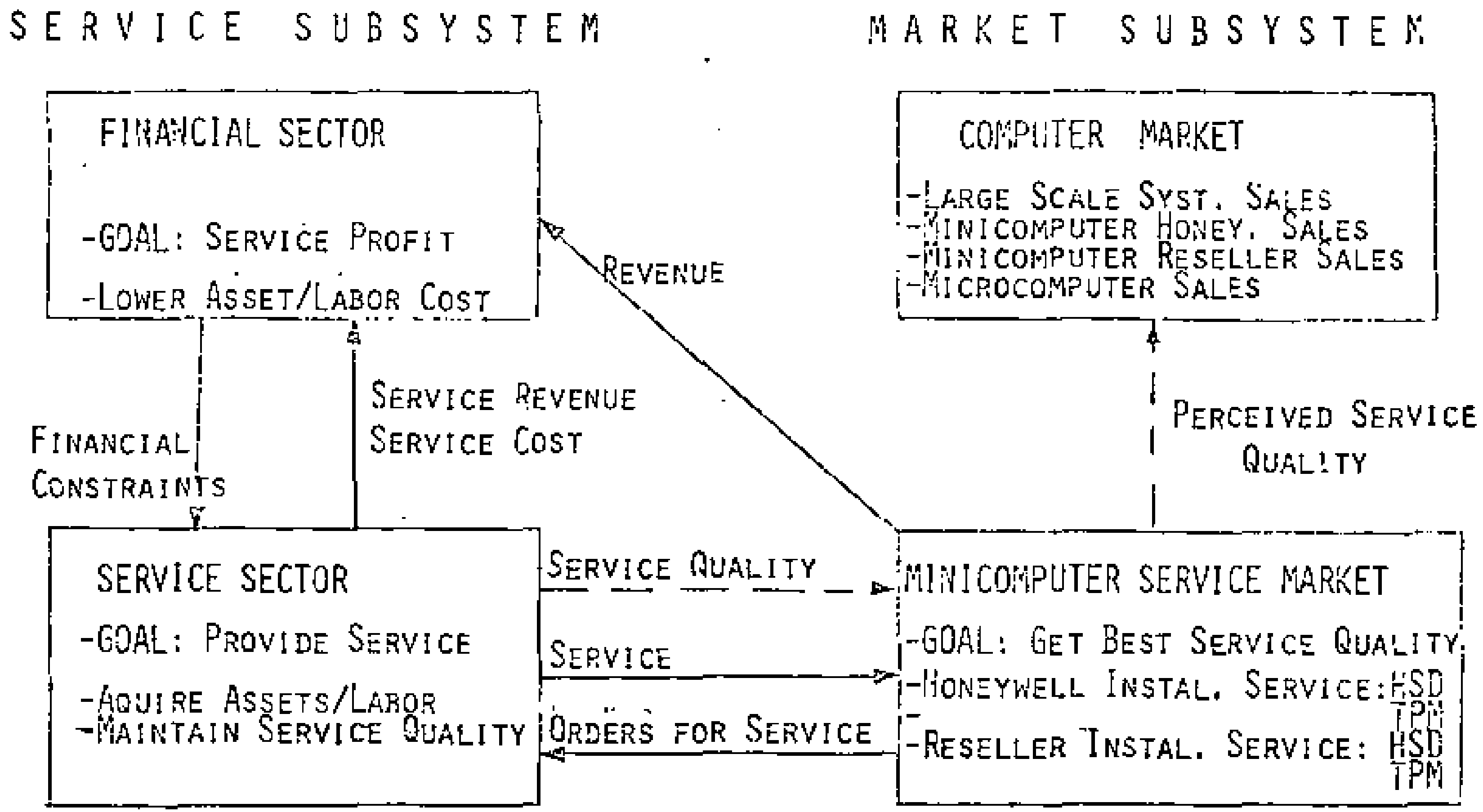

SERVICE SUBSYSTEM
MARKET SUBSYSTEM
FINANCIAL SECTOR
-GOAL: SERVICE PROFIT
-LOWER ASSET/LABOR COST
COMPUTER MARKET
-LARGE SCALE SYST. SALES
-MINICOMPUTER HONEY. SALES
-MINICOMPUTER RESELLER SALES
-MICROCOMPUTER SALES
REVENUE
FINANCIAL CONSTRAINTS
SERVICE REVENUE
SERVICE COST
PERCEIVED SERVICE QUALITY
SERVICE SECTOR
-GOAL: PROVIDE SERVICE
-AQUIRE ASSETS/LABOR
-MAINTAIN SERVICE QUALITY
SERVICE QUALITY
SERVICE
ORDERS FOR SERVICE
MINICOMPUTER SERVICE MARKET
-GOAL: GET BEST SERVICE QUALITY
-HONEYWELL INSTAL. SERVICE: HSD TPM
-RESELLER INSTAL. SERVICE: HSD TPM

FIGURE # 5

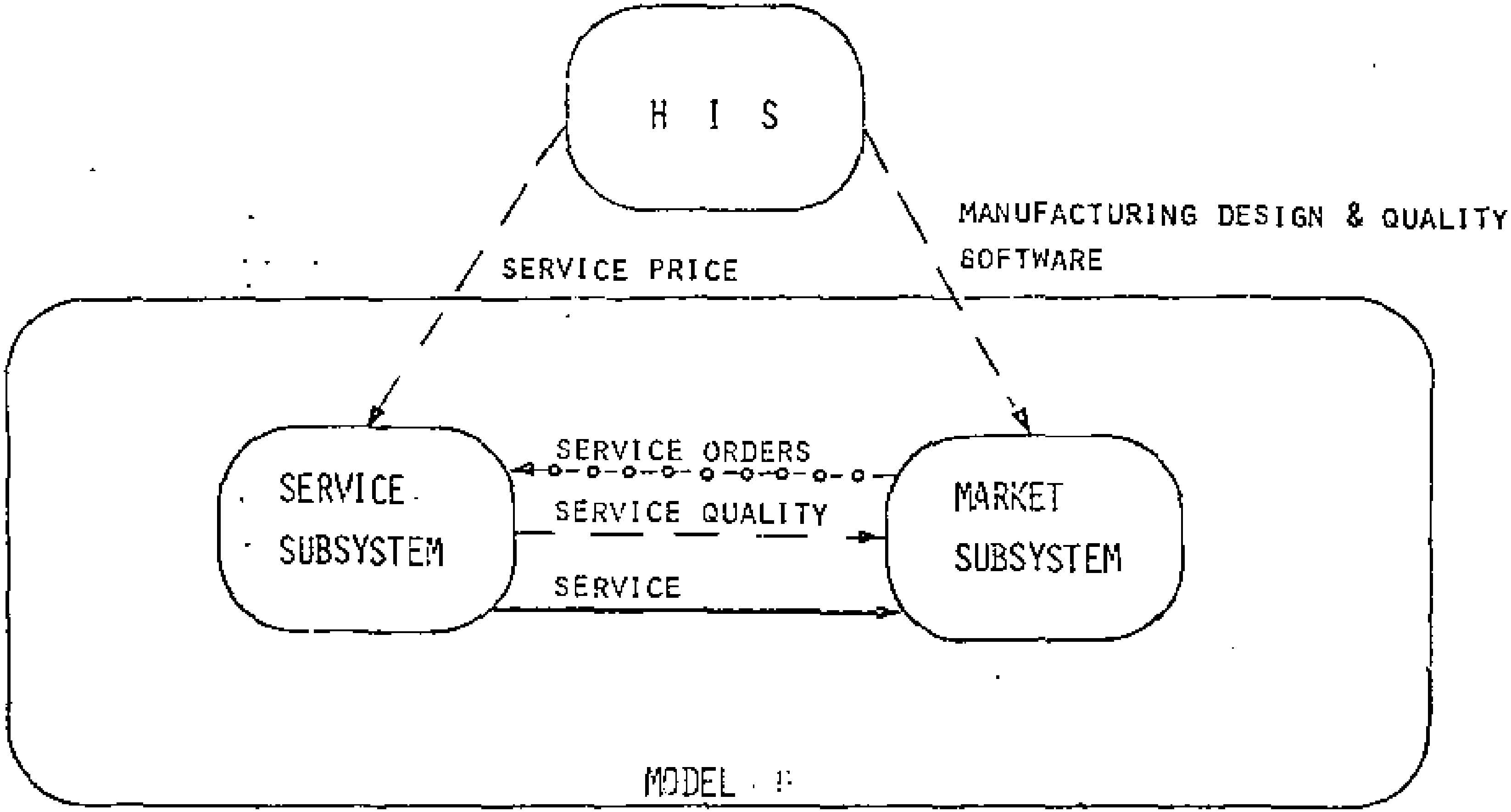

H I S
SERVICE PRICE
MANUFACTURING DESIGN & QUALITY
SOFTWARE
SERVICE SUBSYSTEM
SERVICE ORDERS
SERVICE QUALITY
SERVICE
MARKET SUBSYSTEM
MODEL

FIGURE # 4

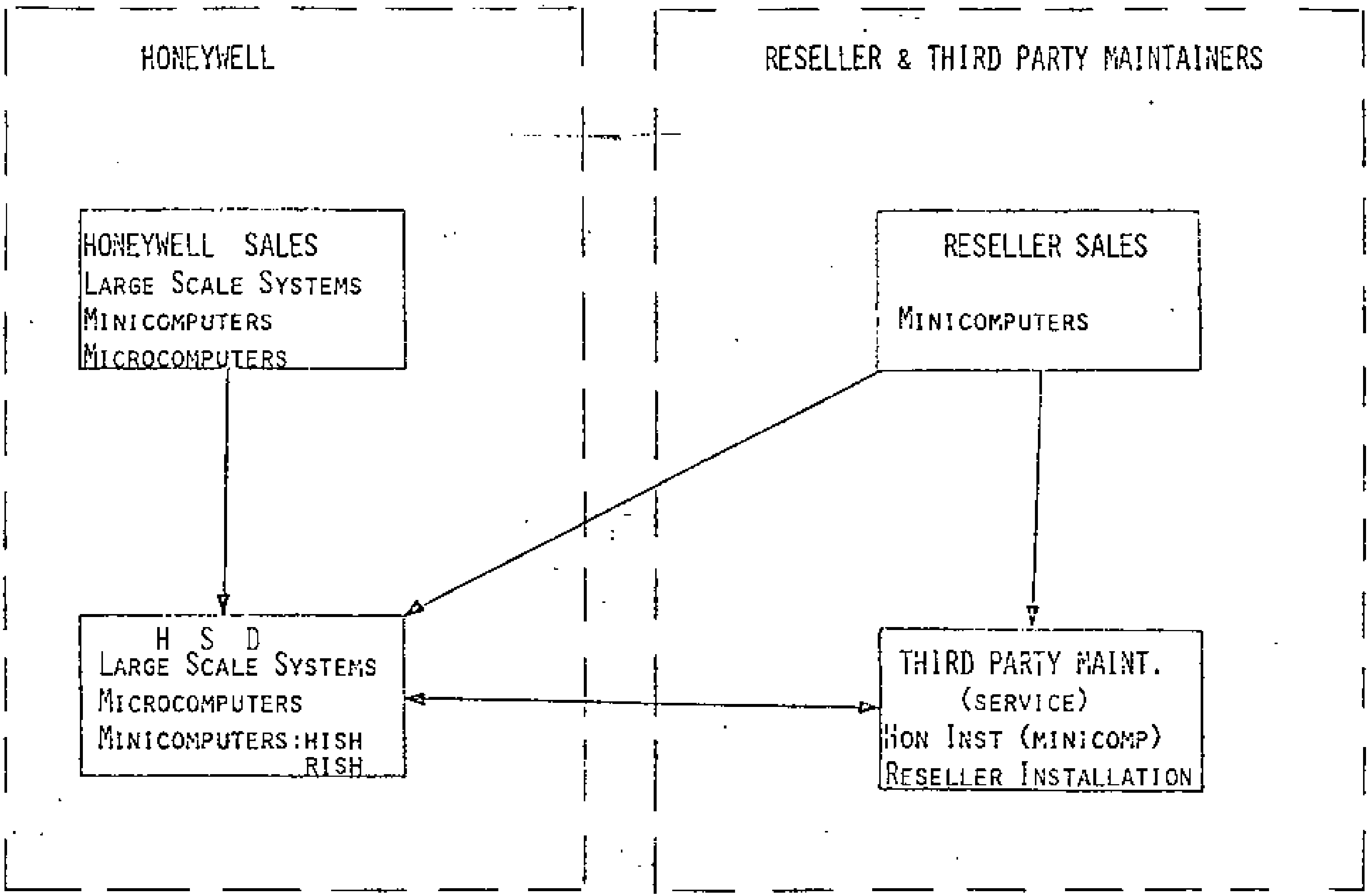
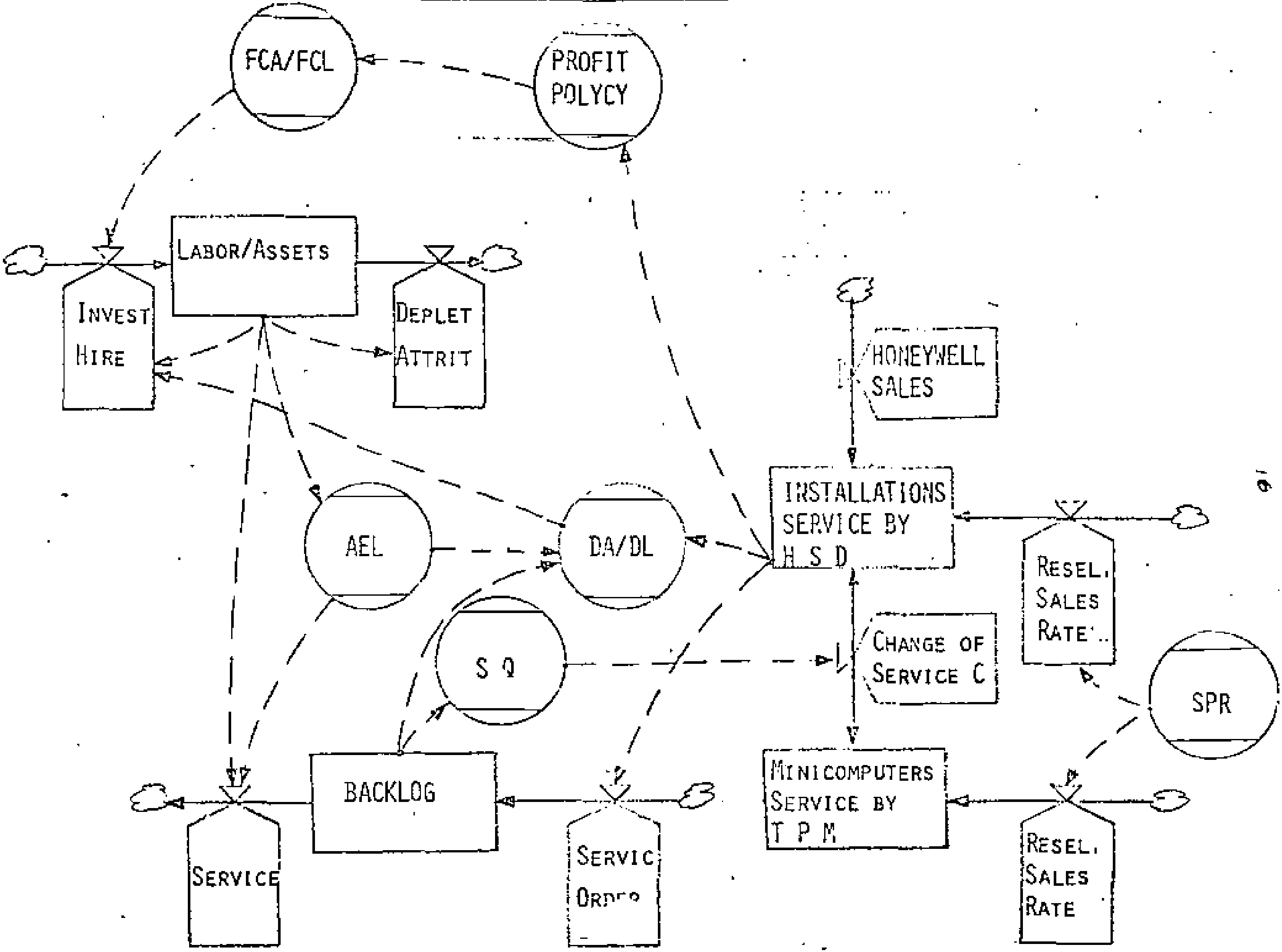

HONEYWELL
RESELLER & THIRD PARTY MAINTAINERS
HONEYWELL SALES
LARGE SCALE SYSTEMS
MINICOMPUTERS
MICROCOMPUTERS
RESELLER SALES
MINICOMPUTERS
H S D
LARGE SCALE SYSTEMS
MICROCOMPUTERS
MINICOMPUTERS:HISH
RISH
THIRD PARTY MAINT.
(SERVICE)
HON INST (MINICOMP)
RESELLER INSTALLATION

FIGURE # 6

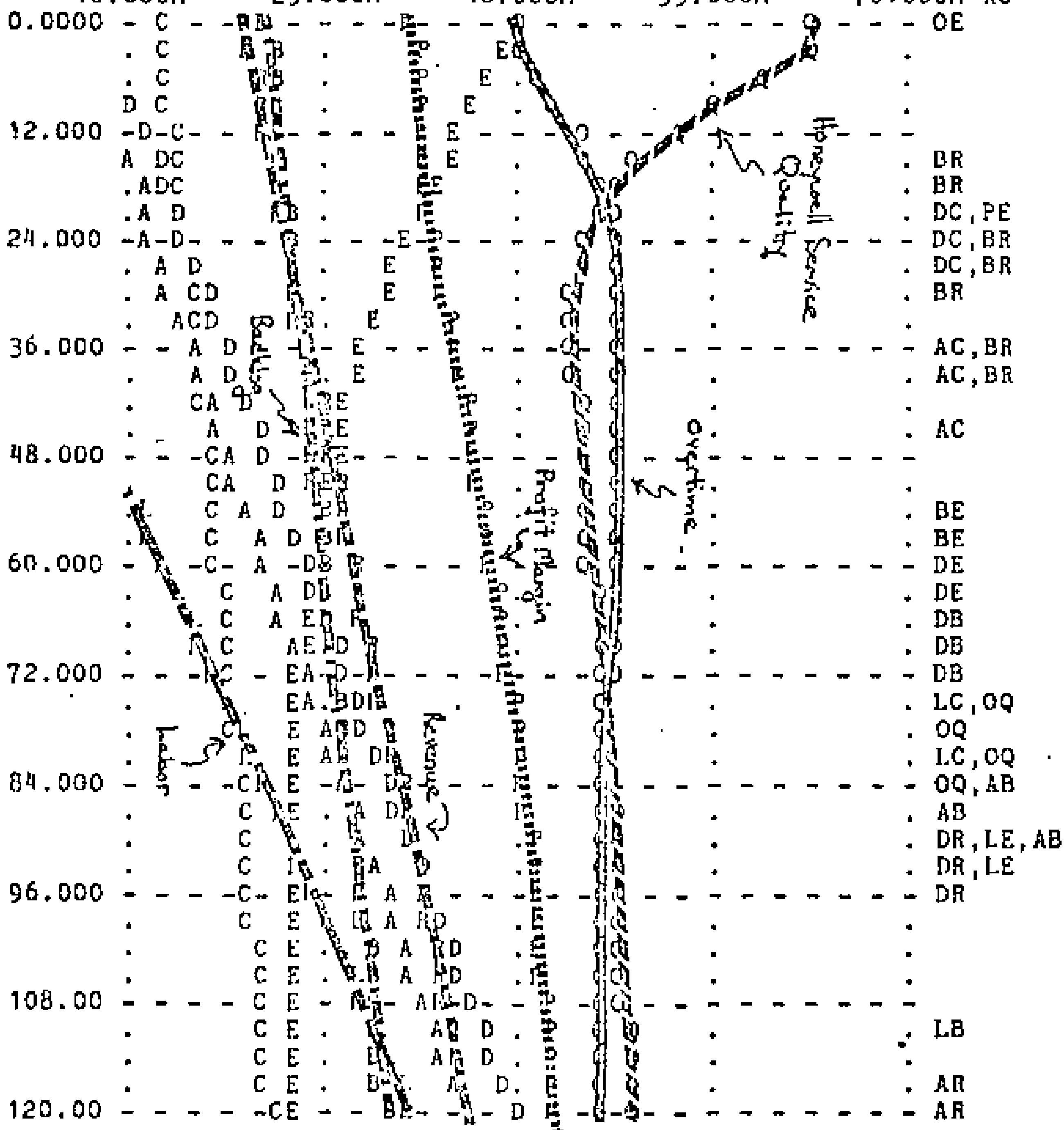
POLICY STRUCTURE DIAGRAM



P- 7 RUN-TEST#5 TEST#5: NON-MINI GROWTH

```
   A=A        RA=D        L=L       MOT=O        B=B
 HSQ=Q       SPM=P      AEL=E      SRPM=R      SCPM=C

  150.00M    200.00M    250.00M    300.00M    350.00M AD
  5.000T     6.250T     7.500T     8.750T     10.000T L
  0.7500     0.8750     1.0000     1.1250     1.2500  O
  0.000T     20.000T    40.000T    60.000T    80.000T B
  0.8250     0.8750     0.9250     0.9750     1.0250  Q
  .20000     .30000     .40000     .50000     .60000  P
  40.000     50.000     60.000     70.000     80.000  E
  10.000M    25.000M    40.000M    55.000M    70.000M RC
```



SIMULATION #1: INFRAME GROWTH

An increase in Mainframes implies an increase in total installations service by Honeywell. In this case, total installations serviced raises the service requirement which influences three areas:

1] Revenue increases due to a greater number of installations serviced;

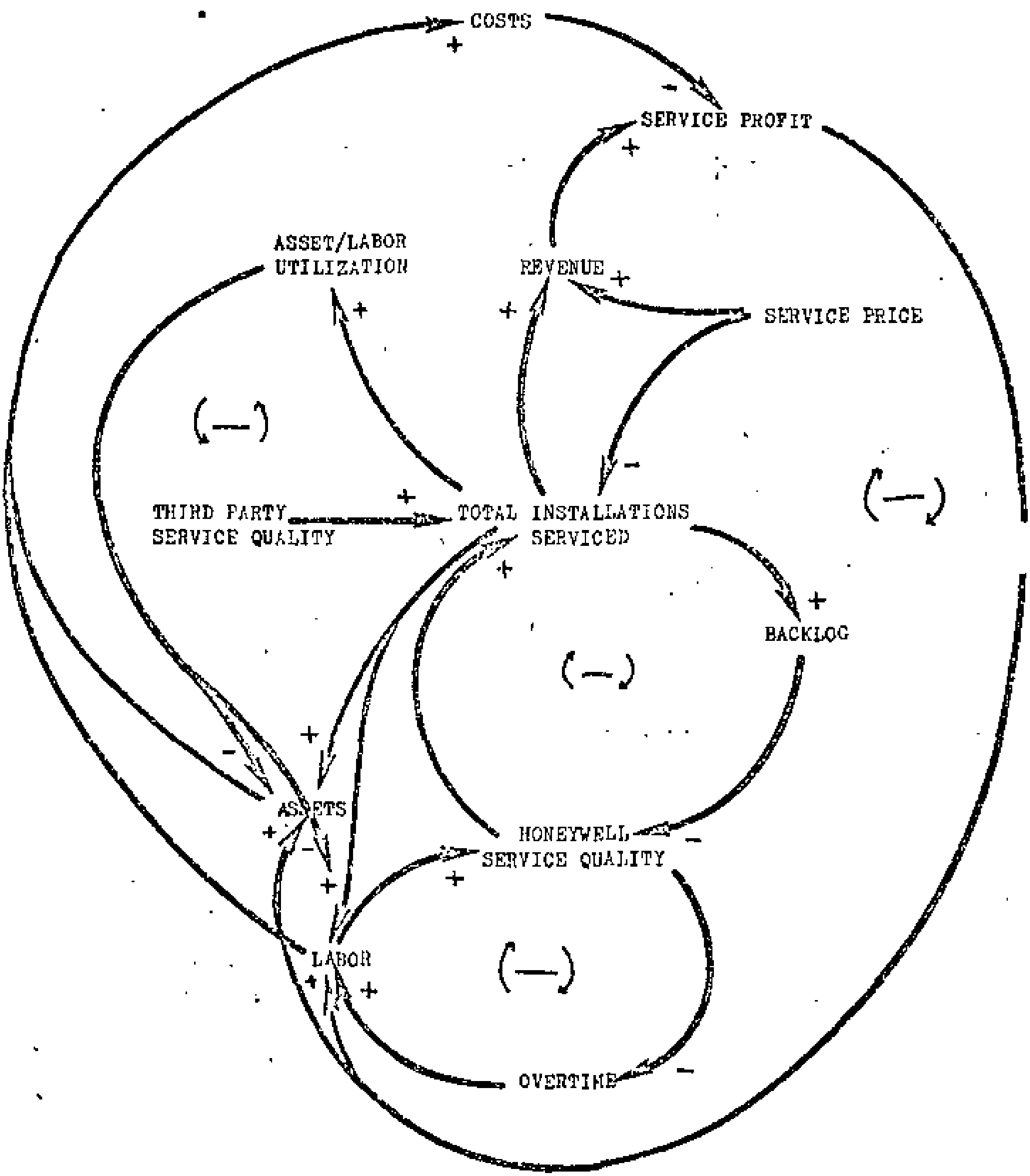
2] Backlog of service calls increases also for the same reason;

3] Required Assets and Labor rises as well.

Overtime increases due to a lag in the aquisition of Labor and Assets. It is necessary to both make up for deficiencies in Labor and to compensate for the decrease in Labor productivity that insufficient Assets causes. Service Profit Margin increases during this same period on account of this aquisition lag as well. Since expenses do not keep pace with the increase in Revenue, a greater Profit Margin is realized.

Honeywell Service Quality decreases because the greater Backlog imposes an increased service requirement upon the Service Division, but again due to lags in aquisition, Assets and Labor are not maintained at required levels. Consequently, Service Quality fall s.

Overtime and Service Quality are plotted as mirror images of one another. This outcome is not suprising since they are linked by a directly by an inverse relationship, a negative causal link. Both are representative of the overall state of the organization. Asset and Labor Utilization, Average Experience of Labor, Backlog of service calls, and Required Labor and Assets all directly feed into Service Quality and Overtime (see Causal Loop Diagram).



CAUSAL LOOP DIAGRAM

3.2 Simulation #2: Minicomputer Growth

The focus of this study deals with Mini-Computer growth and the potential problems which such growth may create. We have assumed a fairly rapid doubling time for mini installations in the market of approximately 15 to 25 months. The Reseller growth has been purposely differentiated from Honeywell by its tendency to increases at a faster rate.

Mini-Computer growth can be divided into two distinct regions:

1] <60 months - approximate linear growth;

2] >60 months - clearly exponential growth.

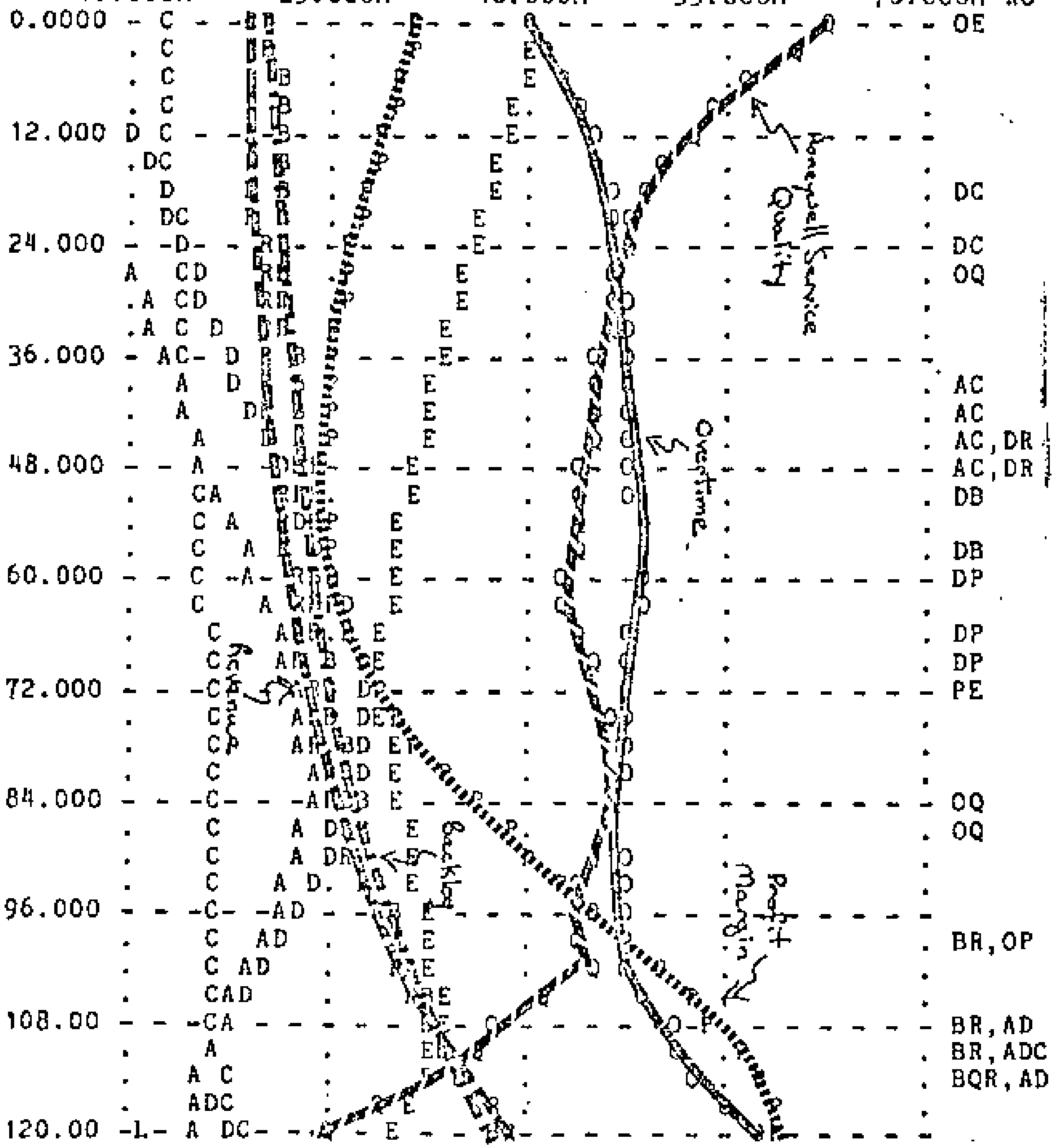
Exponential growth is present all the time, but for the first half of the simulation it's approximately linear. As the number of Honeyell Mini Installations increases, growth increases as well. This result is due to a positive feedback loop in which the growth of installations is dependant upon the total number of installations! As they increase, the loop becomes much stronger and exhibits clear exponential behavior which until then has remained rather hidden.

Service Profit Margin initially declines because minis, during their early stage of growth, are not as profitable to service as mainframes. As growth continues, utilization of Assets and Labor increases. Therefore, Profit Margin rises due to the lowering of Service Cost per installation serviced.

The aquisition lag for Labor and Assets is present in this case as well, but it is not a dominating effect. The change in Utilization due to service volume has a much more direct impact upon profits and service quality than does the aquisition lag.

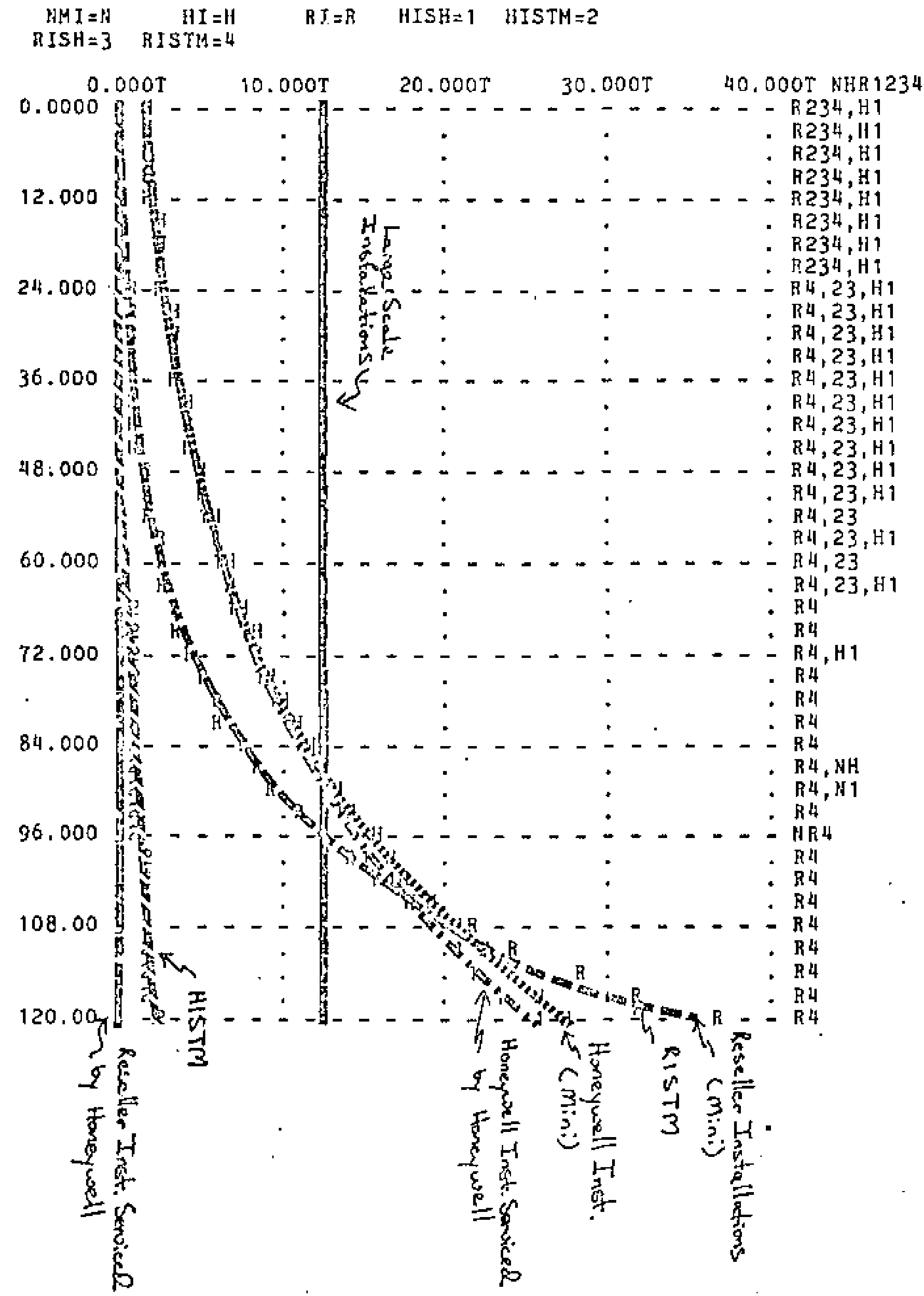
P- 8 RUN-TEST#6 HONEYWELL CUSTOMER SERVICE DIVISION 05/15/82

A=A	RA=D	L=L	MOT=O	B=B	
HSQ=Q	SPM=P	AEL=E	SRPM=R	SCPM=C	
150.00M	200.00M	250.00M	300.00M	350.00M	AD
5.000T	6.250T	7.500T	8.750T	10.000T	L
0.7500	0.8750	1.0000	1.1250	1.2500	O
0.000T	20.000T	40.000T	60.000T	80.000T	B
0.8250	0.8750	0.9250	0.9750	1.0250	Q
.20000	.30000	.40000	.50000	.60000	P
40.000	50.000	60.000	70.000	80.000	E
10.000M	25.000M	40.000M	55.000M	70.000M	RC



SIMULATION #2. MINI-COMPUTER GROWTH

P- 12 RUN-TEST#6 TEST#6: MINI GROWTH



SIMULATION #2: MINI COMPUTER GROWTH

Service Quality and Overtime again move in opposite directions as they did in mainframe growth. This result makes sense. A decline in Quality is most often caused by a deficiency in Labor or/and Assets. As Quality deteriorates, Overtime is steps up in order to counteract any downward movement as much as possible.

3.3 Simulation #3: Establishing a Reference Mode - Combined Growth

We combine mainframe and mini growth together in persuit of a meaningful reference mode. At this time Honeywell is not servicing any reseller installations. We will use this mode as a point of reference from which to evaluate alternative policies.

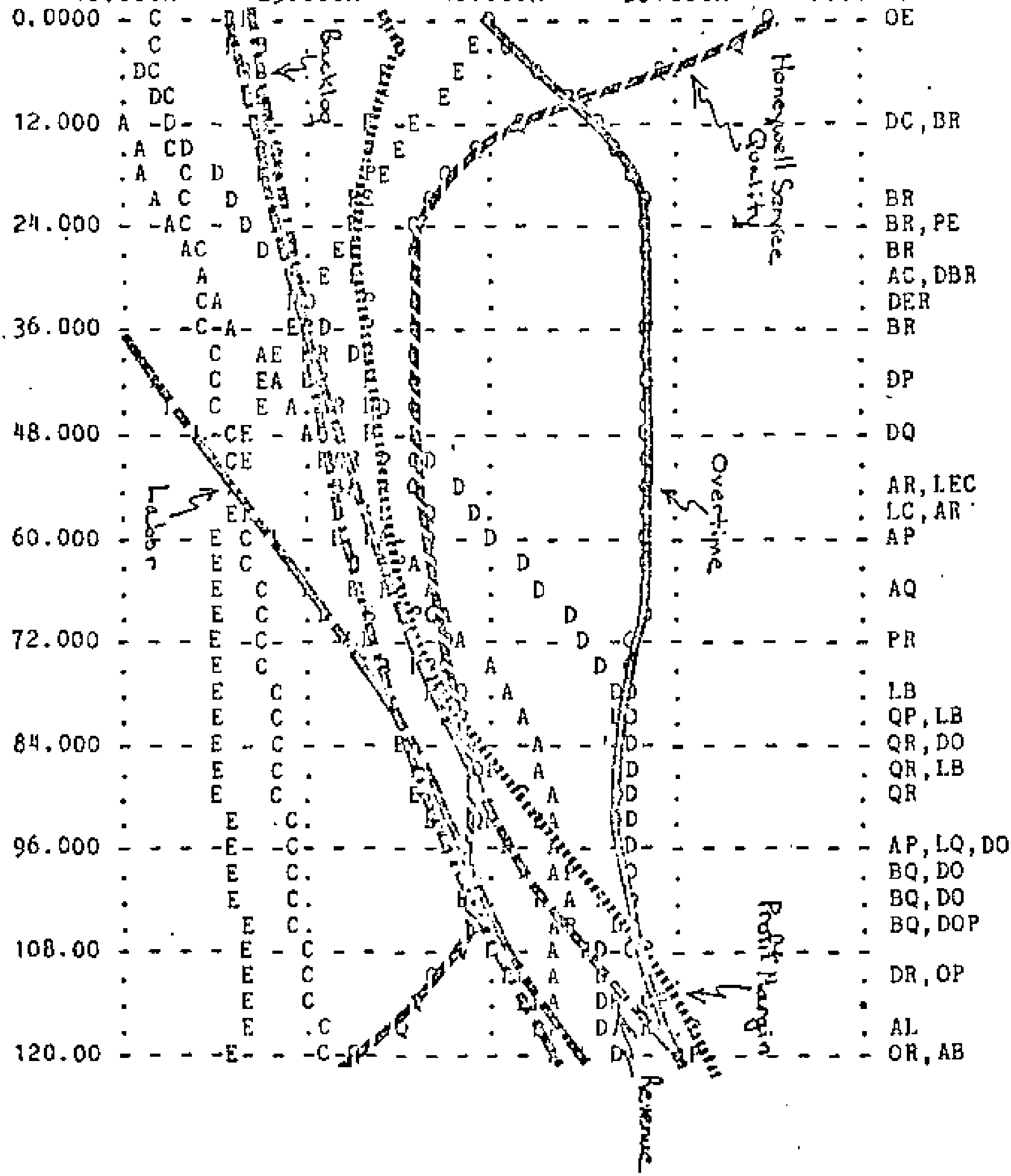
Superposition seems to apply to combined growth, although not absolutely. Overtime, Service Quality, Profit Margin, etc. possess a composite of behavioral characteristics from Simulations #1 and #2. Each of the two types of installations contribute to the overall Service Division behavior according to their relative size. As Mini Installations Serviced by Honeywell increases, then minis will have a greater impact on total behavior. The superposition effect is weighted according to the relative size of the respective installations.

There is a distinct change in the behavior of Labor, Overtime, Service Quality, and Profit Margin circa month 60. At this time more favorable Asset and Labor Utilization is realized. This unambiguous change in utilization has profound effects throughout the system. Utilization

P- 7 RUN-TEST#1 TEST#1: LARGE SCALE AND MINI GROWTH - HONEYWELL CS

A=A	RA=D	L=L	MOT=O	B=B
HSQ=Q	SPM=P	AEL=E	SRPM=R	SCPM=C

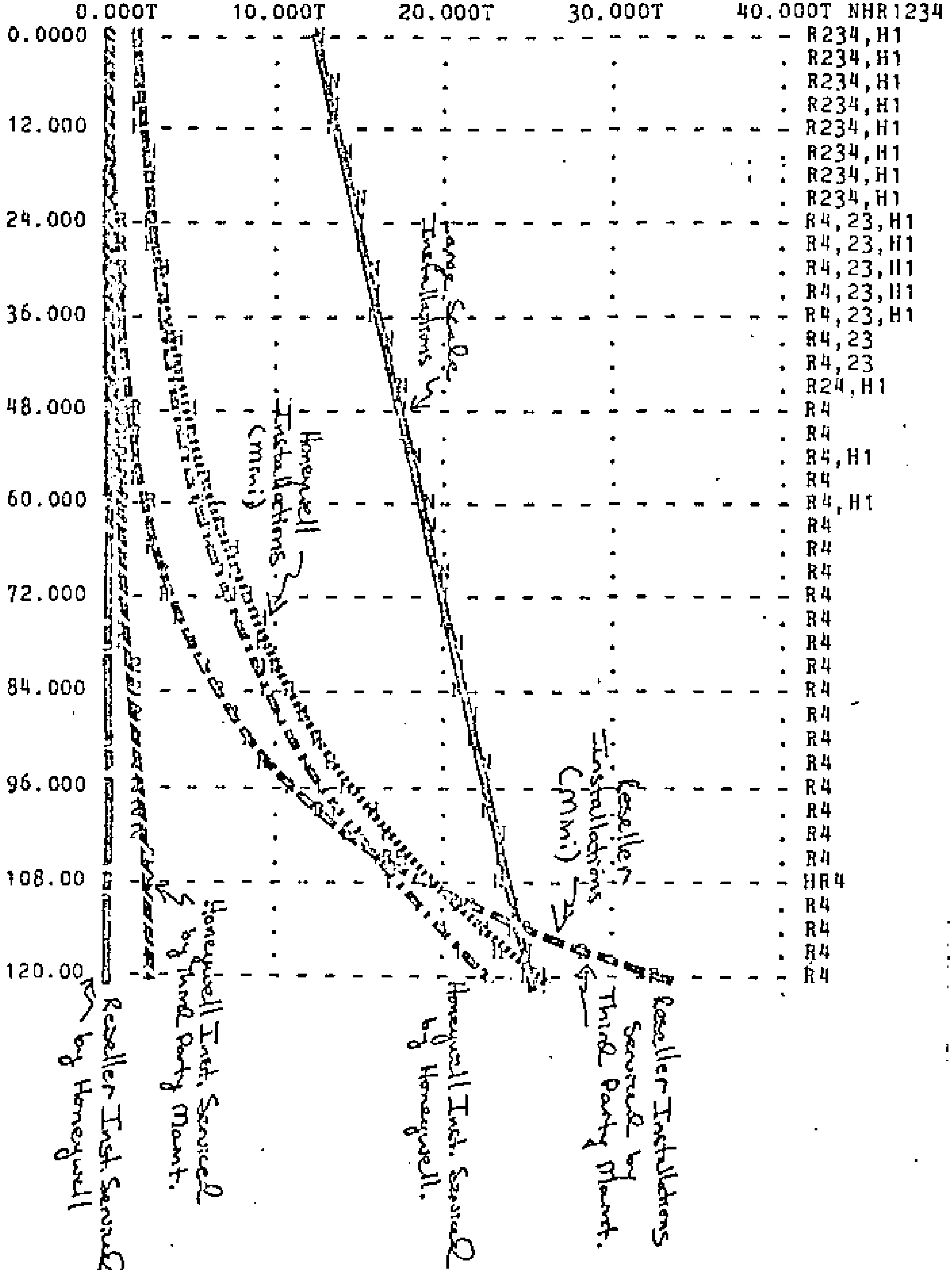
150.00M	200.00M	250.00M	300.00M	350.00M	AD
5.000T	6.250T	7.500T	8.750T	10.000T	L
0.7500	0.8750	1.0000	1.1250	1.2500	O
0.000T	20.000T	40.000T	60.000T	80.000T	B
0.8250	0.8750	0.9250	0.9750	1.0250	Q
.20000	.30000	.40000	.50000	.60000	P
40.000	50.000	60.000	70.000	80.000	E
10.000M	25.000M	40.000M	55.000M	70.000M	RC



SIMULATION #3: COMBIN MINI AND MAINFRAME GROWTH

P- 8 RUN-TEST#1 TEST#1: LARGE SCALE AND MINI GROWTH - HONEYWELL CS

NMI=N HI=H RI=R HISH=1 HISTM=2
RISH=3 RISTM=4



SIMULATION #3: COMBINED MINI AND MAINFRAME GROWTH

1] Honeywell service 75 percnet of subsequent reseller Mini-Computer Installations;

2] Implementation of Man-In-The-Van Program in order to raise Service Quality and reduce Service Cost;

3] Implementation of discount price policy to resellers of 15 percent in order to encourage reseller growth;

4] Reduction in Third Party Maintainers' Service Quality by 25 percent.

It is not totally clear whether or not any of these policies will benefit or impair Honeywell Service Quality, Service Profit, or Mini-Computer growth in the long run.

4.2 Simulation #4: Service Policy Toward Reseller

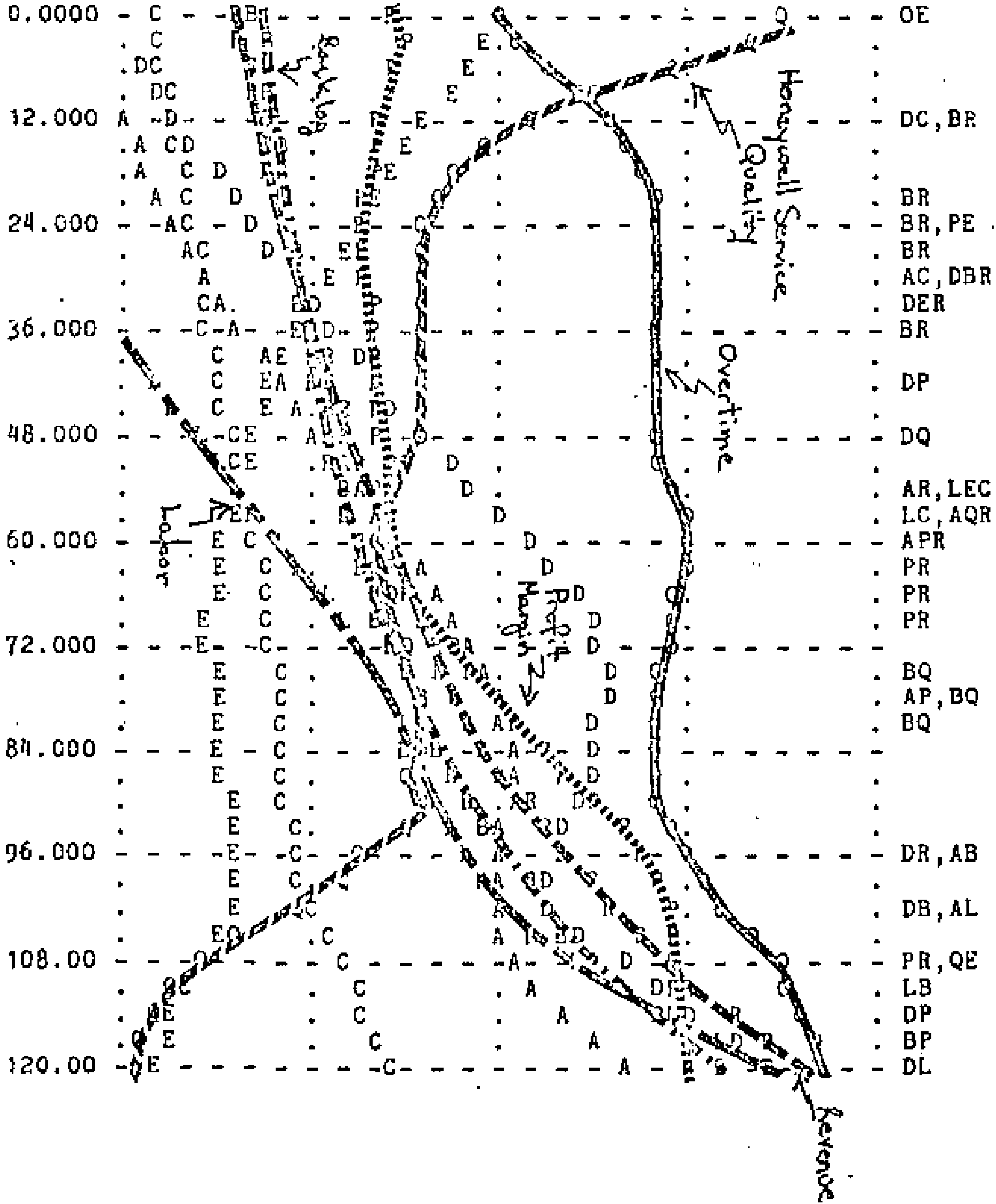
The purpose of this policy test is to determine the consequences for Honeywell of aggressive pursuit of reseller service contracts. We assumed the reference growth mode, and then added the condition that Honeywell will service 75 percnet of all subsequent reseller sales.

There is no change in behavior up until month 48 because the level of reseller installations is small and growth is slow. Profit Margin increases faster than the inital growth case because the number of installations which Honeywell is obligated to service is increasing faster. Therefore Utilization increases at a swifter rate. Profit Margin and Utilization both saturate sooner also on account of augmented growth.

P- 11 RUN-TEST#2 TEST#2: GROWTH & SERVICE POLICY FOR RESELLER 75%

A=A	RA=D	L=L	MOT=O	B=B
HSQ=Q	SPM=P	AEL=E	SRPM=R	SCPM=C

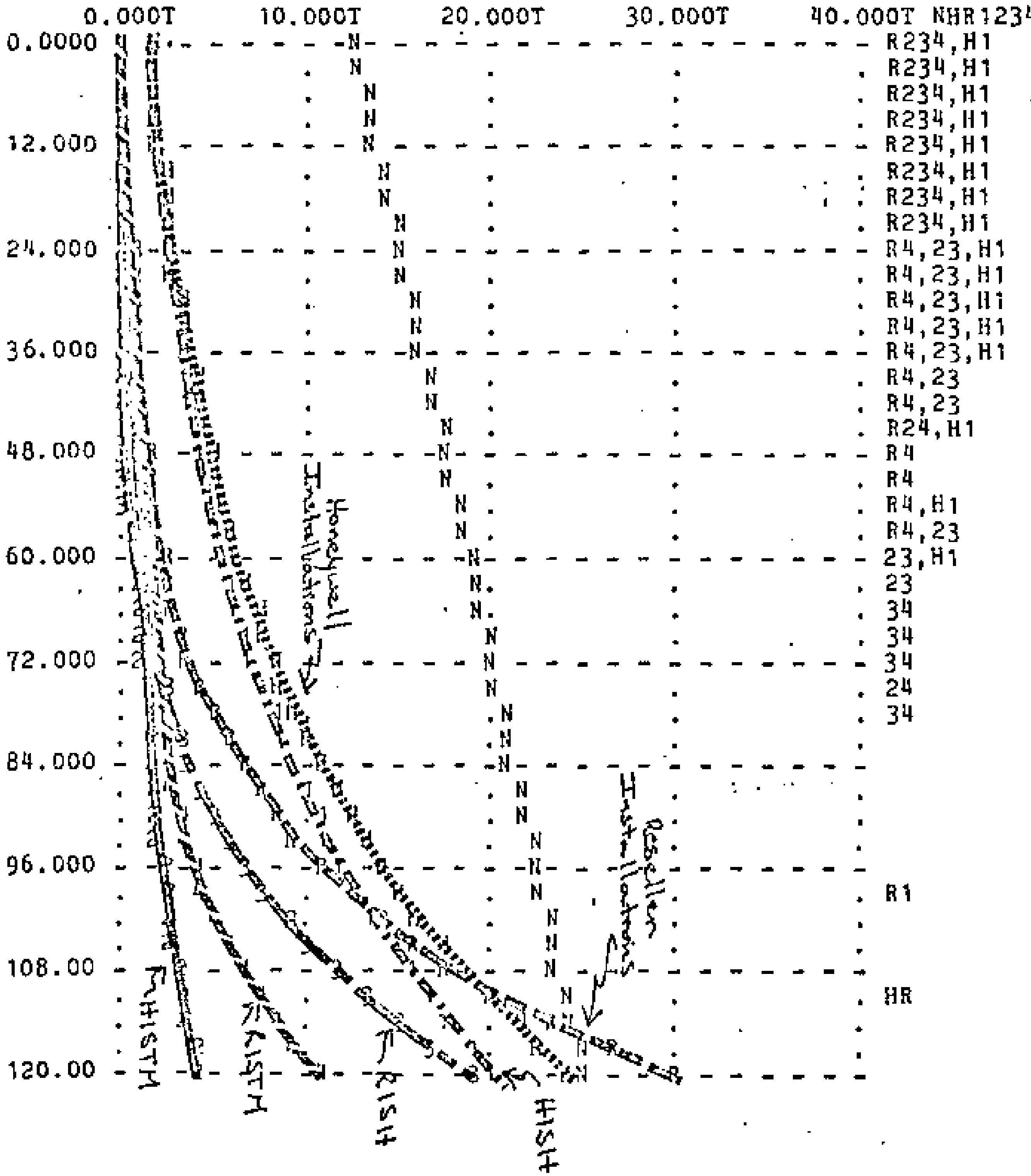
150.00M	200.00M	250.00M	300.00M	350.00M	AD
5.000T	6.250T	7.500T	8.750T	10.000T	L
0.7500	0.8750	1.0000	1.1250	1.2500	O
0.000T	20.000T	40.000T	60.000T	80.000T	B
0.8250	0.8750	0.9250	0.9750	1.0250	Q
.20000	.30000	.40000	.50000	.60000	P
40.000	50.000	60.000	70.000	80.000	E
10.000M	25.000M	40.000M	55.000M	70.000M	RC



SIMULATION #4: SERVICE PO / TOWARD RESELLERS AT 75 PERCENT

P- 12 RUN-TEST#2 TEST#2: GROWTH & SERVICE POLICY FOR RESELLER 75%

NHI=N HI=H RI=R HISH=1 HISTM=2
RISH=3 RISTM=4



SIMULATION #4; SERVICE POLICY TOWARD RESELLERS AT 75 PERCENT

As a consequence of Utilization saturating sooner than in the reference mode, there is less flexibility within the system to be able to meet an increasing demand to service installations. Service Quality therefore declines, and Overtime exceeds its previous levels. Because Overtime is more expensive than ordinary labor, Profit Margin decreases below its comparable value for reference growth. Revenue increases by 5 percent.

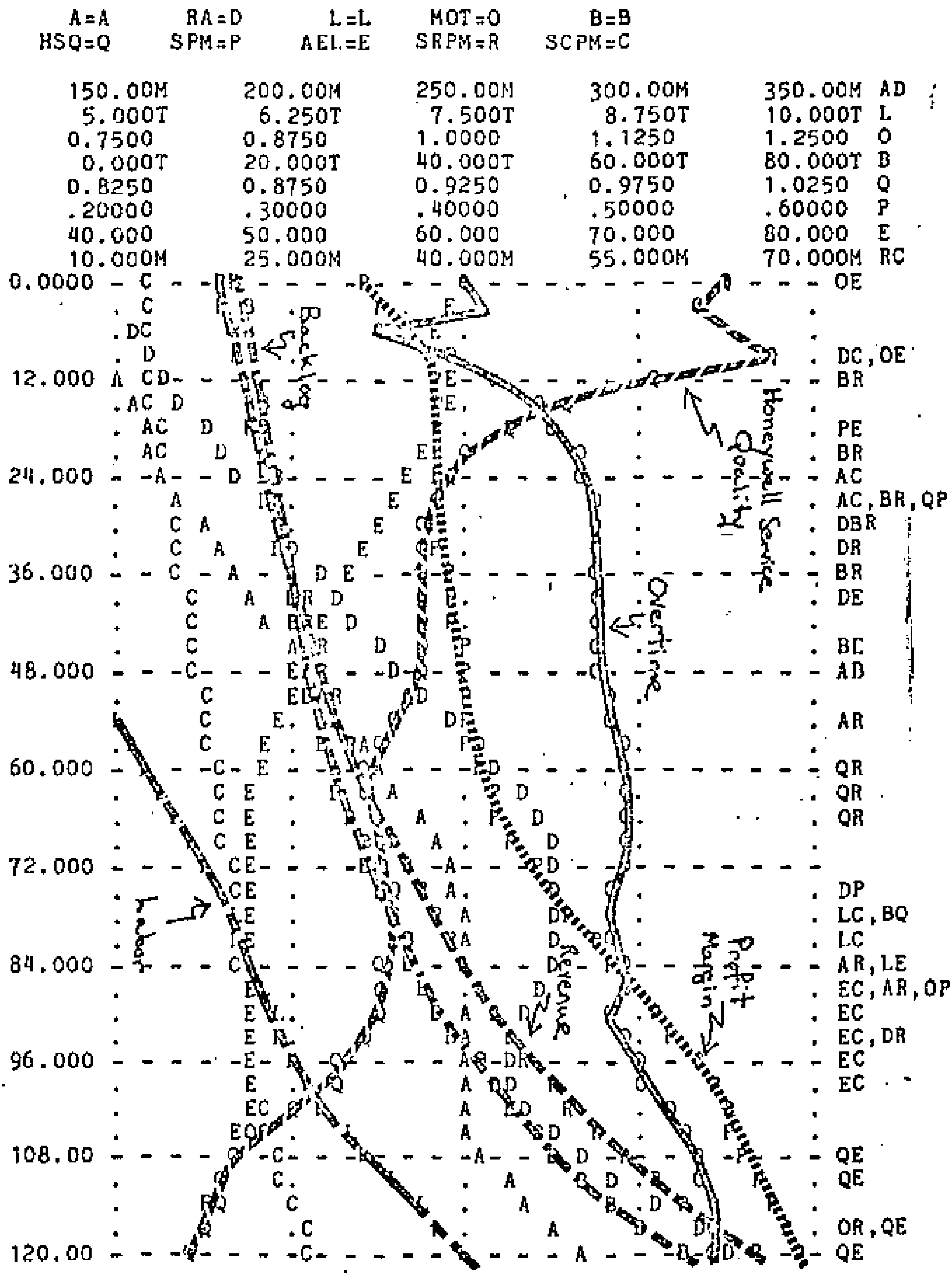
Accumulated Profit over the entire simulation is 10 percent higher than with ordinary growth. This increase is due to higher overall Revenues. Service Qulaity declines to lower values than ever before because the growth of service contracts is higher than previously. The greater the rate of growth of Total Installations Serviced, the lower Service Quality will fall. There is a "give-and-take" between Revenue and Service Quality. An increase in installations forces Revenue up, but at the same time it drives Service Quality down. The optimal course would steer between these two option in order to maximize total profit over time.

Although during reference growth Honeywell does make a 300 percent profit on spares which are sold to resellers and third party maintainers, a much greater Profit and Revenue is realized when the maintenance is performed by Honeywell directly.

4.3 Simulation #5: Man-In-The-Van Program

It looks as though the previous Service Policy for Resellers may be a favorable policy to enact; although Accumulated Profit and Revenue is

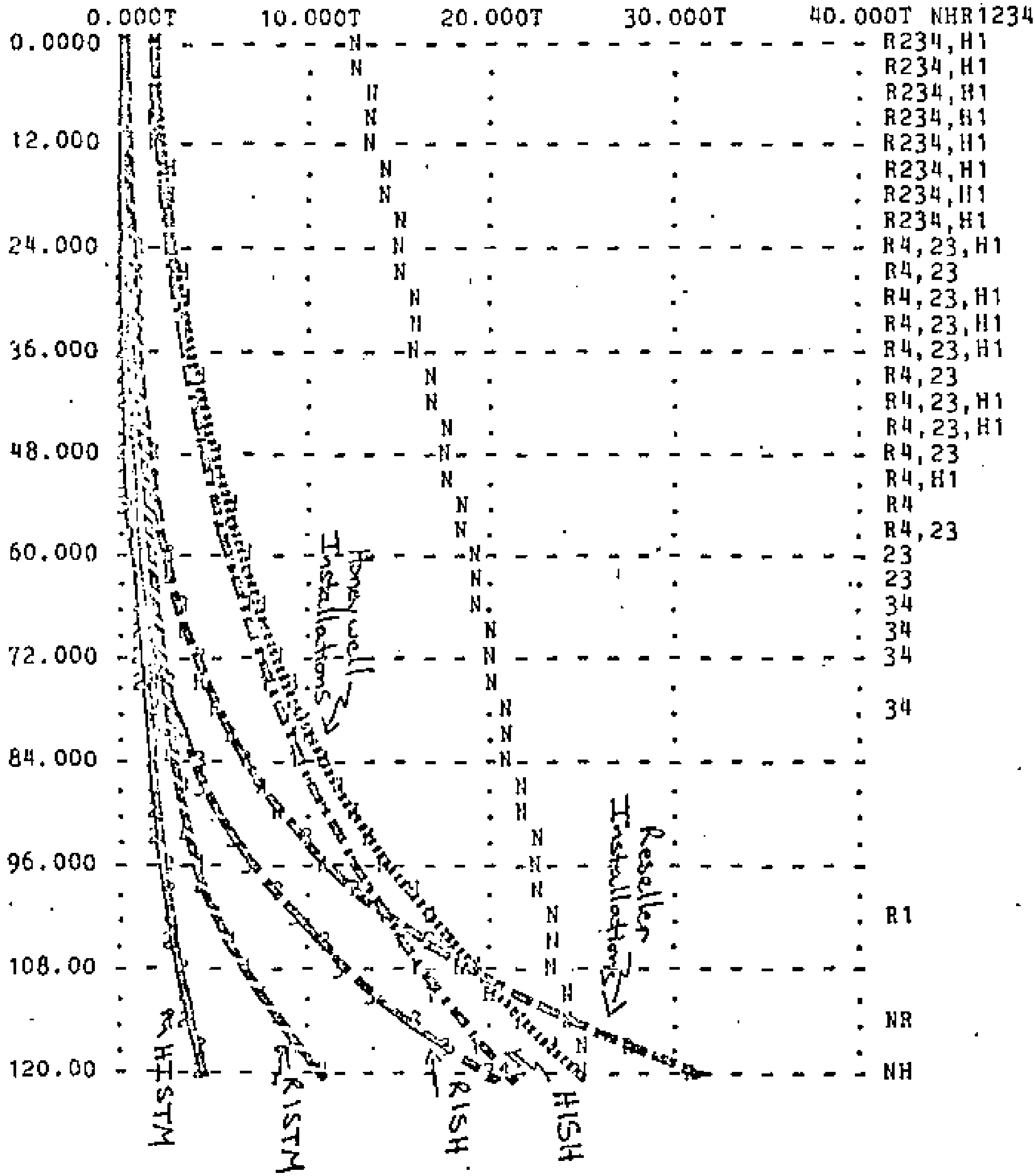
P- 15 RUN-TEST#3 TEST#3: GROWTH, SPR=75%, & MAN-IN-VAN PROGRAM



SIMULATION #5: IN-THE-VAN PROGRAM

P- 16 RUN-TEST#3 TEST#3: GROWTH, SPR=75%, & MAN-IN-VAN PROGRAM

NMI=N HI=H RI=R HISH=1 HISTM=2
RISH=3 RISTM=4



SIMULATION #5: MAN-IN-VAN PROGRAM

up, Service Quality erodes. We will test the consequences of implementing the Man-In-The-Van program in addition to the reseller policy. This policy increases the productivity and effectiveness of field Labor. Therefore, it may affect Service Quality.

We immediately discover upon performing the simulation that the resultant behavior is quite on the contrary to what we might have had expected. Almost all behavior remains unchanged. The Man-In-the-Van does not improve Service Quality over the long run because it allows for the reduction of Labor which has exactly the opposite effect upon quality.

Since this policy reduces the Required labor, it decreases the Cost per Installations Serviced. Also, the percentage of Overtime is the same, but the actual number of Overtime hours is reduced because the Labor force is smaller due to increased productivity. This decline in hours of Overtime reduces cost as well. The decrease in expenses logically increases Profit Margin while Service Quality et alia remains unaffected.

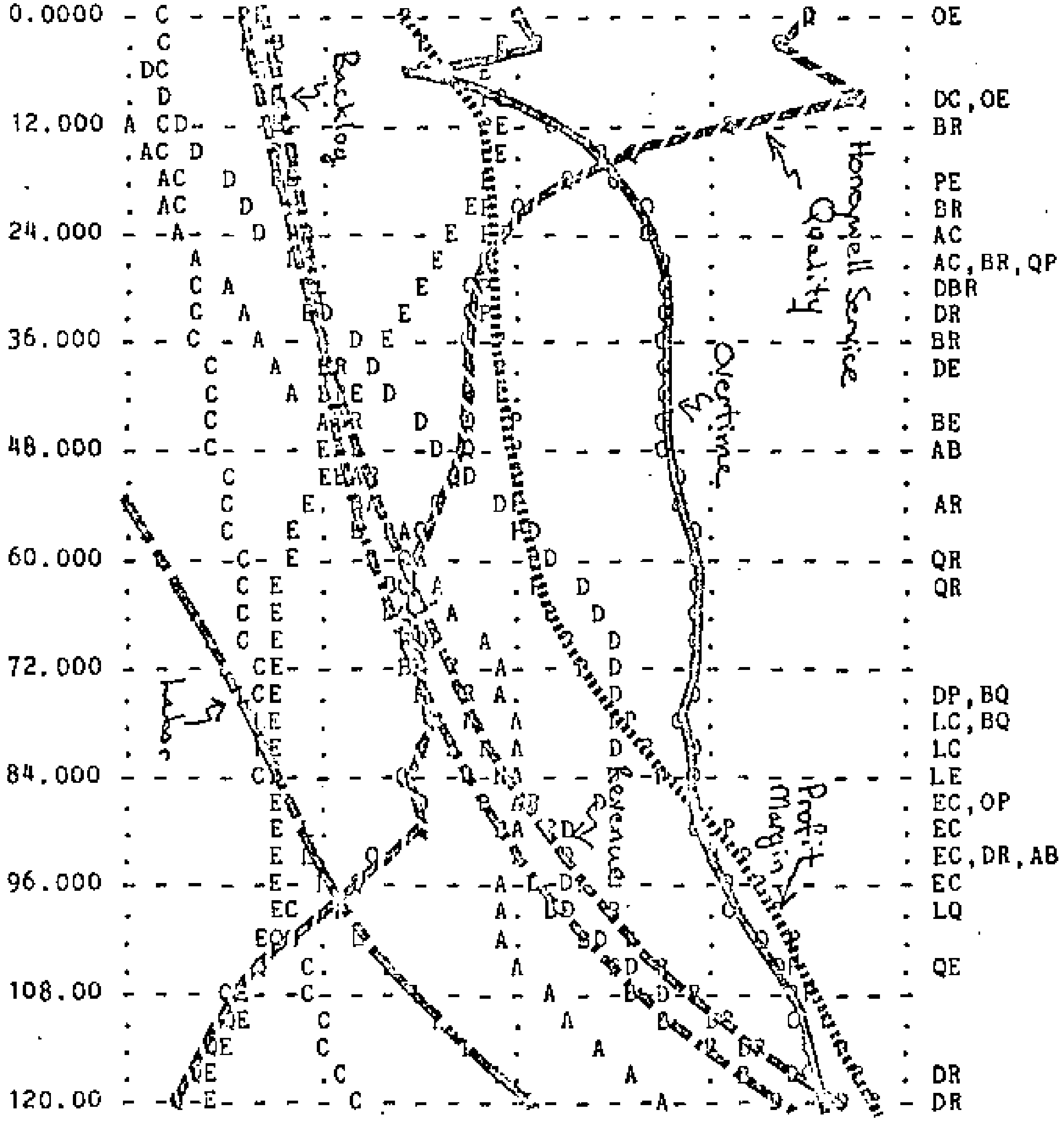
4.4 Simulation #6: Discount Price Policy of 15 Percent Toward Resellers

The introduction of a discount price policy toward resellers has been proposed as a means of encouraging reseller growth. The uncertainty surrounding this policy is whether or not the Revenue lost by the Price decrease can be made up by an increase in sales, and what the impact upon Service Quality and overall Market growth in the long run will be. We hav imposed a discount policy of 15 percent in addition to two policies which were tested in the previous simulation in order to see their cumulative effect.

P- 19 RUN-TEST#4 TEST#4: GROWTH, SPR=75%, MAN-IN-VAN, & DISC. PRICE

A=A	RA=D	L=L	MOT=O	B=B
HSQ=Q	SPM=P	AEL=E	SRPM=R	SCPM=C

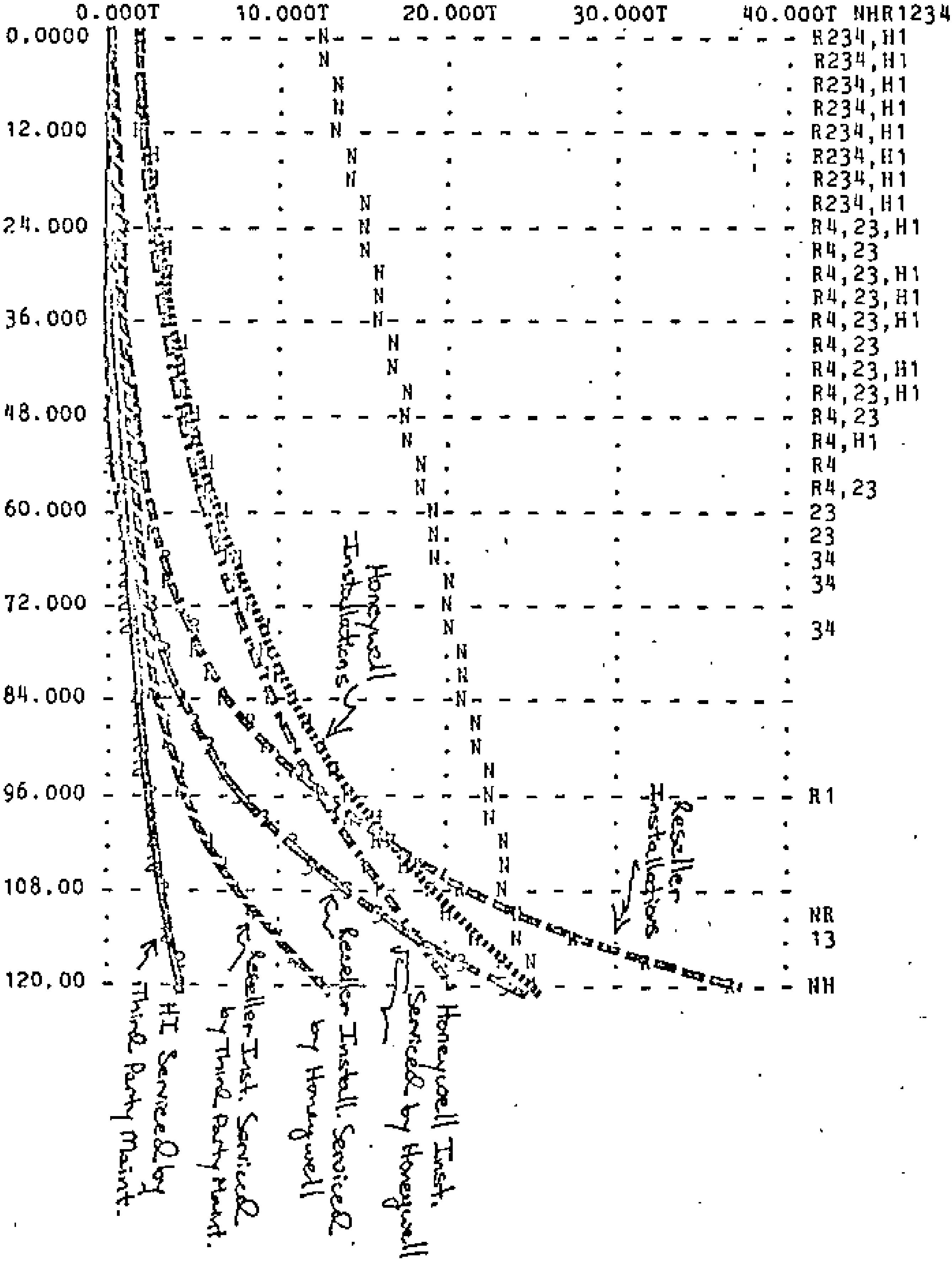
150.00M	200.00M	250.00M	300.00M	350.00M	AD
5.000T	6.250T	7.500T	8.750T	10.000T	L
0.7500	0.8750	1.0000	1.1250	1.2500	O
0.000T	20.000T	40.000T	60.000T	80.000T	B
0.8250	0.8750	0.9250	0.9750	1.0250	Q
.20000	.30000	.40000	.50000	.60000	P
40.000	50.000	60.000	70.000	80.000	E
10.000M	25.000M	40.000M	55.000M	70.000M	RC



SIMULATION #6: DISCOUNT PRICE-POLICY OF 15 PERCENT FOR RESELLERS

P- 20 RUN-TEST#4 TEST#4: GROWTH, SPR=75%, MAN-IN-VAN, & DISC. PRICE

NMI=N HI=H RI=R HISH=1 HISTM=2
RISH=3 RISTM=4



SIMULATION #6: DISCOUNT PRICE POLICY OF 15 PERCENT FOR RESELLERS

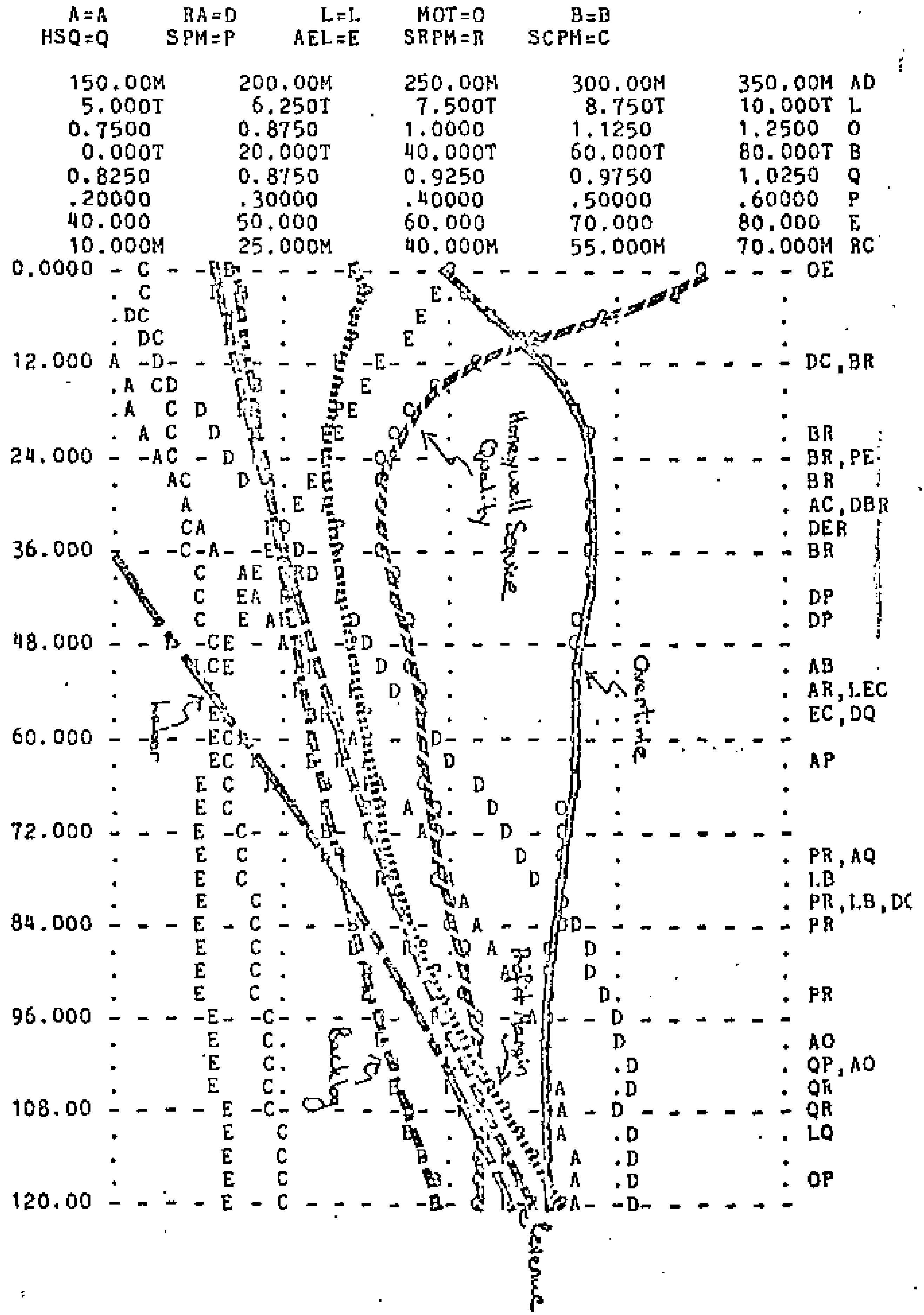
The net effect on Service Division behavior is not very great. Service Profit Margin declines slightly due to a decrease in Revenue per Installation Serviced, but Revenue remains basically unchanged. Although Price per sale is down, the number of sales is up to compensate for a loss in Revenue. Accumulated Profit over the time of simulation decreases by a mere 1 percent (not a very significant change).

Discount Prices to resellers do not seem to affect the overall Profit structure of the organization. The result which the policy undoubtedly achieves is encouraging reseller growth. Service Quality decreases due to the increases in volume, but growth is not very sensitive to such a small decline in Service Quality at this point. The reinforcing (positive feedback) character of growth is very strong toward the latter half of the simulation.

4.5 Simulation #7: Decline in Third Party Maintainer Service Quality

This test was performed in order to see the importance of Third Party and Reseller Service Quality upon the Service Division. We have only assumed the reference growth mode plus this decrease in quality.
Initially, it may be expected that Third Parties do not have that much of an effect upon the behavior of the Service Division itself, but as the size of installations serviced by TPM grows in relation to those service by Honeywell, then TPM Service Quality has a much greater effect.

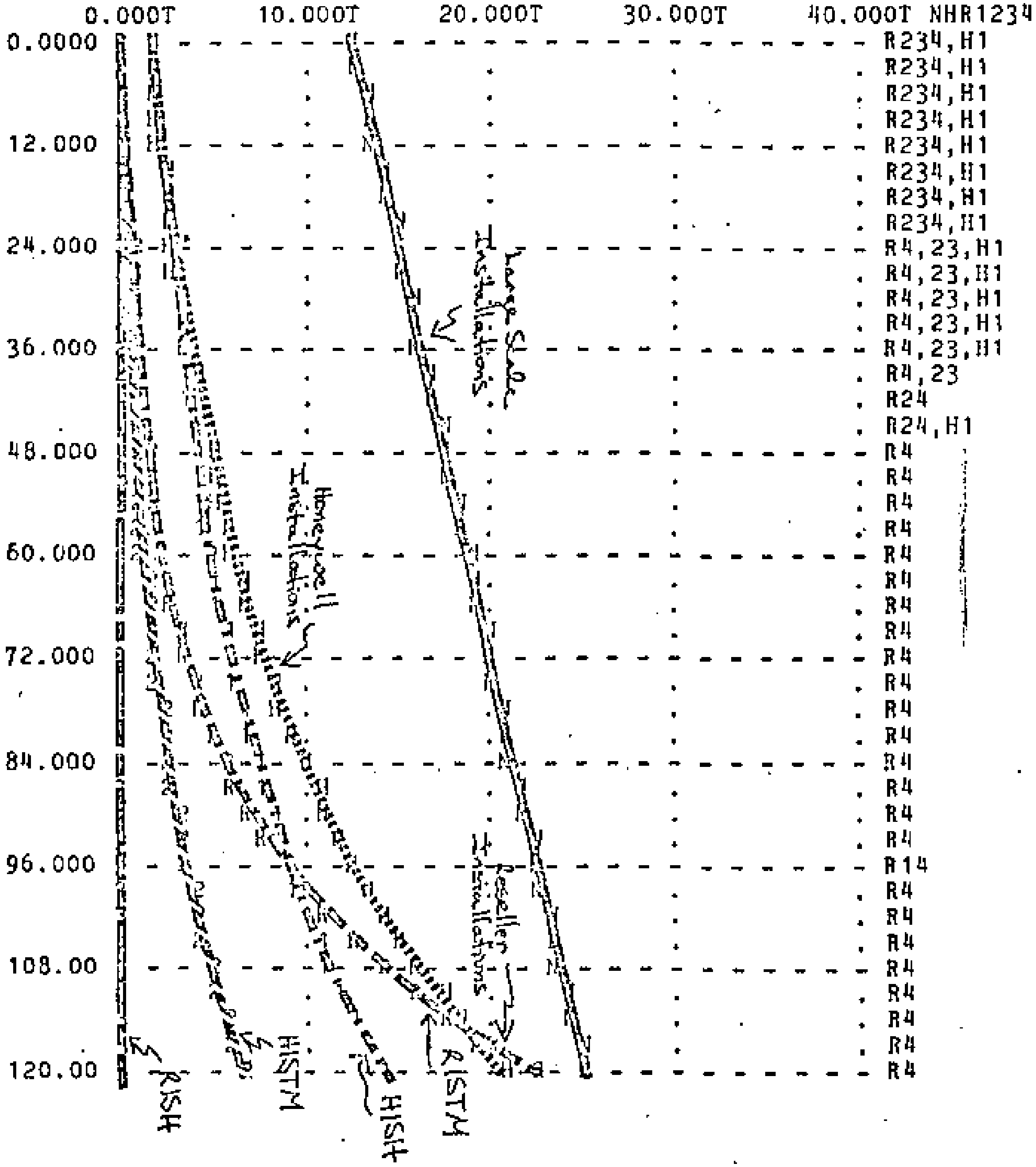
P- 20 RUN-TEST37 TEST#7: GROWTH PLUS THIRD PARTY MAINT. SERVICE QUA



SIMULATION #7: DECLINE OF 25 PERCENT IN THIRD PARTY SERVICE QUALITY

P- 21 RUN-TEST37 TEST#7: GROWTH PLUS THIRD PARTY MAINT. SERVICE QUA

NMI=N HI=H RI=R HISH=1 HISTM=2
RISH=3 RISTM=4



SIMULATION #7: DECLINE OF 25 PERCENT IN THIRD PARTY SERVICE QUALITY

The decrease in TPM Service Quality results in a generally perceived decline of Honeywell Service Qualtiy. Growth is impaired. Utilization of Labor and Assets does not approach saturation as it would otherwise have done. A higher Service Profit Margin is not realized on account of the lack of improvement in Utilization. Honeywell Service Quality increases, and inversely Overtime decreases due to the slower rate of overall growth.

It seems as though Honeywell Customer Service Division and the Marketplace may be very sensitive to TPM Service Quality. We are left with a paradoxical situation:

- When TPM Service Quality is high, Honeywell stands a chance of losing service contracts to TPM and resellers;
- When TPM Service Quality is ailing, its association with the Honeywell name tends to cause Honeywell to lose service contracts anyhow.

In our opinion it is more important for TPM Service Quality to remain high in order to assure growth, than it would be to discourage TPM competition. The benefits of greater Utilization which is afforded by growth far outweighs the disadvantages of Third Party competition.

TABLE # 1

SHORT RUN (1983)

	TEST # 3 GROWTH	TEST # 4 SPR=.75	TEST # 5 4 & MIV	TEST # 6 5 & DPPR	TEST # 7 TPMSQ=.75
ASSETS (M$)	222	222	225	225	220
LABOR	6000	6031	5243	5244	5941
HI (MINI)	6194	6192	6316	6316	5963
RI (MINI)	2207	2206	2279	2344	2072
HSD (MINI)	5427	6165	6428	6476	4795
TMMH (MINI)	8401	8397	8595	8660	8035
HSQ	90%	89%	90%	90%	92%
SPM (%)	34	34	41	41	35
PROFIT (M$/m)	10	10	12	13	10
REVENUE (M$/m)	30	31	31	31	30
ACCUMULATED PROFIT (M$)	485	485	563	563	485
ACCUMULATED REVENUE (M$)	1447	1450	1455	1454	1443

TABLE 5.1

CROP MIX (1993)

	TEST # 3 RECORD	TEST # 4 SEPT.-76	TEST # 5	TEST # 6	TEST # 7
ACREAGE (HA)	222	222	[illegible]	[illegible]	[illegible]
LABOR	6000	[illegible]	[illegible]	[illegible]	[illegible]
HL (HIRE)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HL (MIN)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] (HRS)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] (MTN)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PROFIT (Rs/ha)	10	10	12	[illegible]	10
[illegible] (Rs/ha)	30	[illegible]	[illegible]	[illegible]	30
ACTUAL NET PROFIT (Rs)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] (Rs)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE # 2

LONG RUN (1988)

	TEST # 3 GROWTH	TEST # 4 SPR=.75	TEST # 5 4 & MIV	TEST # 6 5 & DPPR	TEST # 7 TPMSQ=.75
ASSETS (M$)	266	282	284.	288	289
LABOR	8104	9290	7527	7615	7956
MI (MINI)	25,509	24,298	24,854	24,773	20,548
RI (MINI)	32,329	29,823	30,964	36,389	22,585
HSD (MINI)	22,774	39,154	40,577	43,947	13,993
TMMH (MINI)	57,838	54,121	55,819	61,162	43,133
HSQ	88%	83%	85%	84%	93%
SPM (%)	50	50	59	58	47
PROFIT (M$/m)	27	32	38	39	22
REVENUE (M$/m)	54	63	65	65	48
ACCUMULATED PROFIT (M$)	1,517	1,656	1,922	1,904	1,392
ACCUMULATED REVENUE (M$)	3,861	4,069	4,099	4,092	3,708

5. CONCLUSIONS

The basic problem with servicing minicomputers with the present organization of the CSD is that minis are not as profitable as the large scale systems which have been the traditional market. Even so, it is possible to make a good business out of it. It is necesary to reduce cost, and that can be done by reducing the service requirements per installation, particullarly in terms of labor, or by increasing the number of installations serviced which would increase Utilization.

5.1 Recommendations from Model Analysis

The most important recomendations of the analysis are:

-Servicing reseller installations improves business through increased volume and reduced service cost per installation. It generates higher revenue and profit margin, but creates problems in keeping service quality at a high level during times of rapid growth. The way to implement this policy would be to sell the equipment to the reseller under the condition that it will be serviced by Honeywell, so at the time of sale, he should sell the equipment with a CSD service contract. It is not necesary that all computers are serviced by CSD, so if this restriction is valid for areas in which CSD already has an office, the proportion to be serviced could be high, without representing a big increase in the operating cost. The reseller can use the Honeywell name to back up his sales, and CSD can get more customers without any additional marketing effort.

-High rates of growth create pressure on the system to keep a high level of Service Quality. The greater the rate of growth, the lower the Service Quality. Because in many cases there is a tendency to behave very conservatively, particularly for hiring and investing for future requirements, the system tends to have a persistent shortage of assets and labor. The problems caused by these shortages are exacerbated during periods of exponential growth. The main result is low Service Quality which eventually slows growth and encourages customers to change service over to Third Party Maintainers. Although there is a forecasting policy in the model, it is a linear extrapolation of the data (as many organizations do), and it under estimates consistantly the necessary This is a case of a reactive organization rather than a planning organization. The justification for this conservative policy is that it increases profit margin by keeping service costs low.

-Man-in-the-van program proves to be an effective policy to reduce Service Cost and increase Profit Margin, but it does not seem to help raise the level of Honeywell Service Quality. As stated in the first recommendation, any policy that reduces cost per installation is a good policy. The reason that service quality stops improving is the rationale for hiring labor. When the program is implemented, the amount of installations that each field engineer can service is duplicated, and this reduces the need for Labor. The system instead of keeeping an "excess" of labor for future growth and to keep a high service quality, it just reduces the amount of labor according to the new productivity. Behaving as before, but at lower unit service cost, the same problems persist.

-The implementation of discount service price for resellers is a favourable policy to encourage and generate growth. Although discounting prices does reduce revenue, the added growth compensates for such a loss while providing greater sales volume for Honeywell Information Systems as a whole. On the other hand, the reduction is very small and if it is combined with a policy of servicing a certain proportion of reseller installations, reduction in profits can be compensated for.

-The service quality of third party maintainers and resellers has a strong effect upon perceived Honeywell Service Quality within the marketplace. It is necessary that resellers offer high quality service in order to avoid a negative impact upon growth. In the case that third party maintainers may be encouraged through franchices, it is very important that there exists a strong supervision by Honeywell.

5.2 Considerations and Extensions

Some of the results of the model seem to fit very well into with the actual data, although it was never designed to accomplish that purpose. This result creates some confidence about the behavior and structure of the model. Nonetheless, the numerical values of the results should never be considered as forecasts. They are just an indication of the impact that certain policies could have on the system if they are implemented.

The policies tested are programs which are already designed and partially implemented. The results of the model confirm the expectations built from real situations. There are some assumptions that should be further analyzed because they seem to have a big impact on the behavior of the model.

For any continuation of the project, it is necessary that some people within Honeywell learn the details of the model, and its operation, to be able to use it internally. From the discussions of the use of the model, they can come out with the most relevant extensions

The present structure of the model allows to make a large number of tests involving many combinations of policies simulteneusly. They can be from a simple change in service requirement per installation to a more sophisticated variable change in demand for each of the products. This approach should be followed and exhausted before going into more disagregation. The size of the model is large enough to create many problems when modifications are made to it without completely understanding the present version.

During the construction of the model, on several occasions, there were themes that seem to have relevance with the operations of the CSD and that were not included in the model for lack of time and information. It could be very productive to extend the model into such areas as: micro-computers, software development and service, disagregation of labor and assets for minicomputers and non-minicomputers, more detail in the financial sector.

APPENDIX #1 (44)

PURPOSE OF PILOT PROJECT IN SYSTEM DYNAMICS WITH HONEYWELL CSD

A. EXPAND AND CLARIFY IDEAS ABOUT MODELING THE RELATIONSHIPS BETWEEN HONEYWELL CUSTOMER SERVICE DIVISION AND THE MARKET.

B. DEVELOP A PICTURE OF THE ORGANIZATION IN TERMS OF DECISION MAKING PROCESSES.

C. TRANSLATE THE PICTURE OF ORGANIZATIONAL STRUCTURE INTO A SET OF PRECISE MATHEMATICAL EQUATIONS TO BE USED AS A SIMULATION MODEL.

D. EXPLORE THE SHORT- AND LONG-TERM CONSEQUENCES OF POLICY CHANGES IN THE CSD.

E. SEE HOW SYSTEM DYNAMICS CAN BE USED AS A POLICY AND STRATEGY TOOL IN THE ANALYSIS OF CURRENT BUSINESS PROBLEMS.

MOTIVATION FOR STUDY

A. UNPRECEDENTED INCREASE IN SALES OF MINI-COMPUTERS OVER THE NEXT 5 - 10 YEARS WILL NECESSITATE NEW WAYS OF THINKING ABOUT AND PROVIDING SERVICE.

B. DIFFERENT COST AND PROFIT STRUCTURE ASSOCIATED WITH THE INCREASING SERVICE OF MINIS AS OPPOSED TO MAINFRAMES.

C. UNCERTAINTY TOWARD ENCOURAGING FURTHER RESELLER AND THIRD-PARTY MAINTENANCE OF HONEYWELL EQUIPMENT.

D. EXPERIMENTATION WITH NON-TRADITIONAL FORMS OF MAINTENANCE FOR MINIS.

MODEL TESTING #6

SIMULATION #1: MAINFRAME GROWTH

ASSUMPTIONS: A. MATURING LINEAR GROWTH OF LARGE SCALE INSTALLTIONS FROM 12,500 IN 1978 TO 25,000 TEN YEARS LATER.

RESULTS: A. SERVICE CALLS INCREASE DUE TO INCREASE IN INSTALLATIONS.

B. OVERTIME AND PROFIT MARGIN INCREASE DUE TO LAG IN AQUIRING LABOR AND ASSETS.

C. HONEYWELL SERVICE QUALITY DECREASES DUE TO INCREASE INSTALLATIONS AND LAG IN AQUIRING ASSETS AND LABOR.

D. OVERTIME AND SERVICE QUALITY ARE MIRROR IMAGES OF ONE ANOTHER. THEY BOTH ARE REPRESENTATIVE OF THE OVERALL STATE OF THE ORGANIZATION: -ASSET & LABOR UTILIZATON
-AVERAGE EXPERIENCE OF LABOR
-BACKLOG OF SERVICE CALLS
-REQUIRED LABOR AND ASSETS

SIMULATION #2: MINI-COMPUTER GROWTH . . . (42)

ASSUMPTIONS: A. GROWTH IN HONEYWELL AND RESELLER INSTALLATIONS WHERE PERCENTAGE OF RESELLER GROWTH IS GREATER.

RESULTS: A. MINI GROWTH CAN BE DIVIDED INTO TWO DISTINCT REGIONS

1) <60 MONTHS - APPROXIMATE LINEAR GROWTH;

2) >60 MONTHS - CLEARLY EXPONENTIAL GROWTH.

B. PROFIT MARGIN INITIALLY DECLINES. MINIS ARE NOT AS PROFITABLE AS NON-MINIS DURING EARLY STAGES OF GROWTH.

C. AS GROWTH CONTINUES, UTILIZATION OF ASSETS AND LABOR INCREASES. THEREFORE, PROFIT MARGIN RISES DUE TO LOWER COST/INSTALLATION SERVICED.

D. THE LAG TO AQUIRE ASSETS AND LABOR IS PRESENT AS IN SIMULATION #1, BUT IT IS BY FAR NOT A DOMINATING EFFECT.

E. SERVICE QUALITY AND OVERTIME AGAIN MOVE IN OPPOSITE DIRECTIONS. THIS RESULT MAKES SENSE -- AS QUALITY DECLINES, OVERTIME STEPS UP IN ORDER TO COUNTERACT IT.

SIMULATION #3: COMBINED MINI AND MAINFRAME GROWTH

ASSUMPTIONS: A. ACTIVE GROWTH MODES FOR RUNS #1 AND #2.

B. HONEYELL DOES NOT SERVICE RESELLER INSTALLATIONS.

RESULTS: A. SUPERPOSITION SEEMS TO APPLY THOUGH NOT ABSOLUTELY. OVERTIME, SERVICE QUALITY, PROFIT MARGIN, ETC. POSSESS A COMPOSITE OF CHARACTERISTICS FROM RUNS #1 AND #2.

B. CIRCA MONTH 60 THERE IS A DISTINCT CHANGE IN LABOR, OVERTIME, SERVICE QUALITY, AND PROFIT MARGIN AS INCREASED GROWTH RESULTS IN BETTER ASSET AND LABOR UTILIZATION.

C. TOTAL MINI INSTALLATIONS IS LESS THAN RUN #2 BECAUSE OF A LOWER SERVICE QUALITY THAN PREVIOUSLY EXPERIENCED. THIS RESULT IS DUE TO SUPERPOSITION.

D. AT MONTH 48 (EQUIVALENT TO 1982) TOTAL MINIS EQUALS (49) APPROXIMATELY 6000 INSTALLATIONS, WHICH IS ABOUT WHAT IT ACTUALLY WILL IS. THIS RESULT WAS NOT PURPOSELY CONTRIVED, IT HAPPENED AS A CONSEQUENCE OF MODEL. THERE WAS NO WAY TO ACTUALLY KNOW THAT THIS WOULD OCCUR BEFOREHAND.

E. OVERTIME REMAINS CONSISTENTLY AROUND 10 PERCENT SIMILAR TO THE ACTUAL OVERTIME IN THE CSD. AGAIN, THIS RESULT WAS ALSO AN OUTPUT OF THE MODEL, BUT NOT AN ASSUMPTION WHICH WENT INTO IT.

F. SERVICE QUALITY JACKKNIFES DOWNWARD CIRCA MONTH 100 DUE DUE TO SATURATION IN IMPROVEMENT OF ASSET AND LABOR UTILIZATION WHICH THE SYSTEM IS NOT EXPECTING.

SUMMARY OF POLICY TESTS (5d)

A. HONEYWELL SERVICES 75 PERCENT OF SUBSEQUENT RESELLER MINI INSTALLATIONS.

B. IMPLEMENTATION OF MAN-IN-THE-VAN PROGRAM IN ORDER TO RAISE SERVICE QUALITY AND REDUCE COSTS.

C. IMPLEMENTATION OF DISCOUNT PRICE POLICY TO RESELLERS OF 15 PERCENT IN ORDER TO ENCOURAGE RESELLER GROWTH.

D. REDUCTION IN THIRD PARTY MAINTAINERS' SERVICE QUALITY BY 25 PERCENT.

SIMULATION #4: SERVICE POLICY TOWARD RESELLERS AT 75 PERCENT

ASSUMPTIONS: A. GROWTH MODE AS IN RUN #3 PLUS HONEYWELL SERVICE OF 75 PERCENT OF ALL SUBSEQUENT RESELLER SALES.

RESULTS: A. UP TO MONTH 48 THERE IS NO EFFECT BECAUSE THE LEVEL OF RESELLER INSTALLATIONS IS SMALL AND GROWTH IS SLOW.

B. PROFIT MARGIN INCREASES FASTER BECAUSE THE NUMBER OF INSTALLATIONS WHICH HONEYWELL IS OBLIGATED TO SERVICE IS INCREASING AT A FASTER RATE. PROFIT MARGIN SATURA SOONER AS DOES UTILIZATION.

C. PROFIT MARGIN SATURATES FASTER BECAUSE OF UTILIZATION, BUT, SATURATION OCCURS AT A LOWER LEVEL DUE TO EXCESSES IN OVERTIME.

D. ACCUMULATED PROFIT OVER THE ENTIRE SIMULATION IS 10 PERCENT HIGHER THAN WITH ORDINARY GROWTH. REVENUE AT THE COMPLETION OF THE SIMULATION IS 5 PERCENT GREATER THAN FOR REFERENCE GROWTH.

E. SERVICE QUALITY DECLINES LOWER THAN EVER BEFORE BECAUSE GROWTH OF SERVICE CONTRACTS IS GREATER THAN EVER BEFORE. THE GREATER THE RATE OF GROWTH, THE LOWER GOES HONEYWELL SERVICE QUALITY.

F. ALTHOUGH IN PURE GROWTH (RUN #3) HONEYWELL DOES MAKE A 300 PERCENT PROFIT ON SPARES WHICH ARE SOLD TO RESELLERS AND THIRD PARTY MAINTAINERS, MUCH GREATER PROFIT AND REVENUE IS REALIZED WHEN THE MAINTENANCE IS PERFORMED BY HONEYELL DIRECTLY.

G. THERE EXISTS A "GIVE AND TAKE" BETWEEN THE LEVEL OF SERVICE QUALITY AND REVENUE.

SIMULATION #5: MAN-IN-THE-VAN PROGRAM . . .

ASSUMPTIONS: A. GROWTH AND RESELLER SERVICE POLICY AT 75 PERCENT AS IN RUN #5.

B. IMPLEMENTATION OF MAN-IN-THE-VAN PROGRAM WHICH INCREASES PRODUCTIVITY AND EFFECTIVENESS OF FIELD LABOR.

RESULTS: A. ALMOST ALL BEHAVIOR REMAINS UNCHANGED.

B. MAN-IN-THE-VAN DOES NOT IMPROVE SERVICE QUALITY OVER THE LONG RUN BECAUSE IT ALLOWS FOR THE REDUCTION OF LABOR WHICH HAS EXACTLY THE OPPOSITE EFFECT ON QUALITY.

C. PERCENTAGE OF OVERTIME IS THE SAME, BUT THE ACTUAL NUMBER OF OVERTIME HOURS IS REDUCED BECAUSE THE LABOR FORCE IS SMALLER DUE TO INCREASED PRODUCTIVITY. THE SYSTEM NATURALLY TENDS TOWARD OVERTIME.

D. BECAUSE THE MAN-IN-THE-VAN PROGRAM REDUCES THE REQUIRED LABOR, IT DECREASES THE COST/INSTALLATION SERVICED. THIS DECREASE IN EXPENSE LOGICALLY INCREASES PROFIT MARGIN.

SIMULATION #6: DISCOUNT PRICE POLICY TOWARD RESELLERS . . . (5)

ASSUMPTIONS: A. GROWTH, SPR=75%, AND IMPLEMENTATION OF MAN-IN-THE-VAN.

B. DECREASE IN PRICE OF SERVICE CONTRACTS SOLD BY RESELLER BY 15 PERCENT.

RESULTS: A. PROFIT MARGIN DECLINES SLIGHTLY DUE TO A DECREASE IN REVENUE/INSTALLATION SERVICED.

B. REVENUE REMAINS BASICALLY CONSTANT. ALTHOUGH PRICE SALE IS DOWN, THE NUMBER OF SALES IS UP TO COMPENSATE FOR A LOSS OF REVENUE.

C. ACCUMULATED PROFIT OVER THE TIME OF SIMULATION DECREASES BY A MERE 1 PERCENT (NOT A VERY SIGNIFICANT CHANGE). DISCOUNT PRICES TO RESELLERS DO NOT SEEM TO AFFECT THE OVERAL PROFIT STRUCTURE OF THE ORGANIZATION.

D. SERVICE QUALITY DECREASES DUE TO THE INCREASES IN VOLUME, BUT GROWTH IS NOT VERY SENSITIVE TO SUCH A SMALL DECLINE IN SERVICE QUALITY AT THIS POINT.

E. EFFECTIVE AT ENCOURAGING RESELLER GROWTH

SIMULATION #7: DECLINE IN THIRD PARTY SERVICE QUALITY 55

ASSUMPTIONS: A. GROWTH MODE AS IN RUN #3 PLUS DECLINE IN THIRD PARTY SERVICE QUALITY OF 25 PERCENT.

RESULTS: A. DECREASE IN THIRD PARTY SERVICE QUALITY RESULTS IN A GENERALLY PERCEIVED DECLINE OF HONEYWELL SERVICE QUALITY. GROWTH IS IMPAIRED.

B. DUE TO LOWER GROWTH, UTILIZATION OF LABOR AND ASSETS DOES NOT APPROACH SATURATION AS IT WOULD DO OTHERWISE A HIGHER PROFIT MARGIN IS NOT REALIZED ON ACCOUNT OF THE LACK OF IMPROVEMENT IN UTILIZATION.

C. SERVICE QUALITY INCREASES AND INVERSELY OVERTIME DECREASES DUE TO THE SLOWER RATE OF OVERALL GROWTH.

D. PARADOXICAL SITUATION:

- WHEN THIRD PARTY SERVICE QUALITY IS HIGH, HONEYWELL STANDS A CHANCE OF LOSING SERVICE CONTRACTS TO THIRD PARTY MAINTAINERS AND RESELLERS.

- WHEN THIRD PARTY SERVICE QUALITY IS LOW, ITS ASSOCIATION WITH THE HONEYWELL NAME MAY TEND TO CAUSE HONEYWELL TO LOSE SERVICE CONTRACTS ANYHOW.

CONCLUSIONS

INSIGHTS INTO ALTERNATIVE POLICIES . . .

A. SERVICING RESELLER INSTALLATIONS IMPROVES BUSINESS THROUGH INCREASED VOLUME AND REDUCED SERVICE COST PER INSTALLATION. IT GENERATES HIGHER REVENUE AND PROFIT MARGIN , BUT CREATES PROBLEMS IN KEEPING SERVICE QUALITY AT A HIGH LEVEL DURING TIMES OF RAPID GROWTH.

B. THE MAN-IN-THE-VAN PROGRAM PROVES TO BE AN EFFECTIVE POLICY TO REDUCE SERVICE COST AND INCREASE PROFIT MARGIN, BUT IT DOES NOT SEEM TO HELP RAISE THE LEVEL OF HONEYWELL SERVICE QUALITY.

C. IMPLEMENTATION OF A DISCOUNT SERVICE PRICE FOR RESELLERS IS A FAVORABLE POLICY TO ENCOURAGE AND GENERATE GROWTH. ALTHOUGH DISCOUNTING PRICES DOES REDUCE REVENUE, THE ADDED GROWTH COMPENSATES FOR SUCH A LOSS WHILE PROVIDING GREATER SALES VOLUME FOR HONEYWELL INFORMATION SYSTEMS ON THE WHOLE.

D. THE SERVICE QUALITY OF THIRD PARTY MAINTAINERS AND RESELLERS HAS A STRONG EFFECT UPON PERCEIVED HONEYWELL SERVICE QUALITY WITHIN THE MARKETPLACE. IT IS NECESSARY THAT THEY OFFER HIGH QUALITY SERVICE IN ORDER TO AVOID A NEGATIVE IMPACT UPON GROWTH.

(57)

E. THERE IS CONCERN WITHIN THE HONEYWELL ORGANIZATION THAT THE ENCOURAGEMENT OF RESELLER AND THIRD PARTY MAINTAINERS WOULD BE AIDING A POTENTIAL COMPETITOR. ON THE CONTRARY, IT SEEMS FAR MORE IMPORTANT TO ENCOURAGE RESELLERS IN ORDER TO SPUR GROWTH THAN TO WORRY ABOUT COMPETITIVE FACTORS.

INSIGHTS INTO SYSTEM BEHAVIOR . . . (58)

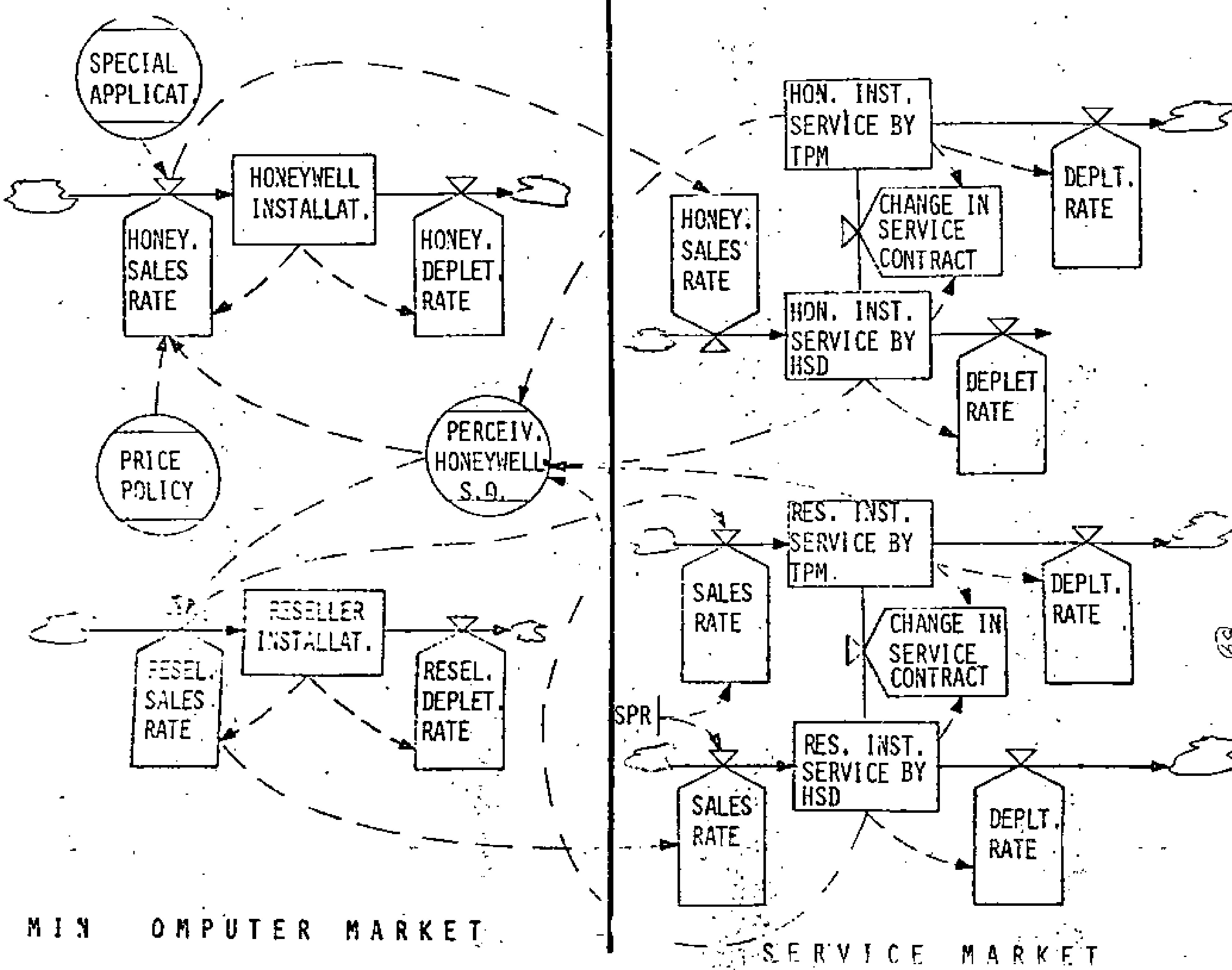
A. OVERTIME IS A REASONABLY GOOD INDICATOR OF THE OVERALL STATE OF THE ORGANIZATION. IT IS REPRESENTATIVE OF SERVICE QUALITY AND CAN BE OBJECTIVELY MEASURED AND COMPARED.

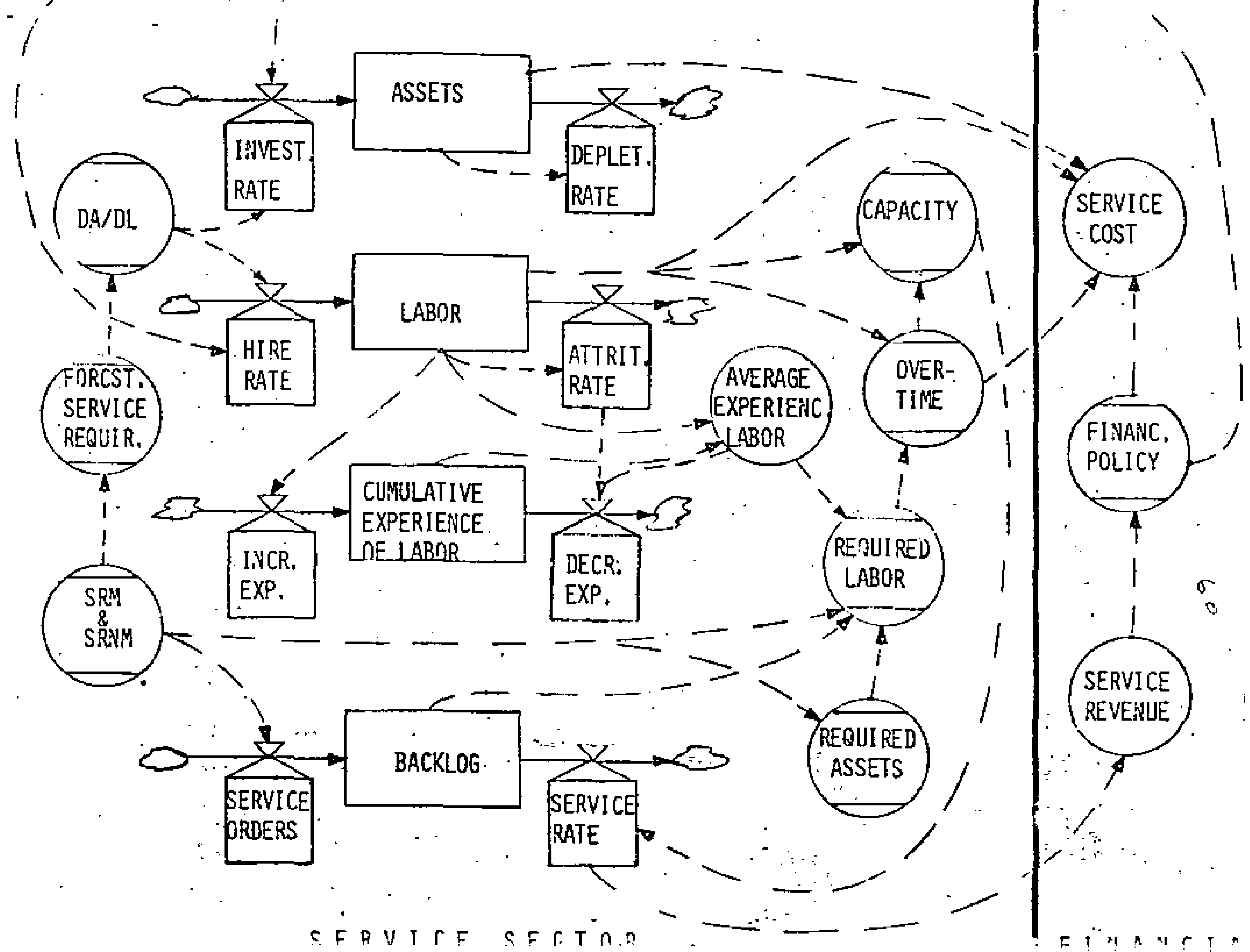
B. AQUISITION LAG IN LABOR AND ASSETS CONTRIBUTES SIGNIFICANTLY TO DECLINING SERVICE QUALITY, INCREASING OVERTIME AND PROFIT MARGIN.

C. EXPONENTIAL GROWTH IS A CHARACTERISTIC OF THIS SYSTEM WHICH MAY REMAIN UNNOTICED DURING PERIODS OF SLOW GROWTH DURING WHICH LINEAR BEHAVIOR IS APPROXIMATED. AS THE LEVEL OF INSTALLATIONS INCREASES, TRUE EXPONENTIAL BEHAVIOR IS EXHIBITED. FORECASTING MECHANISMS ARE LINEAR, AND THEY BREAKDOWN IN PERIODS OF SUCH GROWTH CAUSING SERVICE QUALITY TO DECLINE, ETC.

D. CHANGES IN ASSET AND LABOR UTILIZATION DUE TO EXPONENTIAL GROWTH MARKEDLY AFFECT THE DYNAMIC BEHAVIOR OF THE SYSTEM.

E. THERE IS A TRADE-OFF, A "GIVE AND TAKE", BETWEEN SERVICE QUALITY AND REVENUE.


SPECIAL APPLICAT.
HONEYWELL INSTALLAT.
HONEY. SALES RATE
HONEY. DEPLET. RATE
PRICE POLICY
PERCEIV. HONEYWELL S.Q.
RESELLER INSTALLAT.
RESEL. SALES RATE
RESEL. DEPLET. RATE
MIN OMPUTER MARKET
HON. INST. SERVICE BY TPM
DEPLT. RATE
HONEY. SALES RATE
CHANGE IN SERVICE CONTRACT
HON. INST. SERVICE BY HSD
DEPLET RATE
RES. INST. SERVICE BY TPM.
SALES RATE
DEPLT. RATE
CHANGE IN SERVICE CONTRACT
SPR
RES. INST. SERVICE BY HSD
SALES RATE
DEPLT. RATE
SERVICE MARKET


ASSETS
INVEST RATE
DEPLET. RATE
DA/DL
LABOR
HIRE RATE
ATTRIT. RATE
CAPACITY
OVER-TIME
SERVICE COST
AVERAGE EXPERIENC LABOR
FORCST. SERVICE REQUIR.
CUMULATIVE EXPERIENCE OF LABOR
INCR. EXP.
DECR. EXP.
REQUIRED LABOR
FINANC. POLICY
SRM & SRNM
BACKLOG
SERVICE ORDERS
SERVICE RATE
REQUIRED ASSETS
SERVICE REVENUE
SERVICE SECTOR

(67)

SYSTEM DYNAMICS MODEL

BY

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CAMBRIDGE, MA 02139

MAY 1982

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1.0 MARKET SUBSYSTEM

1.1 HONEYWELL SALES

```
HI.K=HI.J+DT*(HSR.JK-HDR.JK)                                L.6
    HI    - HONEYWELL INSTALLATIONS (MINICOMPUTERS) <6>
    DT    - SOLUTION TIME INTERVAL <112>
    HSR   - HONEYWELL SALES RATE (MINICOMPUTERS/MONTH) <7>
    HDR   - HONEYWELL DEPLETION RATE (MINICOMPUTERS/MONTH)
            <17>
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(62)

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HI=1500                                                    N,6,1      >HSR,R,7/HDR,R,17/TKHH,A,19/HISH,N,29,1/PLOT,
                                                                        PRINT,116
    HI     - HONEYWELL INSTALLATIONS (MINICOMPUTERS) <6>

HSR.KL=HI.K*MHSA.K*MHSP.K*MPHSQ.K/DTHI.K                   R,7        >HI,L,6/HISH,L,29
    HSR    - HONEYWELL SALES RATE (MINICOMPUTERS/MONTH) <7>
    HI     - HONEYWELL INSTALLATIONS (MINICOMPUTERS) <6>
    MHSA   - MULTIPLIER FOR HONEYWELL SPECIAL APPLICATIONS
              (DIMENSIONLESS) <12>
    MHSP   - MULTIPLIER FOR HONEYWELL SERVICE PRICE
              (DIMMENSIONLESS) <9>
    MPHSQ  - MULTIPLIER FOR PERCEIVED HONEYWELL SERVICE
              QUALITY (DIMENSIONLES <14>
    DTHI   - (MONTHS)DOUBLING TIME FOR HONEYWELL
              INSTALLATIONS <8>

DTHI.K=120*(1-STEP(SDTHI,0))                               A,8        >HSR,R,7
SDTHI=0                                                    C,8,1      >DTHI,A,8
    DTHI   - (MONTHS)DOUBLING TIME FOR HONEYWELL
              INSTALLATIONS <8>
    SDTHI  - STEP TEST FOR DTHI (FRACTION) <8>

MHSP.K=TABLE(TMHSP,HSP.K/CSP.K,0,1.5,.25)                  A,9        >HSR,R,7
TMHSP=3,2,1.5,1,1,1,.9,0                                   T,9,1      >MHSP,A,9
    MHSP   - MULTIPLIER FOR HONEYWELL SERVICE PRICE
              (DIMMENSIONLESS) <9>
    TABLE  - TABLE FUNCTION
    TMHSP  - TABLE FOR MULTIPLIER FOR HONEYWELL SERVICE PRICE
              <9>
    HSP    - HONEYWELL SERVICE PRICE (DOLLARS/MONTH) <10>
    CSP    - COMPETITORS SERVICE PRICE (DOLLARS/MONTH) <11>

HSP.K=CSP.K+STEP(STHSP,12)                                 A,10       >MHSP,A,9/DHSP,A,27/SRHISH,A,44
STHSP=0                                                    C,10,1     >HSP,A,10
    HSP    - HONEYWELL SERVICE PRICE (DOLLARS/MONTH) <10>
    CSP    - COMPETITORS SERVICE PRICE (DOLLARS/MONTH) <11>
    STHSP  - STEP TEST FOR HSP (FRACTION) <10>

CSP.K=700                                                  A,11       >MHSP,A,9/HSP,A,10/HRSP,A,23/RSP,A,24
    CSP    - COMPETITORS SERVICE PRICE (DOLLARS/MONTH) <11>

MHSA.K=TABLE(TMHSA,SA.K,0,1.5,.25)                         A,12       >HSR,R,7
TMHSA=.1/.3/.5/.75/1/1.15/1.25                             T,12,1     >MHSA,A,12
    MHSA   - MULTIPLIER FOR HONEYWELL SPECIAL APPLICATIONS
              (DIMENSIONLESS) <12>
    TABLE  - TABLE FUNCTION
    TMHSA  - TABLE FOR HONEYWELL SPECIAL APPLICATIONS <12>
    SA     - HONEYWELL SPECIAL APPLICATIONS (FRACTION) <13>

SA.K=TABLE(TSA,TIME.K,0,120,60)                            A,13       >MHSA,A,12
TSA=1/1/1                                                  T,13,1     >SA,A,13
    SA     - HONEYWELL SPECIAL APPLICATIONS (FRACTION) <13>
    TABLE  - TABLE FUNCTION
    TSA    - TABLE FOR HONEYWELL SPECIAL APPLICATIONS <13>
```

```
MPHSQ.K=TABLE(TMPHSQ,PHSQ.K,0,1.25,.25)                       A,14      >HSR,R,7/RSR,R,21
TMPHSQ=.25,.25,.4,.8,1,1.2                                      T,14.1    >MPHSQ,A,14
    MPHSQ  - MULTIPLIER FOR PERCEIVED HONEYWELL SERVICE
             QUALITY (DIMENSIONLES <14>
    TABLE  - TABLE FUNCTION
    TMPHSQ - TABLE FOR MULTIPLIER FOR PERCEIVED HONEYWELL
             SERVICE QUALITY <14>
    PHSQ   - PERCEIVED HONEYWELL SERVICE QUALITY (FRACTION)
             <15>

PHSQ.K=DELAY3(WSQ.K,TPHSQ)                                      A,15      >MPHSQ,A,14/MHAHSD,A,32/MMTHSD,A,34
TPHSQ=12                                                        C,15.1    >PHSQ,A,15
    PHSQ   - PERCEIVED HONEYWELL SERVICE QUALITY (FRACTION)
             <15>
    DELAY3 - THIRD ORDER AVERAGING MACRO
    WSQ    - WEIGHTED SERVICE QUALITY (FRACTION) <16>
    TPHSQ  - (MONTHS) TIME TO PERCEIVE HONEYWELL SERVICE
             QUALITY <15>

WSQ.K=((RISH.K+HISH.K)*(HSQ.K)+(TPMSQ.K)*(HISTM.K+RISTM.K))/   A,16      >PHSQ,A,15
 TMHM.K
    WSQ    - WEIGHTED SERVICE QUALITY (FRACTION) <16>
    RISH   - RESELLER INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <36>
    HISH   - HONEYWELL INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <29>
    HSQ    - HONEYWELL SERVICE QUALITY (SQ) <96>
    TPMSQ  - THIRD PARTY MAINTAINER SERVICE QUALITY (SQ) <18>
    HISTM  - HONEYWELLINSTALLATIONS SERVICE BY THIRD PARTY
             MAINTAINERS (MINIC <35>
    RISTM  - RESELLER INSTALLATIONS SERVICE BY THIRD PARTY
             MAINTAINERS (MINIC FINANCIAL SUBSYSTEM 2.1
             SERVICE REVENUE <40>
    TMHM   - TOTAL MARKET OF HONEYWELL MINICOMPUTERS
             (MINICOMPUTERS) 1.2 RESELLER SALES <19>

HDR.KL=HI.K/ALI                                                 R,17      >HI,L,6
    HDR    - HONEYWELL DEPLETION RATE (MINICOMPUTERS/MONTH)
             <17>
    HI     - HONEYWELL INSTALLATIONS (MINICOMPUTERS) <6>
    ALI    - (MONTHS) AVERAGE LIFE OF MINICOMPUTER
             INSTALLATIONS <18>

TPMSQ.K=1+STEP(STPMSQ,24)                                       A,18      >WSQ,A,16
STPMSQ=0                                                        C,18.1    >TPMSQ,A,18
ALI=120                                                         C,18.2    >HDR,R,17/RDR,R,28/HISH,L,29/HISTM,L,35/RISH,L,36/
                                                                            RISTM,L,40
    TPMSQ  - THIRD PARTY MAINTAINER SERVICE QUALITY (SQ) <18>
    STPMSQ - STEP TEST FOR TPMSQ (FRACTION) <18>
    ALI    - (MONTHS) AVERAGE LIFE OF MINICOMPUTER
             INSTALLATIONS <18>

TMHM.K=HI.K+RI.K                                                A,19      >WSQ,A,16/PRINT,116
    TMHM   - TOTAL MARKET OF HONEYWELL MINICOMPUTERS
             (MINICOMPUTERS) 1.2 RESELLER SALES <19>
    HI     - HONEYWELL INSTALLATIONS (MINICOMPUTERS) <6>
    RI     - RESELLER INSTALLTIONS (MINICOMPUTERS) <20>
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1.2 RESELLER SALES

```
RI.K=RI.J+DT*(RSR.JK-RDR.JK)                           L,20     >THRH,A,19/RSR,R,21/RDR,R,23/RISH,N,36.1/RISTH,   17
RI=150                                                 N,20.1     PLOT,114/PRINT,116
    RI    - RESELLER INSTALLTIONS (MINICOMPUTERS) <20>
    DT    - SOLUTION TIME INTERVAL <112>
    RSR   - RESELLER SALES RATE (MINICOMPUTERS/MONTH) <21>
    RDR   - RESELLER DEPLETION RATE (MINICOMPUTERS/MONTH)
            1.3 SERVICE MARKET <28>

RSR.KL=RI.K*MRSP.K*MPHSQ.K*PERG/DTRI.K                 R,21     >RI,L,20/RISH,L,36/RISTH,L,40
PERG=1                                                 C,21.1   >RSR,R,21
    RSR   - RESELLER SALES RATE (MINICOMPUTERS/MONTH) <21>
    RI    - RESELLER INSTALLTIONS (MINICOMPUTERS) <20>
    MRSP  - MULTIPLIER FOR RESELLER SERVICE PRICE
            (DIMENSIONLESS) <23>
    MPHSQ - MULTIPLIER FOR PERCEIVED HONEYWELL SERVICE
            QUALITY (DIMENSIONLES <14>
    PERG  - POLICY TO ENCOURAGE RESELLER GROWTH (FRACTION)
            <21>
    DTRI  - DOUBLING TIME FOR RESELLER INSTALLATIONS
            (MONTHS) <22>

DTRI.K=120*(1-STEP(SDTRI,0))                           A,22     >RSR,R,21
SDTRI=0                                                C,22.1   >DTRI,A,22
    DTRI  - DOUBLING TIME FOR RESELLER INSTALLATIONS
            (MONTHS) <22>
    SDTRI - STEP TEST FOR DTRI (FRACTION) <22>

MRSP.K=TABLE(TMRSP,WARSP.K/CSP.K,0,1.5,.25)            A,23     >RSR,R,21
TMRSP=3,2,1.5,1.1,1,.9,0                               T,23.1   >MRSP,A,23
    MRSP  - MULTIPLIER FOR RESELLER SERVICE PRICE
            (DIMENSIONLESS) <23>
    TABLE - TABLE FUNCTION
    TMRSP - TABLE FOR MULTIPLIER FOR RESELLER SERVICE PRICE
            <23>
    WARSP - WEIGHTED AVERAGE RESELLER SERVICE PRICE (DOLLARS/
            MONTH) <25>
    CSP   - COMPETITORS SERVICE PRICE (DOLLARS/MONTH) <11>

RSP.K=CSP.K                                            A,24     >WARSP,A,25
    RSP   - RESELLER SERVICE PRICE (DOLLARS /MONTH) <24>
    CSP   - COMPETITORS SERVICE PRICE (DOLLARS/MONTH) <11>

WARSP.K=(DHSP.K*SPR.K)+((1-SPR.K)*RSP.K)               A,25     >MRSP,A,23
    WARSP - WEIGHTED AVERAGE RESELLER SERVICE PRICE (DOLLRS/
            MONTH) <25>
    DHSP  - DISCOUNT HONEYWELL SERVICE PRICE (DOLLARS/MONTH)
            <27>
    SPR   - SERVICE POLICY FTO RESELLER (FRACTION) <26>
    RSP   - RESELLER SERVICE PRICE (DOLLARS /MONTH) <24>

SPR.K=STEP(STSPR,48)                                   A,26     >WARSP,A,25/RISH,L,36/RISH,N,36.1/RISTH,L,40/RIS..,N,40
STSPR=0                                                C,26.1   >SPR,A,26
    SPR   - SERVICE POLICY FTO RESELLER (FRACTION) <26>
    STSPR - STEP TEST FOR SPR (FRACTION) <26>
```

```
DHSP.K=HSP.K*(1-DPPR)                                   A,27      >WARSP,A,25/SRRISH,A,43
DPPR=0                                                  C,27.1    >DHSP,A,27
    DHSP   - DISCOUNT HONEYWELL SERVICE PRICE (DOLLARS/MONTH)
             <27>
    HSP    - HONEYWELL SERVICE PRICE (DOLLARS/MONTH) <10>
    DPPR   - DISCOUNT PRICING POLICY TO RESELLER (FRACTION)
             <27>

RDR.KL=RI.K/ALI                                         R,28      >RI,L,20
    RDR    - RESELLER DEPLETION RATE (MINICOMPUTERS/MONTH)
             1.3 SERVICE MARKET <28>
    RI     - RESELLER INSTALLATIONS (MINICOMPUTERS) <20>
    ALI    - (MONTHS) AVERAGE LIFE OF MINICOMPUTER
             INSTALLATIONS <18>


             1.3 SERVICE MARKET

HISH.K=HISH.J+DT*(HSR.JK-(HISH.J/ALI))-DT*HICSCR.JK     L,29      >HSQ,A,16/HISHLR,A,31/SRHISH,A,44/SRM,A,97/MLUTIL,A,10
HISH=HI                                                 N,29.1      AHSRM,A,106/PLOT,114/PRINT,116
    HISH   - HONEYWELL INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <29>
    DT     - SOLUTION TIME INTERVAL <112>
    HSR    - HONEYWELL SALES RATE (MINICOMPUTERS/MONTH) <7>
    ALI    - (MONTHS) AVERAGE LIFE OF MINICOMPUTER
             INSTALLATIONS <18>
    HICSCR - HONEYWELL INSTALLATIONS CHANGE OF SERVICE
             CONTRACT RATE (MINICOM <30>
    HI     - HONEYWELL INSTALLATIONS (MINICOMPUTERS) <6>

HICSCR.KL=(HISHLR.K-HISTLR.K)/ATCSC                     R,30      >HISH,L,29/HISTM,L,35
ATCSC=12                                                C,30.1    >HICSCR,R,30/RICSCR,R,37
    HICSCR - HONEYWELL INSTALLATIONS CHANGE OF SERVICE
             CONTRACT RATE (MINICOM <30>
    HISHLR - HONEYWELL INSTALLATIONS SERVICE BY HSD LEAVING
             RATE (MINICOMPUTE <31>
    HISTLR - HONEYWELL INSTALLTIONS SERVICE BY THIRD PARTY
             MAINTAINERS LEAVIN <33>
    ATCSC  - (MONTHS) AVERAGE TIME TO CHANGE SERVICE CONTRACT
             <30>

HISHLR.K=HISH.K*MMAHSD.K                                A,31      >HICSCR,R,30
    HISHLR - HONEYWELL INSTALLATIONS SERVICE BY HSD LEAVING
             RATE (MINICOMPUTE <31>
    HISH   - HONEYWELL INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <29>
    MMAHSD - MULTIPLIER FOR MOVING AWAY FROM HSD
             (DIMENSIONLESS) <32>

MMAHSD.K=TABLE(TMMAHS,PHSQ.K,.5,1.5,.25)                A,32      >HISHLR,A,31/RISHLR,A,38
TMMAHS.K=.5,.25,0,0,0                                   T,32.1    >MMAHSD,A,32
    MMAHSD - MULTIPLIER FOR MOVING AWAY FROM HSD
             (DIMENSIONLESS) <32>
    TABLE  - TABLE FUNCTION
    TMMAHS - TABLE FOR MULTIPLIER FOR MOVING AWAY OF HSD <32>
    PHSQ   - PERCEIVED HONEYWELL SERVICE QUALITY (FRACTION)
             <15>
```

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HISTLR.K=HISTM.K*MMTHSD.K                                A,33     >HICSCR,R,30
    HISTLR - HONEYWELL INSTALLTIONS SERVICE BY THIRD PARTY
              MAINTAINERS LEAVIN <33>
    HISTM  - HONEYWELLINSTALLATIONS SERVICE BY THIRD PARTY
              MAINTAINERS (MINIC <35>
    MMTHSD - MULTIPLIER FOR MOVING TOWARDS HSD
              (DIMENSIONLESS) <34>

MMTHSD.K=TABLE(TMMTHS,PHSQ.K,.5,1.5,.25)                 A,34     >HISTLR,A,33/RISTLR,A,39
TMMTHS=0,0,0,.25,.5                                      T,34.1   >MMTHSD,A,34
    MMTHSD - MULTIPLIER FOR MOVING TOWARDS HSD
              (DIMENSIONLESS) <34>
    TABLE  - TABLE FUNCTION
    TMMTHS - TABLE FOR MULTIPLIER FOR MOVING TOWARDS HSD <34>
    PHSQ   - PERCEIVED HONEYWELL SERVICE QUALITY (FRACTION)
              <15>

HISTM.K=HISTM.J+DT*(HICSCR.JK-HISTM.J/ALI)               L,35     >HSQ,A,16/HISTLR,A,33/SRSP,A,45/CSTMPM,A,51/PLOT,114/
HISTM=)                                                  N,35.1     PRINT,116
    HISTM  - HONEYWELLINSTALLATIONS SERVICE BY THIRD PARTY
              MAINTAINERS (MINIC <35>
    DT     - SOLUTION TIME INTERVAL <112>
    HICSCR - HONEYWELL INSTALLATIONS CHANGE OF SERVICE
              CONTRACT RATE (MINICOM <30>
    ALI    - (MONTHS) AVERAGE LIFE OF MINICOMPUTER
              INSTALLATIONS <18>

RISH.K=RISH.J+DT*(RSR.JK*SPR.J-(RISH.J/ALI)-RICSCR.JK)   L,36     >HSQ,A,16/RISHLR,A,38/SRRISH,A,43/SRM,A,97/MLUTIL,A,10
RISH=RI*SPR                                              N,36.1     AMSRM,A,105/PLOT,114/PRINT,116
    RISH   - RESELLER INSTALLATIONS SERVICE BY HSD
              (MINICOMPUTERS) <36>
    DT     - SOLUTION TIME INTERVAL <112>
    RSR    - RESELLER SALES RATE (MINICOMPUTERS/MONTH) <21>
    SPR    - SERVICE POLICY FTO RESELLER (FRACTION) <26>
    ALI    - (MONTHS) AVERAGE LIFE OF MINICOMPUTER
              INSTALLATIONS <18>
    RICSCR - RESELLER INSTALLATIONS CHANGE OF SERVICE
              CONTRACT RATE (MINICOMP <37>
    RI     - RESELLER INSTALLTIONS (MINICOMPUTERS) <20>

RICSCR.KL=(RISHLR.K-RISTLR.K)/ATCSC                      R,37     >RISH,L,36/RISTM,L,40
    RICSCR - RESELLER INSTALLATIONS CHANGE OF SERVICE
              CONTRACT RATE (MINICOMP <37>
    RISHLR - RESELLER INSTALLATIONS SERVIVE BY HSD LEAVING
              RATE (MINICOMPUTER <38>
    RISTLR - RESELLER INSTALLATIONS SERVICE BY THIRD PARTY
              MAINTAINERS LEAVIN <39>
    ATCSC  - (MONTHS) AVERAGE TIME TO CHANGE SERVICE CONTRACT
              <30>

RISHLR.K=RISH.K*MMAHSD.K                                 A,38     >RICSCR,R,37
    RISHLR - RESELLER INSTALLATIONS SERVIVE BY HSD LEAVING
              RATE (MINICOMPUTER <38>
    RISH   - RESELLER INSTALLATIONS SERVICE BY HSD
              (MINICOMPUTERS) <36>
    MMAHSD - MULTIPLIER FOR MOVING AWAY FROM HSD
              (DIMENSIONLESS) <32>
```

```
RISTLR.K=RISTM.K*MMTHSD.K                                       A,39     >RICSCR,R,37
    RISTLR - RESELLER INSTALLATIONS SERVICE BY THIRD PARTY
             MAINTAINERS LEAVIN &lt;39&gt;
    RISTM  - RESELLER INSTALLATIONS SERVICE BY THIRD PARTY
             MAINTAINERS (MINIC FINANCIAL SUBSYSTEM 2.1
             SERVICE REVENUE &lt;40&gt;
    MMTHSD - MULTIPLIER FOR MOVING TOWARDS HSD
             (DIMENSIONLESS) &lt;34&gt;

RISTM.K=RISTM.J+DT*(RSR.JK*(1-SPR.J)-(RISTM.J/ALI)+RICSCR.JK)  L,40     >HSD,A,16/RISTLR,A,39/SRSP,A,45/CSTMPM,A,51/PLOT,114/
RISTM=RI*(1-SPR)                                                N,40.1     PRINT,116
    RISTM  - RESELLER INSTALLATIONS SERVICE BY THIRD PARTY
             MAINTAINERS (MINIC FINANCIAL SUBSYSTEM 2.1
             SERVICE REVENUE &lt;40&gt;
    DT     - SOLUTION TIME INTERVAL &lt;112&gt;
    RSR    - RESELLER SALES RATE (MINICOMPUTERS/MONTH) &lt;21&gt;
    SPR    - SERVICE POLICY FTO RESELLER (FRACTION) &lt;26&gt;
    ALI    - (MONTHS) AVERAGE LIFE OF MINICOMPUTER
             INSTALLATIONS &lt;18&gt;
    RICSCR - RESELLER INSTALLATIONS CHANGE OF SERVICE
             CONTRACT RATE (MINICOMP &lt;37&gt;
    RI     - RESELLER INSTALLTIONS (MINICOMPUTERS) &lt;20&gt;


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             2.0.0 SERVICE SUBSYSTEM

             2.1.0 FINANCIAL SECTOR

             2.1.1 SERVICE REVENUE

SRPM.K=SRRISH.K+SRHISH.K+SRSP.K+SRNMSH.K                        A,42     >SPM,A,55/AR,L,110/P,A,111/PLOT,113/PRINT,115
    SRPM   - SERVICE REVENUE PER MONTH (DOLLARS) &lt;42&gt;
    SRRISH - SERVICE REVENUE FOR RESELLER INSTALLATIONS
             SERVICED BY HONEYWELL &lt;43&gt;
    SRHISH - SERVICE REVENUE FOR HONEYWELL INSTALLATIONS
             SERVICED BY HONEYWEL &lt;44&gt;
    SRSP   - SERVICE REVENUE DUE TO SPARES (DOLLARS) &lt;45&gt;
    SRNMSH - SERVICE REVENUE FOR NON-MINIS SERVICED BY HONEY.
             (DOLLARS) &lt;47&gt;

SRRISH.K=DHSP.K*RISH.K                                          A,43     >SRPM,A,42
    SRRISH - SERVICE REVENUE FOR RESELLER INSTALLATIONS
             SERVICED BY HONEYWELL &lt;43&gt;
    DHSP   - DISCOUNT HONEYWELL SERVICE PRICE (DOLLARS/MONTH)
             &lt;27&gt;
    RISH   - RESELLER INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) &lt;36&gt;

SRHISH.K=HSP.K*HISH.K                                           A,44     >SRPM,A,42
    SRHISH - SERVICE REVENUE FOR HONEYWELL INSTALLATIONS
             SERVICED BY HONEYWEL &lt;44&gt;
    HSP    - HONEYWELL SERVICE PRICE (DOLLARS/MONTH) &lt;10&gt;
    HISH   - HONEYWELL INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) &lt;29&gt;
```

```
SRSP.K=(HISTM.K+RISTM.K)*PSPPM.K                          A,45      >SRPM,A,42
    SRSP   - SERVICE REVENUE DUE TO SPARES (DOLLARS) <45>
    HISTM  - HONEYWELLINSTALLATIONS SERVICE BY THIRD PARTY
              MAINTAINERS (MINIC <35>
    RISTM  - RESELLER INSTALLATIONS SERVICE BY THIRD PARTY
              MAINTAINERS (MINIC FINANCIAL SUBSYSTEM 2.1
              SERVICE REVENUE <40>
    PSPPM  - PRICE OF SPARES PER MONTH PER INSTALLATION
              (DOLLARS) <46>

PSPPM.K=100                                               A,46      >SRSP,A,45
    PSPPM  - PRICE OF SPARES PER MONTH PER INSTALLATION
              (DOLLARS) <46>

SRNMSH.K=NMI.K*PNMISH.K                                   A,47      >SRPM,A,42
    SRNMSH - SERVICE REVENUE FOR NON-MINIS SERVICED BY HONEY.
              (DOLLARS) <47>
    NMI    - NON-MINI INSTALLATIONS (INSTALLATIONS) <88>
    PNMISH - PRICE OF NON-MINI INSTALLATIONS SERVICED BY
              HONEYWELL (DOLLARS) 2.2 SERVICE COST <48>

PNMISH.K=1400                                             A,48      >SRNMSH,A,47
    PNMISH - PRICE OF NON-MINI INSTALLATIONS SERVICED BY
              HONEYWELL (DOLLARS) 2.2 SERVICE COST <48>


              2.1.2 SERVICE COST

SCPM.K=CLPM.K+CSTMPM.K+CAPM.K+DEP.K                       A,49      >SPM,A,55/PLOT,113/PRINT,115
    SCPM   - SERVICE COST PER MONTH (DOLLARS) <49>
    CLPM   - COST OF LABOR PER MONTH (DOLLARS) <50>
    CSTMPM - COST OF SPARES SOLD TO THIRD PARTY MAINTAINERS
              PER MONTH (DOLLAR <51>
    CAPM   - COST OF ASSETS PER MONTH (DOLLARS) <53>
    DEP    - DEPRECIATION (DOLLARS/MONTH) 2.3 SERVICE PROFIT
              MARGIN <54>

CLPM.K=L.K*AWPM.K+MAX(0,OT.K)*1.5*AWPM.K                  A,50      >SCPM,A,49
    CLPM   - COST OF LABOR PER MONTH (DOLLARS) <50>
    L      - LABOR (PERSONS) <65>
    AWPM   - AVERAGE WAGE PER MONTH (DOLLARS/MONTH) <74>
    MAX    - LOGICAL MAXIMUM FUNCTION
    OT     - OVERTIME (PERSONS) <85>

CSTMPM.K=(HISTM.K+RISTM.K)*CSPPM.K                        A,51      >SCPM,A,49
    CSTMPM - COST OF SPARES SOLD TO THIRD PARTY MAINTAINERS
              PER MONTH (DOLLAR <51>
    HISTM  - HONEYWELLINSTALLATIONS SERVICE BY THIRD PARTY
              MAINTAINERS (MINIC <35>
    RISTM  - RESELLER INSTALLATIONS SERVICE BY THIRD PARTY
              MAINTAINERS (MINIC FINANCIAL SUBSYSTEM 2.1
              SERVICE REVENUE <40>
    CSPPM  - COST OF SPARES PER MONTH (DOLLARS) <52>

CSPPM.K=25                                                A,52      >CSTMPM,A,51
    CSPPM  - COST OF SPARES PER MONTH (DOLLARS) <52>
```

```
CAPM.K=ADR.K                                              A,53     >SCPM,A,49
    CAPM    - COST OF ASSETS PER MONTH (DOLLARS) <53>
    ADR     - ASSET DEPLETION RATE (DOLLARS/MONTH) <64>

DEP.K=2250E3                                              A,54     >SCPM,A,49
    DEP     - DEPRECIATION (DOLLARS/MONTH) 2.3 SERVICE PROFIT
              MARGIN <54>


          2.1.3 SERVICE PROFIT MARGIN

SPM.K=(SRPM.K-SCPM.K)/SRPM.K                              A,55     >SPMT,A,56/SPMR,A,58/P,A,111/PLOT,113/PRINT,115
    SPM     - SERVICE PROFIT MARGIN (PERCENT) <55>
    SRPM    - SERVICE REVENUE PER MONTH (DOLLARS) <42>
    SCPM    - SERVICE COST PER MONTH (DOLLARS) <49>

SPMT.K=MAX(0.1,DELAY3(SPM.K,TCSPMT.K))                    A,56     >SPMR,A,58
    SPMT    - SERVICE PROFIT MARGIN TARGET (PERCENT) <56>
    MAX     - LOGICAL MAXIMUM FUNCTION
    DELAY3  - THIRD ORDER AVERAGING MACRO
    SPM     - SERVICE PROFIT MARGIN (PERCENT) <55>
    TCSPMT  - (MONTHS) TIME TO CHANGE SPMT <57>

TCSPMT.K=36                                               A,57     >SPMT,A,56
    TCSPMT  - (MONTHS) TIME TO CHANGE SPMT <57>

SPMR.K=SPM.K/SPMT.K                                       A,58     >FCA,A,59/FCL,A,60
SPMR=1                                                    N,58.1
    SPMR    - SERVICE PROFIT MARGIN RATIO (DIMENSIONLESS) <58>
    SPM     - SERVICE PROFIT MARGIN (PERCENT) <55>
    SPMT    - SERVICE PROFIT MARGIN TARGET (PERCENT) <56>

FCA.K=TABLE(TFCA,SPMR.K,0.5,1.5,0.25)                     A,59     >AIR,R,62
TFCA=0.75,0.85,1,1.05,1.1                                 T,59.1   >FCA,A,59
    FCA     - FINANCIAL CONSTRAINT ON ASSETS (DIMENSIONLESS)
              <59>
    TABLE   - TABLE FUNCTION
    TFCA    - TABLE FOR FCA <59>
    SPMR    - SERVICE PROFIT MARGIN RATIO (DIMENSIONLESS) <58>

FCL.K=TABLE(TFCL,SPMR.K,0.5,1.5,0.25)                     A,60     >FLMR,R,66
TFCL=0.75,0.85,1,1.05,1.1                                 T,60.1   >FCL,A,60
    FCL     - FINANCIAL CONSTRAINT ON LABOR (DIMENSIONLESS)
              <60>
    TABLE   - TABLE FUNCTION
    TFCL    - TABLE FOR FCL 3.1 ASSET SECTOR <60>
    SPMR    - SERVICE PROFIT MARGIN RATIO (DIMENSIONLESS) <58>
```

2.2.0 SERVICE SECTOR

2.2.1 ASSETS

```
A.K=A.J+DT*(AIR.JK-ADR.JK)                              L,61      >AIR,R,62/ADR,R,64/MEAS,A,80/PLOT,113/PRINT,115
A=142.5E6                                               N,61.1
    A       - ASSETS (DOLLARS) <61>
    DT      - SOLUTION TIME INTERVAL <112>
    AIR     - ASSET INVESTMENT RATE (DOLLARS/MONTH) <62>
    ADR     - ASSET DEPLETION RATE (DOLLARS/MONTH) <64>

AIR.KL=(((DA.K-A.K)/ATAI)+LTADR.K)*FCA.K                R,62      >A,L,61
ATAI=6                                                  C,62.1    >AIR,R,62
    AIR     - ASSET INVESTMENT RATE (DOLLARS/MONTH) <62>
    DA      - DESIRED ASSETS (DOLLARS) 4.0 SUPPLEMENTARY
              EQUATIONS <108>
    A       - ASSETS (DOLLARS) <61>
    ATAI    - (MONTHS) AVERAGE TIME TO AQUIRE ASSET <62>
    LTADR   - LONG TERM ASSET DEPLETION RATE (DOLLARS/MONTH)
              <63>
    FCA     - FINANCIAL CONSTRAINT ON ASSETS (DIMENSIONLESS)
              <59>

LTADR.K=SMOOTH(ADR.K,TSADR)                             A,63      >AIR,R,62
TSADR=12                                                C,63.1    >LTADR,A,63
    LTADR   - LONG TERM ASSET DEPLETION RATE (DOLLARS/MONTH)
              <63>
    SMOOTH  - FIRST ORDER AVERAGING MACRO
    ADR     - ASSET DEPLETION RATE (DOLLARS/MONTH) <64>
    TSADR   - (MONTHS) TIME TO SMOOTH ADR <63>

ADR.KL=A.K/ALA                                          R,64      >CAPM,A,53/A,L,61/LTADR,A,63
ALA=60                                                  C,64.1    >ADR,R,64
    ADR     - ASSET DEPLETION RATE (DOLLARS/MONTH) <64>
    A       - ASSETS (DOLLARS) <61>
    ALA     - (MONTHS) AVERAGE LIFE OF ASSETS 3.2 LABOR SECTOR
              <64>
```

2.2.2 LABOR

```
L.K=L.J+DT*(LHR.JK-LAR.JK)                              L,65      >CLPM,A,50/LHR,R,66/LAR,R,68/CEL,L,72/AEL,A,73/EL,
L=3792.2                                                N,65.1     MOT,A,83/OT,A,85/MCAP,A,87/PLOT,113/PRINT,115
    L       - LABOR (PERSONS) <65>
    DT      - SOLUTION TIME INTERVAL <112>
    LHR     - LABOR HIRE RATE (PERSONS/MONTH) <66>
    LAR     - LABOR ATTRITION RATE (PERSONS/MONTH) <68>
```

```
LHR.KL=(((DL.K-L.K+LTOT.K+LCB.K)/ATHL)+LTLAR.K)*FCL.K         R,66      >L,L,65
ATHL=6                                                        C,66.1    >LHR,R,66
    LHR    - LABOR HIRE RATE (PERSONS/MONTH) <66>
    DL     - DESIRED LABOR (PERSONS) <107>
    L      - LABOR (PERSONS) <65>
    LTOT   - LONG TERM OVERTIME (PERSONS) <69>
    LCB    - LABOR CORRECTION FOR LABOR (PEOPLE/MONTH) <70>
    ATHL   - (MONTHS) AVERAGE TIME TO HIRE LABOR <66>
    LTLAR  - LONG TERM LABOR ATTRITION RATE (PERONS/MONTH)
             <67>
    FCL    - FINANCIAL CONSTRAINT ON LABOR (DIMENSIONLESS)
             <60>

LTLAR.K=SMOOTH(LAR.K,TSLAR)                                   A,67      >LHR,R,66
TSLAR=12                                                      C,67.1    >LTLAR,A,67
    LTLAR  - LONG TERM LABOR ATTRITION RATE (PERONS/MONTH)
             <67>
    SMOOTH - FIRST ORDER AVERAGING MACRO
    LAR    - LABOR ATTRITION RATE (PERSONS/MONTH) <68>
    TSLAR  - (MONTHS) TIME TO SMOOTH LAR <67>

LAR.KL=L.K/ALL                                                R,68      >L,L,65/LTLAR,A,67/CEL,L,72
ALL=60                                                        C,68.1    >LAR,R,68
    LAR    - LABOR ATTRITION RATE (PERSONS/MONTH) <68>
    L      - LABOR (PERSONS) <65>
    ALL    - (MONTHS) AVERAGE LIFE OF LABOR <68>

LTOT.K=SMOOTH(OT.K,TSOT)                                      A,69      >LHR,R,66
TSOT=3                                                        C,69.1    >LTOT,A,69
    LTOT   - LONG TERM OVERTIME (PERSONS) <69>
    SMOOTH - FIRST ORDER AVERAGING MACRO
    OT     - OVERTIME (PERSONS) <85>
    TSOT   - (MONTHS) TIME TO SMOOTH OVERTIME <69>

LCB.K=SMOOTH((DB.K-B.K)/LUTIL.K,3)                            A,70      >LHR,R,66
    LCB    - LABOR CORRECTION FOR LABOR (PEOPLE/MONTH) <70>
    SMOOTH - FIRST ORDER AVERAGING MACRO
    DB     - DESIRED BACKLOG (SERVICE CALLS) <71>
    B      - BACKLOG (SERVICE CALLS) <75>
    LUTIL  - LABOR UTILIZATION (SERVICE CALLS/PERSON) <77>

DB.K=NCAP.K                                                   A,71      >LCB,A,70
    DB     - DESIRED BACKLOG (SERVICE CALLS) <71>
    NCAP   - NORMAL CAPACITY (SERVICE CALLS/MONTH) <87>

CEL.K=CEL.J+DT*(L.J-AEL.K*LAR.JK)                             L,72      >AEL,A,73
CEL=227532                                                    N,72.1
    CEL    - CUMULATIVE EXPERIENCE OF LABOR (MONTHS) <72>
    DT     - SOLUTION TIME INTERVAL <112>
    L      - LABOR (PERSONS) <65>
    AEL    - AVERAGE EXPERIENCE OF LABOR (MONTHS/PERSON) 3.3
             SERVICE PERFORMANCE <73>
    LAR    - LABOR ATTRITION RATE (PERSONS/MONTH) <68>
```

```
AEL.K=CEL.K/L.K                                        A,73     >CEL,L,72/MAEL,A,78/PLOT,113/PRINT,115
   AEL    - AVERAGE EXPERIENCE OF LABOR (MONTHS/PERSON) 3.3
             SERVICE PERFORMANCE <73>
   CEL    - CUMULATIVE EXPERIENCE OF LABOR (MONTHS) <72>
   L      - LABOR (PERSONS) <65>

AWPM.K=2000                                            A,74     >CLPM,A,59
   AWPM   - AVERAGE WAGE PER MONTH (DOLLARS/MONTH) <74>
```

2.2.3 SERVICE PERFORMANCE

```
B.K=B.J+DT*(SRNM.K+SRM.K-CAP.K)                        L,75     >LCB,A,70/RL,A,76/HSQ,A,86/PLOT,113/PRINT,115
B=14000                                                N,75.1
   B      - BACKLOG (SERVICE CALLS) <75>
   DT     - SOLUTION TIME INTERVAL <112>
   SRNM   - SERVICE REQUIREMENT FOR NON-MINIS (SERVICE CALLS/
             MONTH) <89>
   SRM    - SERVICE REQUIREMENT FOR MINIS (SERVICE CALLS/
             MONTH) <97>
   CAP    - CAPACITY (SERVICE CALLS/MONTH) <84>

RL.K=(B.K/LUTIL.K)                                     A,76     >MOT,A,83
   RL     - REQUIRED LABOR (PERSONS) <76>
   B      - BACKLOG (SERVICE CALLS) <75>
   LUTIL  - LABOR UTILIZATION (SERVICE CALLS/PERSON) <77>

LUTIL.K=((MLUTIL.K*DLM.K)+(NMLUTL.K*DLNM.K))/DL.K      A,77     >LCB,A,70/RL,A,76/CAP,A,84/NCAP,A,87
   LUTIL  - LABOR UTILIZATION (SERVICE CALLS/PERSON) <77>
   MLUTIL - MINI LABOR UTILIZATION (SERVICE CALLS/PERSON)
             <103>
   DLM    - DESIRED LABOR FOR MINIS (PERSONS) <102>
   NMLUTL - NON-MINI LABOR UTILIZATION (SERVICE CALLS/
             PERSON) <95>
   DLNM   - DESIRED LABOR FOR NON-MINIS (PERSONS) <94>
   DL     - DESIRED LABOR (PERSONS) <107>

MAEL.K=TABLE(TMAEL1,AEL.K,0,96,12)*SWMAEL.K+TABLE(TMAEL2,   A,78     >NMLUTL,A,95/MLUTIL,A,103
 AEL.K,0,96,12)*(1-SWMAEL.K)
TMAEL1=.5,.8,1,1.05,1.08,1.1,1.1,1.1,1.1               T,78.1   >MAEL,A,78
TMAEL2=.5,1,1.05,1.08,1.1,1.1,1.1,1.1,1.1              T,78.2   >MAEL,A,78
   MAEL   - MULTIPLIER FOR AEL (DIMENSIONLESS) <78>
   TABLE  - TABLE FUNCTION
   TMAEL1 - TABLE#1 FOR MAEL <78>
   AEL    - AVERAGE EXPERIENCE OF LABOR (MONTHS/PERSON) 3.3
             SERVICE PERFORMANCE <73>
   SWMAEL - SWITCH FOR MULTIPLIER FOR AEL (DIMENSIONLESS)
             <79>
   TMAEL2 - TABLE#2 FOR MAEL <78>

SWMAEL.K=1-STEP(1,TSMAEL)                              A,79     >MAEL,A,78
TSMAEL=1000                                            C,79.1   >SWMAEL,A,79
   SWMAEL - SWITCH FOR MULTIPLIER FOR AEL (DIMENSIONLESS)
             <79>
   TSMAEL - TIME TO TURN ON SWMAEL (MONTHS) <79>
```

```
MEAS.K=TABLE(TMEAS,A.K/RA.K,0,2,0.25)                     A,80      >NMLUTL,A,95/MLUTIL,A,103
TMEAS=0,0.2,0.5,0.9,1,1,1,1,1                             T,80.1    >MEAS,A,80
    MEAS   - MULTIPLIER FOR ASSET EFFECT OF SERVICE
             (DIMENSIONLESS) <80>
    TABLE  - TABLE FUNCTION
    TMEAS  - TABLE FOR MEAS <80>
    A      - ASSETS (DOLLARS) <61>
    RA     - REQUIRED ASSETS (DOLLARS) <81>

RA.K=SRNM.K*ANSRNM+SRM.K*ANSRM.K                          A,81      >MEAS,A,80/PLOT,113/PRINT,115
    RA     - REQUIRED ASSETS (DOLLARS) <81>
    SRNM   - SERVICE REQUIREMENT FOR NON-MINIS (SERVICE CALLS/
             MONTH) <89>
    ANSRNM - (ASSETS-MONTH/SERVICE CALLS) ASSETS NEEDED FOR
             SRNM <96>
    SRM    - SERVICE REQUIREMENT FOR MINIS (SERVICE CALLS/
             MONTH) <97>
    ANSRM  - ASSETS NEEDED PER SRM (DOLLARS-MONTH/SERVICE
             CALL) <106>

EL.K=L.K*MOT.K                                            A,82      >CAP,A,84/OT,A,85
    EL     - EQUIVALENT LABOR (PERSONS) <82>
    L      - LABOR (PERSONS) <65>
    MOT    - MULTIPLIER FOR OVERTIME (DIMENSIONLESS) <83>

MOT.K=TABLE(TMOT,RL.K/L.K,0,1.25,0.25)                    A,83      >EL,A,82/PLOT,113/PRINT,115
TMOT=0,.25,.5,.75,1,1.25                                  T,83.1    >MOT,A,83
    MOT    - MULTIPLIER FOR OVERTIME (DIMENSIONLESS) <83>
    TABLE  - TABLE FUNCTION
    TMOT   - TABLE FOR MOT <83>
    RL     - REQUIRED LABOR (PERSONS) <76>
    L      - LABOR (PERSONS) <65>

CAP.K=EL.K*LUTIL.K                                        A,84      >B,L,75
    CAP    - CAPACITY (SERVICE CALLS/MONTH) <84>
    EL     - EQUIVALENT LABOR (PERSONS) <82>
    LUTIL  - LABOR UTILIZATION (SERVICE CALLS/PERSON) <77>

OT.K=EL.K-L.K                                             A,85      >CLPM,A,50/LTOT,A,69
    OT     - OVERTIME (PERSONS) <85>
    EL     - EQUIVALENT LABOR (PERSONS) <82>
    L      - LABOR (PERSONS) <65>

HSQ.K=NCAP.K/B.K                                          A,86      >HSQ,A,16/PLOT,113/PRINT,115
    HSQ    - HONEYWELL SERVICE QUALITY (SQ) <86>
    NCAP   - NORMAL CAPACITY (SERVICE CALLS/MONTH) <87>
    B      - BACKLOG (SERVICE CALLS) <75>

NCAP.K=L.K*LUTIL.K                                        A,87      >DB,A,71/HSQ,A,86
    NCAP   - NORMAL CAPACITY (SERVICE CALLS/MONTH) <87>
    L      - LABOR (PERSONS) <65>
    LUTIL  - LABOR UTILIZATION (SERVICE CALLS/PERSON) <77>
```

2.2.4 SERVICE REQUIREMENTS

2.2.4.1 NON-MINI INSTALLATIONS

```
NMI.K=TABLE(TNMI,TIME.K,0,120,120)                     A,88      >SRNMSH,A,47/SRNM,A,89/PLOT,114
TNMI=12500,12500                                       T,88.1    >NMI,A,88
    NMI    - NON-MINI INSTALLATIONS (INSTALLATIONS) <88>
    TABLE  - TABLE FUNCTION
    TNMI   - TABLE FOR NON MINI INSTALLATIONS <88>

SRNM.K=NMI.K/ER.K                                      A,89      >B,L,75/RA,A,81/ASRNM,A,91/TRSRNM,A,92
    SRNM   - SERVICE REQUIREMENT FOR NON-MINIS (SERVICE CALLS/
             MONTH) <89>
    NMI    - NON-MINI INSTALLATIONS (INSTALLATIONS) <88>
    ER     - (DIMENSIONLESS) EQUIPMENT RELIABILITY <90>

ER.K=1+STEP(STER,TSTER)                                A,90      >SRNM,A,89
STER=0                                                 C,90.1    >ER,A,90
TSTER=6                                                C,90.2    >ER,A,90
    ER     - (DIMENSIONLESS) EQUIPMENT RELIABILITY <90>
    STER   - STEP TEST FOR ER (FARCTION) <90>
    TSTER  - (MONTHS) TIME FOR STEP TEST FOR ER <90>

ASRNM.K=SMOOTH(SRNM.K,TASRNM)                          A,91      >FSRNM,A,93
TASRNM=12                                              C,91.1    >ASRNM,A,91/TRSRNM,A,92
    ASRNM  - AVERAGE SERVICE REQUIREMENT FOR NON-MINIS (CALLS/
             MONTH) <91>
    SMOOTH - FIRST ORDER AVERAGING MACRO
    SRNM   - SERVICE REQUIREMENT FOR NON-MINIS (SERVICE CALLS/
             MONTH) <89>
    TASRNM - (MONTHS) TIME TO AVERAGE SRNM <91>

TRSRNM.K=TREND(SRNM.K,TASRNM,TETRNM,ITSRNM)            A,92      >FSRNM,A,93
TETRNM=18                                              C,92.1    >TRSRNM,A,92
ITSRNM=0                                               C,92.2    >TRSRNM,A,92
    TRSRNM - TREND FOR SRNM (CALLS/MONTH) <92>
    TREND  - TREND MACRO
    SRNM   - SERVICE REQUIREMENT FOR NON-MINIS (SERVICE CALLS/
             MONTH) <89>
    TASRNM - (MONTHS) TIME TO AVERAGE SRNM <91>
    TETRNM - (MONTHS) TIME TO ESTABLISH TREND FOR SRNM <92>
    ITSRNM - (SERVICE CALLS PER MONTH) INITIAL TREND FOR SRNM
             <92>

FSRNM.K=ASRNM.K+FP*TRSRNM.K                            A,93      >DLNM,A,94/DANM,A,96
FP=6                                                   C,93.1    >FSRNM,A,93/FSRM,A,101
    FSRNM  - FORECAST OF SRNM (SERVICE CALLS/MONTH) <93>
    ASRNM  - AVERAGE SERVICE REQUIREMENT FOR NON-MINIS (CALLS/
             MONTH) <91>
    FP     - (MONTHS) FORECAST PERIOD <93>
    TRSRNM - TREND FOR SRNM (CALLS/MONTH) <92>

DLNM.K=FSRNM.K/NMLUTL.K                                A,94      >LUTIL,A,77/DL,A,107
    DLNM   - DESIRED LABOR FOR NON-MINIS (PERSONS) <94>
    FSRNM  - FORECAST OF SRNM (SERVICE CALLS/MONTH) <93>
    NMLUTL - NON-MINI LABOR UTILIZATION (SERVICE CALLS/
             PERSON) <95>
```

```
NMLUTL.K=3.5*MAEL.K*MEAS.K                                    A,95      >LUTIL,A,77/DLNM,A,94
    NMLUTL - NON-MINI LABOR UTILIZATION (SERVICE CALLS/
             PERSON) <95>
    MAEL   - MULTIPLIER FOR AEL (DIMENSIONLESS) <78>
    MEAS   - MULTIPLIER FOR ASSET EFFECT OF SERVICE
             (DIMENSIONLESS) <80>

DANM.K=FSRNM.K*ANSRNM                                         A,96      >DA,A,108
ANSRNM=9E3                                                    C,96.1    >RA,A,81/DANM,A,96
    DANM   - DASIRED ASSETS FOR NON-MINIS (DOLLARS) <96>
    FSRNM  - FORECAST OF SRNM (SERVICE CALLS/MONTH) <93>
    ANSRNM - (ASSETS-MONTH/SERVICE CALLS) ASSETS NEEDED FOR
             SRNM <96>
```

2.2.4.2 MINI INSTALLATIONS

```
SRM.K=(HISM.K+RISM.K)/CIS.K                                   A,97      >B,L,75/RA,A,81/ASRM,A,99/TRSRM,A,100
    SRM    - SERVICE REQUIREMENT FOR MINIS (SERVICE CALLS/
             MONTH) <97>
    HISM   - HONEYWELL INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <29>
    RISM   - RESELLER INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <36>
    CIS    - (DIMENSIONLESS) CUSTOMER INITIATED SERVICE <98>

CIS.K=1+STEP(STCIS,TSTCIS)                                    A,98      >SRM,A,97
STCIS=0                                                       C,98.1    >CIS,A,98
TSTCIS=6                                                      C,98.2    >CIS,A,98
    CIS    - (DIMENSIONLESS) CUSTOMER INITIATED SERVICE <98>
    STCIS  - STEP TEST FOR CIS (FRACTION) <98>
    TSTCIS - (MONTHS) TIME FOR STEP TEST FOR CIS <98>

ASRM.K=SMOOTH(SRM.K,TSSRM)                                    A,99      >FSRM,A,101
TSSRM=12                                                      C,99.1    >ASRM,A,99/TRSRM,A,100
    ASRM   - AVERAGE SERVICE REQUIREMENT FOR MINIS (CALLS/
             MONTH) <99>
    SMOOTH - FIRST ORDER AVERAGING MACRO
    SRM    - SERVICE REQUIREMENT FOR MINIS (SERVICE CALLS/
             MONTH) <97>
    TSSRM  - (MONTHS) TIME TO SMOOTH SRM <99>

TRSRM.K=TREND(SRM.K,TSSRM,TETSRM,ITSRM)                       A,100     >FSRM,A,101
TETSRM=18                                                     C,100.1   >TRSRM,A,100
ITSRM=0                                                       C,100.2   >TRSRM,A,100
    TRSRM  - TREND FOR SRM (CALLS/MONTH) <100>
    TREND  - TREND MACRO
    SRM    - SERVICE REQUIREMENT FOR MINIS (SERVICE CALLS/
             MONTH) <97>
    TSSRM  - (MONTHS) TIME TO SMOOTH SRM <99>
    TETSRM - (MONTHS) TIME TO SETABLISH TREND FOR SRM <100>
    ITSRM  - (SERVICE CALLS /MONTH) INITIAL TREND FOR SRM
             <100>
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FSRM.K=ASRM.K+TRSRM.K*FP                                   A,101    >DLM,A,102/DAM,A,105
    FSRM   - FORECAST FOR SRM (SERVICE CALLS/MONTH) <101>
    ASRM   - AVERAGE SERVICE REQUIREMENT FOR MINIS (CALLS/
             MONTH) <99>
    TRSRM  - TREND FOR SRM (CALLS/MONTH) <100>
    FP     - (MONTHS) FORECAST PERIOD <93>

DLM.K=FSRM.K/MLUTIL.K                                      A,102    >LUTIL,A,77/DL,A,107
    DLM    - DESIRED LABOR FOR MINIS (PERSONS) <102>
    FSRM   - FORECAST FOR SRM (SERVICE CALLS/MONTH) <101>
    MLUTIL - MINI LABOR UTILIZATION (SERVICE CALLS/PERSON)
             <103>

MLUTIL.K=TABLE(TMLUT,(RISH.K+HISH.K),1.5E3,21.5E3,5E3)*MMIV.K* A,103 >LUTIL,A,77/DLM,A,102
 MAEL.K*MEAS.K
TMLUT=2.5,4.0,6.5,9,10                                     T,103.1  >MLUTIL,A,103
    MLUTIL - MINI LABOR UTILIZATION (SERVICE CALLS/PERSON)
             <103>
    TABLE  - TABLE FUNCTION
    TMLUT  - TABLE FOR MLUTIL <103>
    RISH   - RESELLER INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <36>
    HISH   - HONEYWELL INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <29>
    MMIV   - (DIMENSIONLESS) MULTIPLIER FOR MAN IN THE VAN
             PROGRAM <104>
    MAEL   - MULTIPLIER FOR AEL (DIMENSIONLESS) <78>
    MEAS   - MULTIPLIER FOR ASSET EFFECT OF SERVICE
             (DIMENSIONLESS) <80>

MMIV.K=1+STEP(STMMIV,TMMIV)                                A,104    >MLUTIL,A,103
STMMIV=0                                                   C,104.1  >MMIV,A,104
TMMIV=6                                                    C,104.2  >MMIV,A,104
    MMIV   - (DIMENSIONLESS) MULTIPLIER FOR MAN IN THE VAN
             PROGRAM <104>
    STMMIV - (FRACTION) STEP TEST FOR MAN IN THE VAN PROGRAM
             <104>
    TMMIV  - (MONTHS) TIME FOR STEP TESTR FOR MAN IN THE VAN
             PROGRAM <104>

DAM.K=FSRM.K*ANSRM.K                                       A,105    >DA,A,109
    DAM    - DESIRED ASSETS FOR MINIS (DOLLARS) <105>
    FSRM   - FORECAST FOR SRM (SERVICE CALLS/MONTH) <101>
    ANSRM  - ASSETS NEEDED PER SRM (DOLLARS-MONTH/SERVICE
             CALL) <106>

ANSRM.K=TABLE(TLANM,(RISH.K+HISH.K),1.5E3,21.5E3,5E3)      A,106    >RA,A,81/DAM,A,105
TLANM=20E3,14E3,7.5E3,4.0E3,2.5E3                          T,106.1  >ANSRM,A,106
    ANSRM  - ASSETS NEEDED PER SRM (DOLLARS-MONTH/SERVICE
             CALL) <106>
    TABLE  - TABLE FUNCTION
    TLANM  - TABLE FOR ANSRM <106>
    RISH   - RESELLER INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <36>
    HISH   - HONEYWELL INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <29>
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DL.K=DLM.K+DLNM.K                                    A,107    >LHR,R,66/LUTIL,A,77
    DL     - DESIRED LABOR (PERSONS) <107>
    DLM    - DESIRED LABOR FOR MINIS (PERSONS) <102>
    DLNM   - DESIRED LABOR FOR NON-MINIS (PERSONS) <94>

DA.K=DAM.K+DANM.K                                    A,108    >AIR,R,62
    DA     - DESIRED ASSETS (DOLLARS) 4.0 SUPPLEMENTARY
               EQUATIONS <108>
    DAM    - DESIRED ASSETS FOR MINIS (DOLLARS) <105>
    DANM   - DASIRED ASSETS FOR NON-MINIS (DOLLARS) <96>


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           3.0  SUPPLEMENTARY  EQUATIONS

AP.K=AP.J+DT*P.J                                     L,109    >PRINT,116
AP=0                                                 N,109.1
    AP     - ACCUMULATED PROFIT (DOLLARS) <109>
    DT     - SOLUTION TIME INTERVAL <112>
    P      - PROFIT PER MONTH (PERCENT) 5.0 DYNAMO
               DEFINITIONS <111>

AR.K=AR.J+DT*SRPM.J                                  L,110    >PRINT,116
AR=0                                                 N,110.1
    AR     - ACCUMULATED REVENUE (DOLLARS) <110>
    DT     - SOLUTION TIME INTERVAL <112>
    SRPM   - SERVICE REVENUE PER MONTH (DOLLARS) <42>

P.K=SRPM.K*SPM.K                                     A,111    >AP,L,109/PRINT,116
    P      - PROFIT PER MONTH (PERCENT) 5.0 DYNAMO
               DEFINITIONS <111>
    SRPM   - SERVICE REVENUE PER MONTH (DOLLARS) <42>
    SPM    - SERVICE PROFIT MARGIN (PERCENT) <55>


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              4.0  CONTROL CARDS

SPEC DT=0.25/LENGTH=24/PLTPER=0/PRTPER=3              112
    DT     - SOLUTION TIME INTERVAL <112>
    LENGTH - LENGTH OF SIMULATION <112>
    PLTPER - PLOT PERIOD <112>
    PRTPER - PRINT PERIOD <112>
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PLOT A=A,RA=D(150E6,350E6)/L=L(5E3,10E3)/MOT=O(0.75,1.25)/        113
 B=B(0,80E3)/HSQ=Q(0.825,1.025)/SPM=P(0.2,0.6)/AEL=E(40,80)/
 SRPM=R,SCPM=C(10E6,70E6)
     A      - ASSETS (DOLLARS) <61>
     RA     - REQUIRED ASSETS (DOLLARS) <81>
     L      - LABOR (PERSONS) <65>
     MOT    - MULTIPLIER FOR OVERTIME (DIMENSIONLESS) <83>
     B      - BACKLOG (SERVICE CALLS) <75>
     HSQ    - HONEYWELL SERVICE QUALITY (SQ) <86>
     SPM    - SERVICE PROFIT MARGIN (PERCENT) <55>
     AEL    - AVERAGE EXPERIENCE OF LABOR (MONTHS/PERSON) 3.3
                SERVICE PERFORMANCE <73>
     SRPM   - SERVICE REVENUE PER MONTH (DOLLARS) <42>
     SCPM   - SERVICE COST PER MONTH (DOLLARS) <49>

PLOT NMI=N,HI=H,RI=R,HISH=1,HISTM=2,RISH=3,RISTM=4(0,40E3)        114
     NMI    - NON-MINI INSTALLATIONS (INSTALLATIONS) <88>
     HI     - HONEYWELL INSTALLATIONS (MINICOMPUTERS) <6>
     RI     - RESELLER INSTALLTIONS (MINICOMPUTERS) <20>
     HISH   - HONEYWELL INSTALLATIONS SERVICE BY HSD
                (MINICOMPUTERS) <29>
     HISTM  - HONEYWELLINSTALLATIONS SERVICE BY THIRD PARTY
                MAINTAINERS (MINIC <35>
     RISH   - RESELLER INSTALLATIONS SERVICE BY HSD
                (MINICOMPUTERS) <36>
     RISTM  - RESELLER INSTALLATIONS SERVICE BY THIRD PARTY
                MAINTAINERS (MINIC FINANCIAL SUBSYSTEM 2.1
                SERVICE REVENUE <40>

PRINT A,RA,L,MOT,B,HSQ,SPM,AEL,SRPM,SCPM                          115
     A      - ASSETS (DOLLARS) <61>
     RA     - REQUIRED ASSETS (DOLLARS) <81>
     L      - LABOR (PERSONS) <65>
     MOT    - MULTIPLTER FOR OVERTIME (DIMENSIONLESS) <83>
     B      - BACKLOG (SERVICE CALLS) <75>
     HSQ    - HONEYWELL SERVICE QUALITY (SQ) <86>
     SPM    - SERVICE PROFIT MARGIN (PERCENT) <55>
     AEL    - AVERAGE EXPERIENCE OF LABOR (MONTHS/PERSON) 3.3
                SERVICE PERFORMANCE <73>
     SRPM   - SERVICE REVENUE PER MONTH (DOLLARS) <42>
     SCPM   - SERVICE COST PER MONTH (DOLLARS) <49>
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PRINT HI,RI,HISH,RISH,HISTM,RISTM,AP,AR,P,THHM                     116
    HI     - HONEYWELL INSTALLATIONS (MINICOMPUTERS) <6>
    RI     - RESELLER INSTALLTIONS (MINICOMPUTERS) <20>
    HISH   - HONEYWELL INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <29>
    RISH   - RESELLER INSTALLATIONS SERVICE BY HSD
             (MINICOMPUTERS) <36>
    HISTM  - HONEYWELLINSTALLATIONS SERVICE BY THIRD PARTY
             MAINTAINERS (MINIC <35>
    RISTM  - RESELLER INSTALLATIONS SERVICE BY THIRD PARTY
             MAINTAINERS (MINIC FINANCIAL SUBSYSTEM 2.1
             SERVICE REVENUE <40>
    AP     - ACCUMULATED PROFIT (DOLLARS) <109>
    AR     - ACCUMULATED REVENUE (DOLLARS) <110>
    P      - PROFIT PER MONTH (PERCENT) 5.0 DYNAMO
             DEFINITIONS <111>
    THHM   - TOTAL MARKET OF HONEYWELL MINICOMPUTERS
             (MINICOMPUTERS) 1.2 RESELLER SALES <19>

OPT TXT=4/PLW=50/P                                                 117
RUN BASE                                                           118
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LIST OF VARIABLES

SYMBOL	T	WHR-CMP	DEFINITION
A	L	61	ASSETS (DOLLARS) <61>
	N	61.1	
ADR	R	64	ASSET DEPLETION RATE (DOLLARS/MONTH) <64>
AEL	A	73	AVERAGE EXPERIENCE OF LABOR (MONTHS/PERSON) 3.3 SERVICE PERFORMANCE <73>
AIR	R	62	ASSET INVESTMENT RATE (DOLLARS/MONTH) <62>
ALA	C	64.1	(MONTHS) AVERAGE LIFE OF ASSETS 3.2 LABOR SECTOR <64>
ALI	C	18.2	(MONTHS) AVERAGE LIFE OF MINICOMPUTER INSTALLATIONS <18>
ALL	C	68.1	(MONTHS) AVERAGE LIFE OF LABOR <68>
ANSRM	A	106	ASSETS NEEDED PER SRM (DOLLARS-MONTH/SERVICE CALL) <106>
ANSRNM	C	96.1	(ASSETS-MONTH/SERVICE CALLS) ASSETS NEEDED FOR SRNM <96>
AP	L	109	ACCUMULATED PROFIT (DOLLARS) <109>
	N	109.1	
AR	L	110	ACCUMULATED REVENUE (DOLLARS) <110>
	N	110.1	
ASRM	A	99	AVERAGE SERVICE REQUIREMENT FOR MINIS (CALLS/MONTH) <99>
ASRNM	A	91	AVERAGE SERVICE REQUIREMENT FOR NON-MINIS (CALLS/MONTH) <91>
ATAI	C	62.1	(MONTHS) AVERAGE TIME TO AQUIRE ASSET <62>
ATCSC	C	30.1	(MONTHS) AVERAGE TIME TO CHANGE SERVICE CONTRACT <30>
ATHL	C	66.1	(MONTHS) AVERAGE TIME TO HIRE LABOR <66>
AWPM	A	74	AVERAGE WAGE PER MONTH (DOLLARS/MONTH) <74>
B	L	75	BACKLOG (SERVICE CALLS) <75>
	N	75.1	
CAP	A	84	CAPACITY (SERVICE CALLS/MONTH) <84>
CAPM	A	53	COST OF ASSETS PER MONTH (DOLLARS) <53>
CEL	L	72	CUMULATIVE EXPERIENCE OF LABOR (MONTHS) <72>
	N	72.1	
CIS	A	98	(DIMENSIONLESS) CUSTOMER INITIATED SERVICE <98>
CLPM	A	50	COST OF LABOR PER MONTH (DOLLARS) <50>
CSP	A	11	COMPETITORS SERVICE PRICE (DOLLARS/MONTH) <11>
CSPPM	A	52	COST OF SPARES PER MONTH (DOLLARS) <52>
CSTMPM	A	51	COST OF SPARES SOLD TO THIRD PARTY MAINTAINERS PER MONTH (DOLLAR <51>
DA	A	108	DESIRED ASSETS (DOLLARS) 4.0 SUPPLEMENTARY EQUATIONS <108>
DAM	A	105	DESIRED ASSETS FOR MINIS (DOLLARS) <105>
DANM	A	96	BASIRED ASSETS FOR NON-MINIS (DOLLARS) <96>
DB	A	71	DESIRED BACKLOG (SERVICE CALLS) <71>
DELAY3			THIRD ORDER AVERAGING MACRO
DEP	A	54	DEPRECIATION (DOLLARS/MONTH) 2.3 SERVICE PROFIT MARGIN <54>
DHSP	A	27	DISCOUNT HONEYWELL SERVICE PRICE (DOLLARS/MONTH) <27>
DL	A	107	DESIRED LABOR (PERSONS) <107>
DLM	A	102	DESIRED LABOR FOR MINIS (PERSONS) <102>

DLNM	A	94	DESIRED LABOR FOR NON-MINIS (PERSONS) <94>
DPPR	C	27.1	DISCOUNT PRICING POLICY TO RESELLER (FRACTION) <27>
DT	C	112	SOLUTION TIME INTERVAL <112>
DTHI	A	8	(MONTHS)DOUBLING TIME FOR HONEYWELL INSTALLATIONS <8>
DTRI	A	22	DOUBLING TIME FOR RESELLER INSTALLATIONS (MONTHS) <22>
EL	A	82	EQUIVALENT LABOR (PERSONS) <82>
ER	A	90	(DIMENSIONLESS) EQUIPMENT RELIABILITY <90>
FCA	A	59	FINANCIAL CONSTRAINT ON ASSETS (DIMENSIONLESS) <59>
FCL	A	60	FINANCIAL CONSTRAINT ON LABOR (DIMENSIONLESS) <60>
FP	C	93.1	(MONTHS) FORECAST PERIOD <93>
FSRM	A	101	FORECAST FOR SRM (SERVICE CALLS/MONTH) <101>
FSRNM	A	93	FORECAST OF SRNM (SERVICE CALLS/MONTH) <93>
HDR	R	17	HONEYWELL DEPLETION RATE (MINICOMPUTERS/MONTH) <17>
HI	L	6	HONEYWELL INSTALLATIONS (MINICOMPUTERS) <6>
	N	6.1	
HICSCR	R	30	HONEYWELL INSTALLATIONS CHANGE OF SERVICE CONTRACT RATE (MINICOM <30>
HISH	L	29	HONEYWELL INSTALLATIONS SERVICE BY HSD
	N	29.1	(MINICOMPUTERS) <29>
HISHLR	A	31	HONEYWELL INSTALLATIONS SERVICE BY HSD LEAVING RATE (MINICOMPUTE <31>
HISTLR	A	33	HONEYWELL INSTALLTIONS SERVICE BY THIRD PARTY MAINTAINERS LEAVIN <33>
HISTM	L	35	HONEYWELLINSTALLATIONS SERVICE BY THIRD PARTY
	N	35.1	MAINTAINERS (MINIC <35>
HSP	A	10	HONEYWELL SERVICE PRICE (DOLLARS/MONTH) <10>
HSQ	A	86	HONEYWELL SERVICE QUALITY (SQ) <86>
HSR	R	7	HONEYWELL SALES RATE (MINICOMPUTERS/MONTH) <7>
ITSRM	C	100.2	(SERVICE CALLS /MONTH) INITIAL TREND FOR SRM <100>
ITSRNM	C	92.2	(SERVICE CALLS PER MONTH) INITIAL TREND FOR SRNM <92>
L	L	65	LABOR (PERSONS) <65>
	N	65.1	
LAR	R	68	LABOR ATTRITION RATE (PERSONS/MONTH) <68>
LCB	A	70	LABOR CORRECTION FOR LABOR (PEOPLE/MONTH) <70>
LENGTH	C	112	LENGTH OF SIMULATION <112>
LHR	R	66	LABOR HIRE RATE (PERSONS/MONTH) <66>
LTADR	A	63	LONG TERM ASSET DEPLETION RATE (DOLLARS/MONTH) <63>
LTLAR	A	67	LONG TERM LABOR ATTRITION RATE (PERONS/MONTH) <67>
LTOT	A	69	LONG TERM OVERTIME (PERSONS) <69>
LUTIL	A	77	LABOR UTILIZATION (SERVICE CALLS/PERSON) <77>
MAEL	A	78	MULTIPLIER FOR AEL (DIMENSIONLESS) <78>
MAX			LOGICAL MAXIMUM FUNCTION
MEAS	A	80	MULTIPLIER FOR ASSET EFFECT OF SERVICE (DIMENSIONLESS) <80>
MHSA	A	12	MULTIPLIER FOR HONEYWELL SPECIAL APPLICATIONS (DIMENSIONLESS) <12>

MHSP	A	9	MULTIPLIER FOR HONEYWELL SERVICE PRICE (DIMENSIONLESS) <9>
MLUTIL	A	103	MINI LABOR UTILIZATION (SERVICE CALLS/PERSON) <103>
MMAHSD	A	32	MULTIPLIER FOR MOVING AWAY FROM HSD (DIMENSIONLESS) <32>
MMIV	A	104	(DIMENSIONLESS) MULTIPLIER FOR MAN IN THE VAN PROGRAM <104>
MMTHSD	A	34	MULTIPLIER FOR MOVING TOWARDS HSD (DIMENSIONLESS) <34>
MOT	A	83	MULTIPLIER FOR OVERTIME (DIMENSIONLESS) <83>
MPHSQ	A	14	MULTIPLIER FOR PERCEIVED HONEYWELL SERVICE QUALITY (DIMENSIONLES <14>
MRSP	A	23	MULTIPLIER FOR RESELLER SERVICE PRICE (DIMENSIONLESS) <23>
NCAP	A	87	NORMAL CAPACITY (SERVICE CALLS/MONTH) <87>
NMI	A	88	NON-MINI INSTALLATIONS (INSTALLATIONS) <88>
NMLUTIL	A	95	NON-MINI LABOR UTILIZATION (SERVICE CALLS/PERSON) <95>
OT	A	85	OVERTIME (PERSONS) <85>
P	A	111	PROFIT PER MONTH (PERCENT) 5.0 DYNAMO DEFINITIONS <111>
PERG	C	21.1	POLICY TO ENCOURAGE RESELLER GROWTH (FRACTION) <21>
PHSQ	A	15	PERCEIVED HONEYWELL SERVICE QUALITY (FRACTION) <15>
PLTPER	C	112	PLOT PERIOD <112>
PNMISH	A	48	PRICE OF NON-MINI INSTALLATIONS SERVICED BY HONEYWELL (DOLLARS) 2.2 SERVICE COST <48>
PRTPER	C	112	PRINT PERIOD <112>
PSPPM	A	46	PRICE OF SPARES PER MONTH PER INSTALLATION (DOLLARS) <46>
RA	A	81	REQUIRED ASSETS (DOLLARS) <81>
RDR	R	28	RESELLER DEPLETION RATE (MINICOMPUTERS/MONTH) 1.3 SERVICE MARKET <28>
RI	L	20	RESELLER INSTALLTIONS (MINICOMPUTERS) <20>
	N	20.1	
RICSCR	R	37	RESELLER INSTALLATIONS CHANGE OF SERVICE CONTRACT RATE (MINICOMP <37>
RISH	L	36	RESELLER INSTALLATIONS SERVICE BY HSD
	N	36.1	(MINICOMPUTERS) <36>
RISHLR	A	38	RESELLER INSTALLATIONS SERVIVE BY HSD LEAVING RATE (MINICOMPUTER <38>
RISTLR	A	39	RESELLER INSTALLATIONS SERVICE BY THIRD PARTY MAINTAINERS LEAVIN <39>
RISTM	L	40	RESELLER INSTALLATIONS SERVICE BY THIRD PARTY
	N	40.1	MAINTAINERS (MINIC FINANCIAL SUBSYSTEM 2.1 SERVICE REVENUE <40>
RL	A	76	REQUIRED LABOR (PERSONS) <76>
RSP	A	24	RESELLER SERVICE PRICE (DOLLARS /MONTH) <24>
RSR	R	21	RESELLER SALES RATE (MINICOMPUTERS/MONTH) <21>
SA	A	13	HONEYWELL SPECIAL APPLICATIONS (FRACTION) <13>
SCPM	A	49	SERVICE COST PER MONTH (DOLLARS) <49>
SDTHI	C	8.1	STEP TEST FOR DTHI (FRACTION) <8>
SDTRI	C	22.1	STEP TEST FOR DTRI (FRACTION) <22>
SMOOTH			FIRST ORDER AVERAGING MACRO

SPM	A	55	SERVICE PROFIT MARGIN (PERCENT) <55>
SPMR	A	58	SERVICE PROFIT MARGIN RATIO (DIMENSIONLESS) <58>
	N	58.1	*
SPMT	A	56	SERVICE PROFIT MARGIN TARGET (PERCENT) <56>
SPR	A	26	SERVICE POLICY FTO RESELLER (FRACTION) <26>
SRHISH	A	44	SERVICE REVENUE FOR HONEYWELL INSTALLATIONS SERVICED BY HONEYWEL <44>
SRM	A	97	SERVICE REQUIREMENT FOR MINIS (SERVICE CALLS/ MONTH) <97>
SRNM	A	89	SERVICE REQUIREMENT FOR NON-MINIS (SERVICE CALLS/ MONTH) <89>
SRNMSH	A	47	SERVICE REVENUE FOR NON-MINIS SERVICED BY HONEY, (DOLLARS) <47>
SRPM	A	42	SERVICE REVENUE PER MONTH (DOLLARS) <42>
SRRISH	A	43	SERVICE REVENUE FOR RESELLER INSTALLATIONS SERVICED BY HONEYWELL <43>
SRSP	A	45	SERVICE REVENUE DUE TO SPARES (DOLLARS) <45>
STCIS	C	98.1	STEP TEST FOR CIS (FRACTION) <98>
STER	C	90.1	STEP TEST FOR ER (FARCTION) <90>
STHSP	C	10.1	STEP TEST FOR HSP (FRACTION) <10>
STMMIV	C	104.1	(FRACTION) STEP TEST FOR MAN IN THE VAN PROGRAM <104>
STPMSQ	C	18.1	STEP TEST FOR TPMSQ (FRACTION) <18>
STSPR	C	26.1	STEP TEST FOR SPR (FRACTION) <26>
SWMAEL	A	79	SWITCH FOR MULTIPLIER FOR AEL (DIMENSIONLESS) <79>
TABLE			TABLE FUNCTION
TASRNM	C	91.1	(MONTHS) TIME TO AVERAGE SRNM <91>
TCSPMT	A	57	(MONTHS) TIME TO CHANGE SPMT <57>
TETRNM	C	92.1	(MONTHS) TIME TO ESTABLISH TREND FOR SRNM <92>
TETSRM	C	100.1	(MONTHS) TIME TO SETABLISH TREND FOR SRM <100>
TFCA	T	59.1	TABLE FOR FCA <59>
TFCL	T	60.1	TABLE FOR FCL 3.1 ASSET SECTOR <60>
TLANM	T	106.1	TABLE FOR ANSRM <106>
TMAEL1	T	78.1	TABLE#1 FOR MAEL <78>
TMAEL2	T	78.2	TABLE#2 FOR MAEL <78>
TMEAS	T	80.1	TABLE FOR MEAS <80>
TMHM	A	19	TOTAL MARKET OF HONEYWELL MINICOMPUTERS (MINICOMPUTERS) 1.2 RESELLER SALES <19>
TMHSA	T	12.1	TABLE FOR HONEYWELL SPECIAL APPLICATIONS <12>
TMHSP	T	9.1	TABLE FOR MULTIPLIER FOR HONEYWELL SERVICE PRICE <9>
TMLUT	T	103.1	TABLE FOR MLUTIL <103>
TMMAHS	T	32.1	TABLE FOR MULTIPLIER FOR MOVING AWAY OF HSD <32>
TMMIV	C	104.2	(MONTHS) TIME FOR STEP TESTR FOR MAN IN THE VAN PROGRAM <104>
TMMTHS	T	34.1	TABLE FOR MULTIPLIER FOR MOVING TOWARDS HSD <34>
TMOT	T	83.1	TABLE FOR MOT <83>
TMPHSQ	T	14.1	TABLE FOR MULTIPLIER FOR PERCEIVED HONEYWELL SERVICE QUALITY <14>
TMRSP	T	23.1	TABLE FOR MULTIPLIER FOR RESELLER SERVICE PRICE <23>
TNMI	T	88.1	TABLE FOR NON MINI INSTALLATIONS <88>
TPHSQ	C	15.1	(MONTHS) TIME TO PERCEIVE HONEYWELL SERVICE QUALITY <15>
TPMSQ	A	18	THIRD PARTY MAINTAINER SERVICE QUALITY (SQ) <18>

TREND			TREND MACRO
TRSRM	A	100	TREND FOR SRM (CALLS/MONTH) <100>
TRSRNM	A	92	TREND FOR SRNM (CALLS/MONTH) <92>
TSA	T	13.1	TABLE FOR HONEYWELL SPECIAL APPLICATIONS <13>
TSADR	C	63.1	(MONTHS) TIME TO SMOOTH ADR <63>
TSLAR	C	67.1	(MONTHS) TIME TO SMOOTH LAR <67>
TSMAEL	C	79.1	TIME TO TURN ON SUMAEL (MONTHS) <79>
TSOT	C	69.1	(MONTHS) TIME TO SMOOTH OVERTIME <69>
TSSRM	C	99.1	(MONTHS) TIME TO SMOOTH SRM <99>
TSTCIS	C	98.2	(MONTHS) TIME FOR STEP TEST FOR CIS <98>
TSTER	C	90.2	(MONTHS) TIME FOR STEP TEST FOR ER <90>
WARSP	A	25	WEIGHTED AVERAGE RESELLER SERVICE PRICE (DOLLARS/ MONTH) <25>
WSQ	A	16	WEIGHTED SERVICE QUALITY (FRACTION) <16>

WHERE-USED LIST

SYMBOL	WHERE-USED
A	AIR,R,62/AGR,R,64/MEAS,A,80/PLOT,113/PRINT,115
ADR	CAPM,A,53/A,L,61/LTALR,A,63
AEL	CEL,L,72/MAEL,A,78/PLOT,113/PRINT,115
AIR	A,L,61
ALA	ADR,R,64
ALI	HDR,R,17/RDR,R,28/HISH,L,29/HISTM,L,35/RISH,L,36/RISTM,L,40
ALL	LAR,R,68
ANSRM	RA,A,91/DAM,A,105
ANSRNM	RA,A,91/DANM,A,96
AP	PRINT,116
AR	PRINT,116
ASRM	FSRM,A,101
ASRNM	FSRNM,A,93
ATAI	AIR,R,62
ATCSC	HICSCR,R,30/RICSCR,R,37
ATHL	LHR,R,66
AVPM	CLPM,A,50
B	LCB,A,70/RL,A,76/HSQ,A,86/PLOT,113/PRINT,115
CAP	B,L,75
CAPM	SCPM,A,49
CEL	AEL,A,73
CIS	SRM,A,97
CLPM	SCPM,A,49
CSP	MHSP,A,9/HSP,A,10/MRSP,A,23/RSP,A,24
CSPPM	CSTMPM,A,51
CSTMPM	SCPM,A,49
DA	AIR,R,62
DAM	DA,A,108
DANM	DA,A,108
DB	LCB,A,70
DELAY3	PHSQ,A,15/SPMT,A,56
DEP	SCPM,A,49
DHSP	WARSP,A,25/SRRISH,A,43
DL	LHR,R,66/LUTIL,A,77
DLM	LUTIL,A,77/DL,A,107
DLNM	LUTIL,A,77/DL,A,107
DPPR	DHSP,A,27
DTRI	HSR,R,7
DTRI	RSR,R,21
EL	CAP,A,84/DT,A,85
ER	SRNM,A,89
FCA	AIR,R,62
FCL	LHR,R,65
FP	FSRNM,A,93/FSRM,A,101
FSRM	DLM,A,102/DAM,A,105
FSRNM	DLNM,A,94/DANM,A,96
HDR	HI,L,6
HI	HSR,R,7/HDR,R,17/THHM,A,19/HISH,N,29.1/PLOT,114/PRINT,116
HICSCR	HISH,L,29/HISTM,L,35
HISH	WSQ,A,16/HISHLR,A,31/SRHISH,A,44/SRM,A,97/PLUTIL,A,103/ ANSRM,A,106/PLOT,114/PRINT,116
HISHLR	HICSCR,R,30
HISTLR	HICSCR,R,30
HISTM	WSQ,A,16/HISTLR,A,33/SRSP,A,45/CSTMPM,A,51/PLOT,114/PRINT,116

```
!SP     MHSP,A,9/DHSP,A,27/SRHISH,A,44
'SQ     WSQ,A,16/PLOT,113/PRINT,115
SR      HI,L,6/HISH,L,29
ITSRM   TRSRM,A,100
'TSRMM  TRSRMM,A,92
        CLPM,A,50/LHR,R,66/LAR,R,68/CEL,L,72/AEL,A,73/EL,A,82/MOT,A,83/
         OT,A,85/MCAP,A,87/PLOT,113/PRINT,115
LAR     L,L,65/LTLAR,A,67/CEL,L,72
CB      LHR,R,66
.AR     L,L,65
LTADR   AIR,R,62
'TLAR   LHR,R,66
TOT     LHR,R,66
1UTIL   LCP,A,70/RL,A,76/CAP,A,84/MCAP,A,87
'AEL    MMLUTIL,A,95/MLUTIL,A,103
AX      CLPM,A,50/SPMT,A,56
EAS     MMLUTL,A,95/MLUTIL,A,103
MHSA    HSR,R,7
HSP     HSR,R,7
.LUTIL  LUTIL,A,77/BLM,A,102
MAHSD   HISHLR,A,31/RISHLR,A,38
IIV     MLUTIL,A,103
MTHSD   HISTLR,A,33/RISTLR,A,39
MOT     EL,A,82/PLOT,113/PRINT,115
'PHSQ   HSR,R,7/RSP,R,21
RSP     RSR,R,21
CAP     DB,A,71/HSQ,A,86
MMI     SRMMSH,A,47/SRMM,A,89/PLOT,114
MLUTL   LUTIL,A,77/BLMM,A,94
.T      CLPM,A,50/LTOT,A,69
P       AP,L,109/PRINT,116
ERG     RSR,R,21
HSQ     MPHSQ,A,14/MMAHSD,A,32/MMTHSD,A,34
PNMISH  SRMMSH,A,47
'SPPM   SRSP,A,45
A       MEAS,A,80/PLOT,113/PRINT,115
RDR     RI,L,20
RI      TMMM,A,19/RSR,R,21/RDR,R,20/RISH,N,36.1/RISTM,N,40.1/PLOT,114/
         PRINT,116
.ICSCR  RISH,L,36/RISTM,L,40
RISH    WSQ,A,16/RISHLR,A,38/SRRISH,A,43/SRM,A,97/MLUTIL,A,103/
         ANSRM,A,106/PLOT,114/PRINT,116
ISHLR   RICSCR,R,37
RISTLR  RICSCR,R,37
'ISTM   WSQ,A,16/RISTLR,A,39/SRSP,A,45/CSTMPM,A,51/PLOT,114/PRINT,116
L       MOT,A,83
RSP     WARSP,A,25
RSR     RI,L,20/RISH,L,36/RISTM,L,40
A       MHSA,A,12
SCPM    SPM,A,55/PLOT,113/PRINT,115
SDTHI.  DTHI,A,8
DTRI    DTRI,A,22
MODTH   LTADR,A,63/LTLAR,A,67/LTOT,A,69/LCB,A,70/ASRMM,A,91/ASRM,A,99
SPM     SPMT,A,56/SPMR,A,58/P,A,111/PLOT,113/PRINT,115
'PMR    FCA,A,59/FCL,A,60
PMT     SPMR,A,58
SPR     WARSP,A,25/RISH,L,36/RISH,N,36.1/RISTM,L,40/RISTM,N,40.1
SRHISH  SSRM,A,42
```

SRM	B,L,75/RA,A,81/ASRM,A,99/TRSRM,A,100
SRNM	B,L,75/RA,A,81/ASRNM,A,91/TRSRNM,A,92
SRNMSH	SRPM,A,42
SRPM	SPM,A,55/AR,L,110/P,A,111/PLOT,113/PRINT,115
SRRISH	SRPM,A,42
SRSP	SRPM,A,42
STCIS	CIS,A,98
STEP	DTHI,A,8/HSP,A,10/TPMSQ,A,18/DTRI,A,22/SPR,A,26/SWMAEL,A,79/ ER,A,90/CIS,A,98/HMIV,A,104
STER	ER,A,90
STHSP	HSP,A,10
STHMIV	HMIV,A,104
STPMSQ	TPMSQ,A,18
STSPR	SPR,A,26
SWMAEL	MAEL,A,78
TABLE	MHSP,A,9/MHSA,A,12/SA,A,13/MPHSQ,A,14/MRSP,A,23/MMAHSD,A,32/ MMTHSD,A,34/FCA,A,59/FCL,A,60/MAEL,A,78/MEAS,A,80/MOT,A,83/ MMI,A,88/MLUTIL,A,103/AMSRM,A,106
TASRNM	ASRNM,A,91/TRSRNM,A,92
TCSPMT	SPMT,A,56
TETRNM	TRSRNM,A,92
TETSRM	TRSRM,A,100
TFCA	FCA,A,59
TFCL	FCL,A,60
TIME	SA,A,13/MMI,A,88
TLAMM	AMSRM,A,106
TMAEL1	MAEL,A,78
TMAEL2	MAEL,A,78
TMEAS	MEAS,A,80
TMHM	WSQ,A,16/PRINT,116
TMHSA	MHSA,A,12
TMHSP	MHSP,A,9
TMLUT	MLUTIL,A,103
TMMAHS	MMAHSD,A,32
TMMIV	MMIV,A,104
TMMTHS	MMTHSD,A,34
TMOT	MOT,A,83
TMPHSQ	MPHSQ,A,14
TMRSP	MRSP,A,23
TMMI	MMI,A,88
TPHSQ	PHSQ,A,15
TPMSQ	WSQ,A,16
TREND	TRSRNM,A,92/TRSRM,A,100
TRSRM	FSRM,A,101
TRSRNM	FSRNM,A,93
TSA	SA,A,13
TSADR	LTADR,A,63
TSLAR	LTLAR,A,67
TSMAEL	SWMAEL,A,79
TSOT	LTOT,A,69
TSSRM	ASRM,A,99/TRSRM,A,100
TSTCIS	CIS,A,98
TSTER	ER,A,90
WARSP	MRSP,A,23
WSQ	PHSQ,A,15

APPENDIX #4

(8B)

```
*          HONEYWELL CUSTOMER SERVICE DIVISION
NOTE             SYSTEM DYNAMICS MODEL
NOTE                      BY
NOTE                 DAVID DANIELS
NOTE                   LUIS LEON
NOTE      MASSACHUSETTS  INSTITUTE OF TECHNOLOGY
NOTE           SLOAN SCHOOL OF MANAGEMENT
NOTE              CAMBRIDGE, MA 02139
NOTE                    MAY 1982
NOTE
NOTE************************************************************
NOTE
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NOTE
NOTE           1.0    MARKET SUBSYSTEM
NOTE
NOTE                   1.1   HONEYWELL SALES
NOTE                   1.2   RESELLER SALES
NOTE                   1.3   SERVICE MARKET
NOTE
NOTE           2.0    SERVICE SUBSYSTEM
NOTE
NOTE                  2.1.0  FINANCIAL SECTOR
NOTE
NOTE                        2.1.1  SERVICE REVENUE
NOTE                        2.1.2  SERVICE COST
NOTE                        2.1.3  SERVICE PROFIT MARGIN
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NOTE                  2.2.0  SERVICE SECTOR
NOTE
NOTE                        2.2.1  ASSETS
NOTE                        2.2.2  LABOR
NOTE                        2.2.3  SERVICE PERFORMANCE
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NOTE
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NOTE
NOTE           4.0    CONTROL CARDS
NOTE
NOTE           5.0    RERUN STATEMENTS
NOTE
NOTE************************************************************
NOTE
NOTE           1.0    MARKET SUBSYSTEM
NOTE
NOTE              1.1 HONEYWELL SALES
NOTE
L   HI.K=HI.J+DT*(HSR.JK-HDR.JK)
N   HI=1500
    HSR.KL=HI.K*MHSA.K*MHSP.K*MPHSQ.K/DTHI.K
A   DTHI.K=120*(1-STEP(SDTHI,0))
C   SDTHI=0
A   MHSP.K=TABLE(TMHSP,HSP.K/CSP.K,0,1.5,.25)
T   TMHSP=3,2,1.5,1.1,1,.9,0
A   HSP.K=CSP.K+STEP(STHSP,12)
C   STHSP=0
```

```
A   CSP.K=700
A   HHSA.K=TABLE(TMHSA,SA.K,0,1.5,.25)
T   TMHSA=.1/.3/.5/.75/1/1.15/1.25
    SA.K=TABLE(TSA,TIME.K,0,120,60)
.   TSA=1/1/1
A   MPHSQ.K=TABLE(TMPHSQ,PHSQ.K,0,1.25,.25)
T   TMPHSQ=.25,.25,.4,.8,1,1.2
A   PHSQ.K=DELAY3(WSQ.K,TPHSQ)
C   TPHSQ=12
A   WSQ.K=((RISH.K+HISH.K)*(HSQ.K)+(TPMSQ.K)*(HISTM.K+RISTM.K))/TMHM.K
R   HDR.KL=HI.K/ALI
A   TPMSQ.K=1+STEP(STPMSQ,24)
C   STPMSQ=0
C   ALI=120
A   TMHM.K=HI.K+RI.K
NOTE
NOTE           1.2  RESELLER SALES
NOTE
L   RI.K=RI.J+DT*(RSR.JK-RDR.JK)
N   RI=150
R   RSR.KL=RI.K*MRSP.K*MPHSQ.K*PERG/DTRI.K
C   PERG=1
A   DTRI.K=120*(1-STEP(SDTRI,0))
C   SDTRI=0
A   MRSP.K=TABLE(TMRSP,WARSP.K/CSP.K,0,1.5,.25)
T   TMRSP=3,2,1.5,1.1,1,.9,0
A   RSP.K=CSP.K
A   WARSP.K=(DHSP.K*SPR.K)+((1-SPR.K)*RSP.K)
    SPR.K=STEP(STSPR,48)
    STSPR=0
A   DHSP.K=HSP.K*(1-DPPR)
C   DPPR=0
R   RDR.KL=RI.K/ALI
NOTE
NOTE            1.3 SERVICE MARKET
NOTE
L   HISH.K=HISH.J+DT*(HSR.JK-(HISH.J/ALI))-DT*HICSCR.JK
N   HISH=HI
R   HICSCR.KL=(HISHLR.K-HISTLR.K)/ATCSC
C   ATCSC=12
A   HISHLR.K=HISH.K*MMAHSD.K
A   MMAHSD.K=TABLE(TMMAHS,PHSQ.K,.5,1.5,.25)
T   TMMAHS.K=.5,.25,0,0,0
A   HISTLR.K=HISTM.K*MMTHSD.K
A   MMTHSD.K=TABLE(TMMTHS,PHSQ.K,.5,1.5,.25)
T   TMMTHS=0,0,0,.25,.5
L   HISTM.K=HISTM.J+DT*(HICSCR.JK-HISTM.J/ALI)
N   HISTM=0
L   RISH.K=RISH.J+DT*(RSR.JK*SPR.J-(RISH.J/ALI)-RICSCR.JK)
N   RISH=RI*SPR
R   RICSCR.KL=(RISHLR.K-RISTLR.K)/ATCSC
A   RISHLR.K=RISH.K*MMAHSD.K
    RISTLR.K=RISTM.K*MMTHSD.K
_   RISTM.K=RISTM.J+DT*(RSR.JK*(1-SPR.J)-(RISTM.J/ALI)+RICSCR.JK)
N   RISTM=RI*(1-SPR)
NOTE
NOTE***************************************************************
NOTE
```

```
NOTE           2.0.0 SERVICE SUBSYSTEM
NOTE
N              2.1.0 FINANCIAL SECTOR
NOTE
NOTE           2.1.1 SERVICE REVENUE
NOTE
A   SRPM.K=SRRISH.K+SRHISH.K+SRSP.K+SRNMSH.K
A   SRRISH.K=DHSP.K*RISH.K
A   SRHISH.K=HSP.K*HISH.K
A   SRSP.K=(HISTM.K+RISTM.K)*PSPPM.K
A   PSPPM.K=100
A   SRNMSH.K=NMI.K*PNMISH.K
A   PNMISH.K=1400
NOTE
NOTE           2.1.2 SERVICE COST
NOTE
A   SCPM.K=CLPM.K+CSTMPM.K+CAPM.K+DEP.K
A   CLPM.K=L.K*AWPM.K+MAX(0,OT.K)*1.5*AWPM.K
A   CSTMPM.K=(HISTM.K+RISTM.K)*CSPPM.K
A   CSPPM.K=25
A   CAPM.K=ADR.K
A   DEP.K=2250E3
NOTE
NOTE        2.1.3 SERVICE PROFIT MARGIN
NOTE
A   SPM.K=(SRPM.K-SCPM.K)/SRPM.K
     SPMT.K=MAX(0.1,DELAY3(SPM.K,TCSPMT.K))
    TCSPMT.K=36
A   SPMR.K=SPM.K/SPMT.K
N   SPMR=1
A   FCA.K=TABLE(TFCA,SPMR.K,0.5,1.5,0.25)
T   TFCA=0.75,0.85,1,1.05,1.1
A   FCL.K=TABLE(TFCL,SPMR.K,0.5,1.5,0.25)
T   TFCL=0.75,0.85,1,1.05,1.1
NOTE
NOTE          2.2.0 SERVICE SECTOR
NOTE
NOTE             2.2.1  ASSETS
NOTE
L   A.K=A.J+DT*(AIR.JK-ADR.JK)
    A=142.5E6
R   AIR.KL=(((DA.K-A.K)/ATAI)+LTADR.K)*FCA.K
C   ATAI=6
A   LTADR.K=SMOOTH(ADR.K,TSADR)
    TSADR=12
R   ADR.KL=A.K/ALA
C   ALA=60
NOTE
NOTE             2.2.2  LABOR
NOTE
    L.K=L.J+DT*(LHR.JK-LAR.JK)
    L=3792.2
R   LHR.KL=(((DL.K-L.K+LTOT.K+LCB.K)/ATHL)+LTLAR.K)*FCL.K
C   ATHL=6
    LTLAR.K=SMOOTH(LAR.K,TSLAR)
C   TSLAR=12
R   LAR.KL=L.K/ALL
    ALL=60
```

```
A   LTOT.K=SMOOTH(OT.K,TSOT)
C   TSOT=3
A   LCB.K=SMOOTH((DB.K-B.K)/LUTIL.K,3)
A   DB.K=NCAP.K
L   CEL.K=CEL.J+DT*(L.J-AEL.K*LAR.JK)
N   CEL=227532
A   AEL.K=CEL.K/L.K
A   AWPM.K=2000
NOTE
NOTE            2.2.3 SERVICE PERFORMANCE
NOTE
L   B.K=B.J+DT*(SRNM.K+SRM.K-CAP.K)
N   B=14000
A   RL.K=(B.K/LUTIL.K)
A   LUTIL.K=((MLUTIL.K*DLM.K)+(NMLUTL.K*DLNM.K))/DL.K
A   MAEL.K=TABLE(TMAEL1,AEL.K,0,96,12)*SWMAEL.K+TABLE(TMAEL2,AEL.K,0,96,
X         12)*(1-SWMAEL.K)
T   TMAEL1=.5,.8,1,1.05,1.08,1.1,1.1,1.1,1.1
T   TMAEL2=.5,1,1.05,1.08,1.1,1.1,1.1,1.1,1.1
A   SWMAEL.K=1-STEP(1,TSMAEL)
C   TSMAEL=1000
A   MEAS.K=TABLE(TMEAS,A.K/RA.K,0,2,0.25)
T   TMEAS=0,0.2,0.5,0.9,1,1,1,1,1
A   RA.K=SRNM.K*ANSRNM+SRM.K*ANSRM.K
A   EL.K=L.K*MOT.K
A   MOT.K=TABLE(TMOT,RL.K/L.K,0,1.25,0.25)
T   TMOT=0,.25,.5,.75,1,1.25
    CAP.K=EL.K*LUTIL.K
A   OT.K=EL.K-L.K
A   HSQ.K=NCAP.K/B.K
A   NCAP.K=L.K*LUTIL.K
NOTE
NOTE             2.2.4 SERVICE REQUIREMENTS
NOTE
NOTE          2.2.4.1 NON-MINI INSTALLATIONS
NOTE
A   NMI.K=TABLE(TNMI,TIME.K,0,120,120)
T   TNMI=12500,12500
A   SRNM.K=NMI.K/ER.K
A   ER.K=1+STEP(STER,TSTER)
C   STER=0
C   TSTER=6
A   ASRNM.K=SMOOTH(SRNM.K,TASRNM)
C   TASRNM=12
A   TRSRNM.K=TREND(SRNM.K,TASRNM,TETRNM,ITSRNM)
C   TETRNM=18
C   ITSRNM=0
A   FSRNM.K=ASRNM.K+FP*TRSRNM.K
C   FP=6
A   DLNM.K=FSRNM.K/NMLUTL.K
A   NMLUTL.K=3.5*MAEL.K*MEAS.K
    DANM.K=FSRNM.K*ANSRNM
C   ANSRNM=9E3
NOTE
NOTE         2.2.4.2  MINI INSTALLATIONS
NOTE
A   SRM.K=(HISH.K+RISH.K)/CIS.K
A   CIS.K=1+STEP(STCIS,TSTCIS)
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C   STCIS=0                                                           0000097
C   TSTCIS=6                                                          0000097
A   ASRM.K=SMOOTH(SRM.K,TSSRM)                                        00
C   TSSRM=12                                                          00
A   TRSRM.K=TREND(SRM.K,TSSRM,TETSRM,ITSRM)                           000009
C   TETSRM=18                                                         0000095
C   ITSRM=0                                                           0000095
A   FSRM.K=ASRM.K+TRSRM.K*FP                                          000010
A   DLM.K=FSRM.K/MLUTIL.K                                             000010
A   MLUTIL.K=TABLE(TMLUT,(RISH.K+HISH.K),1.5E3,21.5E3,5E3)*MMIV.K*    000010
X        MAEL.K*MEAS.K                                                000010
T   TMLUT=2.5,4.0,6.5,9,10                                            000010
A   MMIV.K=1+STEP(STMMIV,TMMIV)                                       000010
C   STMMIV=0                                                          000010
C   TMMIV=6                                                           000010
A   DAM.K=FSRM.K*ANSRM.K                                              000010
A   ANSRM.K=TABLE(TLANM,(RISH.K+HISH.K),1.5E3,21.5E3,5E3)             000010
T   TLANM=20E3,14E3,7.5E3,4.0E3,2.5E3                                 000010
A   DL.K=DLM.K+DLNM.K                                                 000010
A   DA.K=DAM.K+DANM.K                                                 000010
NOTE                                                                  000010
NOTE*********************************************************************  000010
NOTE                                                                  000010
NOTE        3.0  SUPPLEMENTARY  EQUATIONS                             000010
NOTE                                                                  000010
L   AP.K=AP.J+DT*P.J                                                  000010
N   AP=0                                                              000
    AR.K=AR.J+DT*SRPM.J                                               000
    AR=0                                                              0000
A   P.K=SRPM.K*SPM.K                                                  000011
NOTE                                                                  000011
NOTE*********************************************************************  000011
NOTE                                                                  000011
NOTE                4.0  CONTROL CARDS                                000011
NOTE                                                                  000011
SPEC DT=0.25/LENGTH=24/PLTPER=0/PRTPER=3                              0000111
PLOT A=A,RA=D(150E6,350E6)/L=L(5E3,10E3)/MOT=O(0.75,1.25)/B=B(0,80E3)/  000011
X        HSQ=Q(0.825,1.025)/SPM=P(0.2,0.6)/AEL=E(40,80)/SRPM=R,SCPM=  000011
X        C(10E6,70E6)                                                 000011
PLOT NMI=N,HI=H,RI=R,HISH=1,HISTM=2,RISH=3,RISTM=4(0,40E3)            000011
PRINT A,RA,L,MOT,B,HSQ,SPM,AEL,SRPM,SCPM                              000011
PRINT HI,RI,HISH,RISH,HISTM,RISTM,AP,AR,P,TMHM                        000011
OPT TXI=4/PLW=50/P                                                    000011
RUN BASE                                                              000011
NOTE                                                                  000011
NOTE*********************************************************************  000011
NOTE          5.0 RERUN STATEMENTS                                    000011
NOTE                                                                  0000117
NOTE * TEST#1: NON-MINI GROWTH -HONEYWELL CSD                         0000117
CP LENGTH=120/ITSRNM=102.5                                            000011
T  TNMI=12500,25000                                                   000011
RUN TEST#1                         * TEST#2: MINI GROWTH -HONEYWELL CSD  0000
C   DTHI=0.75/SDTRI=0.85/ITSRNM=O                                     000
RUN TEST#2                         * TEST#3: GROWTH OF MINIS AND NON-    000012
NOTE                               MINIS                              000012
TP TNMI=12500,25000/ITSRNM= 102.5                                     000012
RUN TEST#3                         * TEST#4: GROWTH PLUS THIRD PARTY SQ  000012
NOTE                               = 75%                              000012
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( STPMSQ=-0.25                                                              000
RUN TEST#4                     * TEST#5: GROWTH & SERVICE POLICY            000012
NOTE                           FOR RESELLER 75%                             000012
CP STSPR=0.75                                                               000012
RUN TEST#5                     * TEST#6: GROWTH, SPR=75%, & MAN-IN-         000012
NOTE                           VAN PROGRAM                                  000012
CP STMMIV=2                                                                 000012
RUN TEST#6                     * TEST#7: GROWTH, SPR=75%, MAN-IN-           000012
NOTE                           VAN, & DISC. PRICE 15%                       000012
CP DPPR=0.15                                                                000012
RUN TEST#7                                                                  000012
```

DIVISION DE EDUCACION CONTINUA
FACULTAD DE INGENIERIA U.N.A.M.

DINAMICA DE SISTEMAS (FORRESTER)

EXPERIENCIA EN LA CONSTRUCCION DE UN MODELO SOBRE LA OPERACION DE INTERMEDIACION BANCACIA

DN. MARIANO RAFAEL BLANCO

MARZO, 1984

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Impresiones y experiencia recogidas durante el proceso de construcción de un modelo de simulación, bajo la metodología de Dinámica de Sistemas, desde el punto de vista del usuario, solicitante de la construcción de dicho modelo.- Antecedentes sobre el propósito y uso del mismo, así como de la operación que se busca representar (la intermediación bancaria). Descripción del modelo: su estructura, su funcionamiento, su aplicación.- Descripción del proceso de construcción y de implantación.- Conclusiones respecto a la utilidad que se espera del modelo así como de los requerimientos para su uso.

26-Abril-82

DIVISION DE EDUCACION CONTINUA
FACULTAD DE INGENIERIA U.N.A.M.

DINAMICA DE SISTEMAS

LA DINAMICA DE LA MATRIZ INSUMO PRODUCTO (I-O)

M. en I. Jorge Silva Midences

MARZO, 1984

I N D I C E

"EL ANALISIS INSUMO-PRODUCTO NO ES MAS QUE UNA CONSECUENCIA PRACTICA DE AQUELLA TEORIA CLASICA QUE POSTULA LA INTERDEPENDENCIA GENERAL DE LAS VARIABLES ECONOMICAS. CONSIDERA ESTA TEORIA QUE EL CONJUNTO DE LA ECONOMIA DE UNA REGION, UN PAIS O EL MUNDO CONSTITUYE UN SISTEMA UNICO, Y SE ESFUERZA POR EXPRESAR LA TOTALIDAD DE SUS FUNCIONES EN TERMINOS DE AQUELLAS, DE SUS PROPIEDADES ESTRUCTURALES QUE SON SUSCEPTIBLES DE CUANTIFICAR..."

Wassili LEONTIEF

"LAS EMPRESAS ESTADOUNIDENSES INVIERTEN CADA AÑO MILLONES DE DOLARES EN ELABORAR PREVISIONES DE VENTAS, BUSCANDO CON ELLO PERFECCIONAR SUS ESTIMACIONES CON RESPECTO A LOS MERCADOS FUTUROS DE SUS PRODUCTOS (estimaciones que necesitan para poder elaborar sus programas internos de producción y sus planes de inversión)... DESGRACIADAMENTE, ESTAS PREVISIONES SON MAS CONOCIDAS POR SUS FRACASOS QUE POR SUS EXITOS..."

LEONTIEF

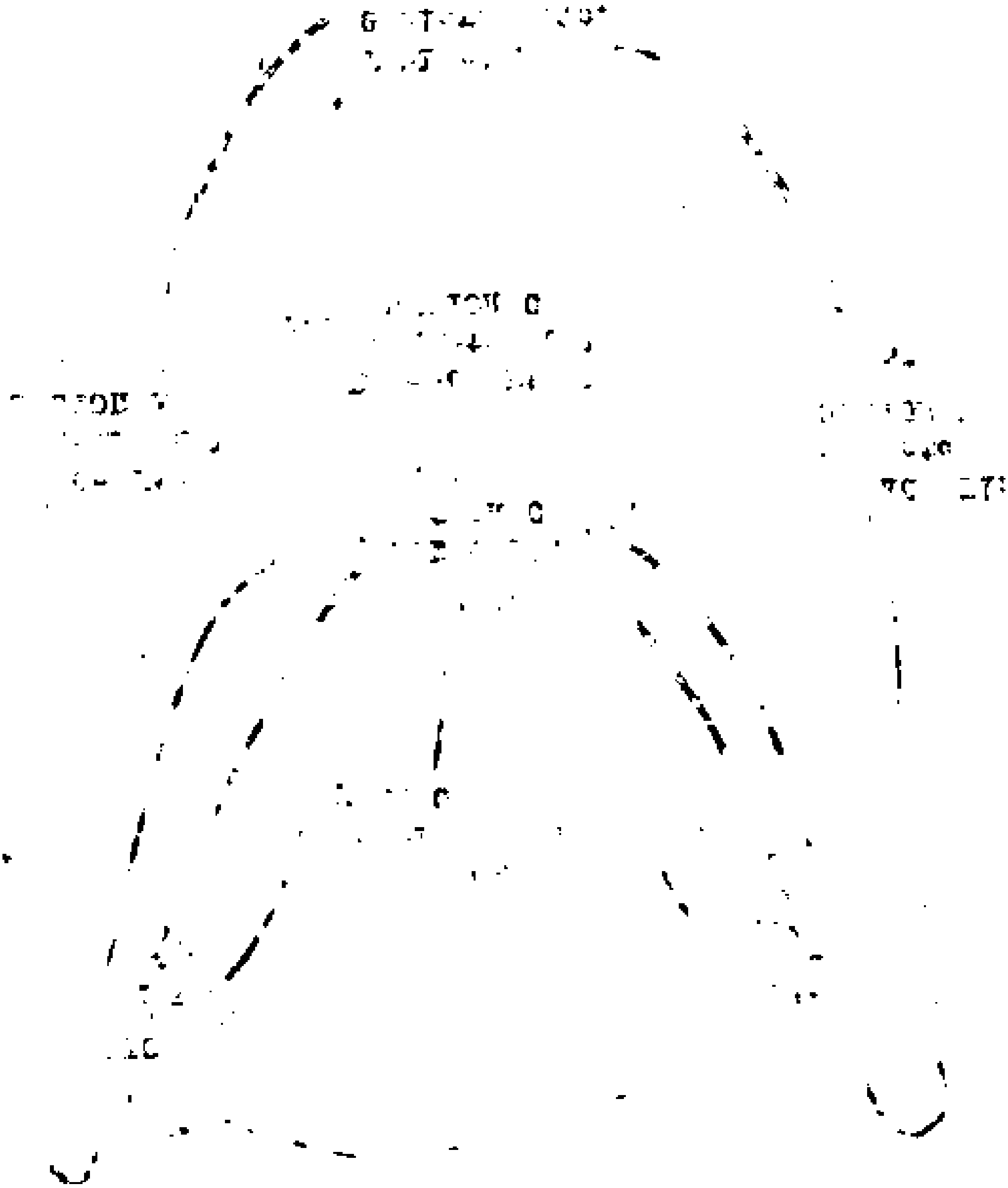
LA INDUSTRIA SIDERURGICA PROCURA ESTIMAR SUS VENTAS DE PLANCHAS DE ACERO DURANTE EL PROXIMO AÑO O DURANTE EL PROXIMO QUINQUENIO A PARTIR DEL VOLUMEN DE PEDIDOS QUE ESPERA QUE LE HAGAN LAS DISTINTAS EMPRESAS DEDICADAS A LA CONSTRUCCION NAVAL.

LAS EMPRESAS DE CONSTRUCCION NAVAL PROCURAN ESTIMAR, - al mismo tiempo, QUE LA INDUSTRIA SIDERURGICA HACE SUS PREVISIONES, LA DEMANDA FUTURA DE GASOLINA CON OBJETO DE PODER DETERMINAR EL NUMERO DE "PETROLEROS" QUE LES ENCARGARAN PROBABLEMENTE EL PROXIMO AÑO.

A SU VEZ, A LOS ANALISTAS DE MERCADO DE LA INDUSTRIA DEL PETROLEO LES INTERESA CONOCER LOS NIVELES DE PRODUCCION DE LOS PRINCIPALES SECTORES DE LA ECONOMIA QUE CONSUMEN PRODUCTOS PETROLIFEROS, CON OBJETO DE DETERMINAR LA POSIBLE DEMANDA DE LOS MISMOS.

"SIMULTANEAMENTE, AUNQUE CON INDEPENDENCIA LAS UNAS DE LAS OTRAS TODAS LA EMPRESAS, GRANDES, MEDIANAS Y PEQUEÑAS, DE LOS DIFERENTES SECTORES QUE COMPONEN LA ECONOMIA DE UN PAIS, ESTAN COMPROMETIDAS EN UN juego de conjeturas extremadamente costoso e inútil." (Leontief)

LA MATRIZ DE INSUMO-PRODUCTO NOS DA EL FLUJO DE BIENES Y SERVICIOS QUE SE HA ESTABLECIDO ENTRE LOS DIFERENTES SECTORES DE UNA ECONOMIA DURANTE UN DETERMINADO PERIODO DE TIEMPO.



LA DINAMICA DE LA MATRIZ INSUMO-PRODUCTO (I-O)

I. INTRODUCCION

"SI HOY EN DIA, JAMES CLERK MAXWELL, UNO DE LOS FISICOS MAS EMINENTES DEL SIGLO XIX, ASISTIERA A ALGUNAS DE LAS REUNIONES QUE REGULARMENTE CELEBRA LA *American Phisical Society* LE SERIA SEGURAMENTE MUY DIFICIL SEGUIR EL HILO DE LAS DISCUSIONES. ESTO, SIN EMBARGO, LE HABRIA RESULTADO MUY FACIL SI EN LUGAR DE HABERSE DEDICADO A LA FISICA SE HUBIERA DEDICADO A LA ECONOMIA, COMO SU CONTEMPORANEO JOHN STUART MILL. LA FISICA, AL TRAVES DE LA APLICACION DEL METODO INDUCTIVO A LOS HECHOS OBSERVADOS Y EXPRESADOS EN FORMA CUANTITATIVA, HA RENOVADO TOTALMENTE SUS PREMISAS. LA ECONOMIA, EN CAMBIO, CONTINUA SIENDO ESENCIALMENTE UNA CIENCIA DEDUCTIVA FUNDADA EN UN GRUPO ESTATICO DE PREMISAS, QUE EN SU MAYORIA ERAN YA CONOCIDAS POR STUART MILL Y ALGUNAS DE LAS CUALES ENCONTRAMOS YA EN *La Riqueza de las Naciones*, DE ADAM SMITH."

EN LA ACTUALIDAD NO TODOS LOS ECONOMISTAS SE MUESTRAN SATISFECHOS DEL ESTADO EN QUE ENCUENTRA LA ECONOMIA. LOS NOMBRES DE ALGUNOS DE LOS MAS IMPORTANTES ECONOMISTAS ENTRE LOS FALLECIDOS DENTRO DE LA PRIMERA MITAD DEL SIGLO XX, *León Walras, Vilfredo Pareto, Irving Fisher*, APARECEN ASOCIADOS AL ESFUERZO REALIZADO POR ENCONTRAR METODOS CUANTITATIVOS APLICABLES A LA ENORME CANTIDAD DE DATOS EMPIRICOS INVOLUCRADOS EN LAS SITUACIONES ECONOMICAS REALES. SIN EMBARGO, BUENA PARTE DE LOS ECONOMISTAS PROFESIONALES TODAVIA SE MUESTRAN REACIOS A ACEPTAR ESTOS METODOS. LA RAZON DE ELLO NO ES SOLO QUE LES RESULTA ANTIPATICO EL RIGOR MATEMATICO QUE CARACTERIZA A LOS MISMOS, SINO EL QUE ESTOS RARAS

VECES HAN PERMITO OBTENER RESULTADOS QUE FUERAN SENSIBLEMENTE ME JORES QUE LOS OBTENIDOS UTILIZANDO LOS METODOS TRADICIONALES. DESPUÉS DE TODO, PARA TODA CIENCIA EXPERIMENTAL LO UNICO QUE CUENTA SON LOS RESULTADOS. ESTO EXPLICA EL PORQUE MUCHOS ECONOMISTAS SIGUEN CONFIANDO EN SU "INTUICION PROFESIONAL" Y EN SU "BUEN SENTIDO" CUANDO SE TRATA DE ESTABLECER LA RELACION EXISTEN ENTRE LOS HECHOS Y LA TEORIA ECONOMICA

A PESAR DE TODO, EN LOS ULTIMOS AÑOS EL NUMERO DE DATOS Y CIFRAS DE INDOLE ECONOMICA SUMINISTRADOS POR LOS SERVICIOS DE INFORMACION, TANTO PARTICULARES COMO GUBERNAMENTALES, SE HA INCREMENTADO EXTRAORDINARIAMENTE. BUENA PARTE DE ESTA INFORMACION ES PUBLICADA PERIODICAMENTE PARA QUE SIRVA DE REFERENCIA Y NO GUARDA RELACION ALGUNA CON NINGUN METODO PARTICULAR DE ANALISIS. EN CONSECUENCIA, EL PANORAMA QUE OFRECE LA ECONOMIA HOY EN DIA ES EL SIGUIENTE:

"...DE UN LADO TENEMOS UNA TEORIA MUY DESARROLLADA SIN HECHOS QUE LA CORROBOREN Y DE OTRO UNA INMENSA CANTIDAD DE DATOS SIN NINGUNA TEORIA QUE LOS INTEGRE..."

EL ANALISIS INSUMO PRODUCTO (I-O) SE REFIERE A UN PROCEDIMIENTO QUE PRETENDE COMBINAR, EN EL TERRENO ECONOMICO, LOS HECHOS CON LA TEORIA Y QUE SE CONOCE CON LOS NOMBRES DE "Análisis Intersectorial" e "Análisis I-O". SE TRATA EN ESENCIA, DE UN PROCEDIMIENTO ANALITICO FUNDADO EN EL HECHO DE QUE LOS FLUJOS DE BIENES Y SERVICIOS QUE SE DAN ENTRE LOS DIFERENTES ELEMENTOS QUE INTEGRAN UNA ECONOMIA SON RELATIVAMENTE ESTABLES, LO QUE PERMITE ELABORAR UN CUADRO ESTADISTICO MUCHO MAS COMPLETO DEL SISTEMA E INGRARLO DENTRO DEL AMBITO EN QUE SE MUEVE LA TEORIA ECONOMICA. EL METODO COMO TAL, NO HA PODIDO DESARROLLARSE HASTA QUE APARECIE -

RON LAS COMPUTADORAS Y EN LOS APARATOS GUBERNAMENTALES Y PRIVADOS SE SINTIERON INCLINADOS A ACUMULAR DATOS.

AHORA BIEN, LA TEORIA ECONOMICA SE ESFUERZA POR EXPLICAR AQUELLOS ASPECTOS Y OPERACIONES MATERIALES DE NUESTRA SOCIEDAD EN FUNCION de las interacciones que se dan entre variables tales como la <u>oferta y la demanda</u> o los <u>salarios y los precios</u>. POR REGLA GENERAL, LOS ECONOMISTAS HABIAN FUNDADO SUS DEDUCCIONES ANALITICAS EN DATOS RELATIVAMENTE SIMPLES, COMO SON EL PRODUCTO NACIONAL BRUTO, LOS TIPOS DE INTERES O LOS NIVELES DE SALARIOS. PERO, EN LA REALIDAD, LAS COSAS NO SON TAN SIMPLES. Entre el instante en que se modifican los salarios y aquel en el que dicha modificación se deja sentir en los precios, TIENE LUGAR UNA COMPLEJA SERIE DE TRANSACCIONES A TRAVES DE LAS CUALES LAS PERSONAS reales SE INTERCAMBIAN ENTRE SI BIENES Y SERVICIOS. POR REGLA GENERAL, LA FORMULA CLASICA QUE RELACIONA LAS DOS VARIABLES MENCIONADAS (los salarios y los precios), NO DICE NADA ACERCA DE ESTOS PASOS INTERMEDIOS. NATURALMENTE, ES CIERTO QUE LAS TRANSACCIONES PARTICULARES, AL IGUAL QUE LOS ATOMOS Y LAS MOLECULAS QUE ESTUDIA LA FISICA, SON DEMASIADO NUMEROSAS PARA QUE PODAMOS OBSERVARLAS Y DESCRIBIRLAS CON DETALLE. PERO PODEMOS Y TAMBIEN PODEMOS EN EL CASO DE LAS PARTICULAS FISICAS, ORDENARLAS DE ALGUN MODO CLASIFICANDOLAS Y FORMANDO GRUPOS CON ELLAS. ESTE ES EL PROCEDIMIENTO EMPLEADO POR EL ANALISIS I-O CON OBJETO DE AUMENTAR LA COMPRESION DE LA TEORIA ECONOMICA CON RESPECTO A LOS HECHOS A LOS QUE DEBE ENFRENTARSE EN LAS SITUACIONES REALES.

II. <u>MARCO DE REFERENCIA</u>

EN NUESTRO PAIS Y BAJO LA RESPONSABILIDAD DE LA Secretaría de Programación y Presupuesto, LAS CUENTAS NACIONALES CONSTITUYEN "LA

ESTRUCTURA CONCEPTUALMENTE ORGANIZADA EN QUE SE INSERTA LA INFORMACION ESTADISTICA DE QUE DISPONEMOS. LAS CUENTAS NACIONALES PERMITEN CONOCER LA ESTRUCTURA Y FORMA EN QUE ESTA OPERANDO LA ECONOMIA: QUE PRODUCE, CUANTO SE PRODUCE, PARA QUIEN O PARA QUE SE PRODUCE, A QUE SE DESTINA EL INGRESO, ESTO ES, QUE Y CUANTO SE CONSUME, CUANTO SE AHORRA Y CUANTO SE INVIERTE"

"EL CONOCIMIENTO DE LA ESTRUCTURA DE LA ECONOMIA Y SU COMPORTAMIENTO RESULTA FUNDAMENTAL PARA LA TOMA DE DECISIONES Y PARA LA PROGRAMACION DE ACTIVIDADES DE LOS SECTORES PUBLICO, PRIVADO Y SOCIAL DEL PAIS, ASI COMO PARA EVALUAR EL EFECTO DE ESAS ACCIONES Y DECISIONES"

"LA MATRIZ I-O, PARTE INTEGRANTE DEL SISTEMA DE CUENTAS NACIONALES, MUESTRA LAS RELACIONES QUE EXISTEN ENTRE LOS DISTINTOS SECTORES DE LA ECONOMIA, POR EJEMPLO, PERMITE CONOCER LAS ADQUISICIONES QUE UN SECTOR HACE DE LOS OTROS SECTORES, ASI COMO LO QUE LES PROVEE"

"COMO HERAMIENTA DE ANALISIS ECONOMICO, UNA MATRIZ I-O ES DE MUCHA UTILIDAD. PERMITE APRECIAR, POR EJEMPLO, LA ESTRUCTURA DE COSTOS DE UNA DETERMINADA RAMA O IDENTIFICAR A LOS DEMANDANTES DE LOS BIENES Y SERVICIOS PRODUCIDOS EN TODA LA ECONOMIA"

"ES, SIN EMBARGO, COMO INSTRUMENTO DE PLANEACION, EN DONDE LOS USOS SON MAYORES. SU EMPLEO PERMITE RESPONDER A MULTIPLES INTERROGANTES:

¿ QUE REPERCUSIONES SE ESPERARIAN EN LA PRODUCCION DEL CONJUNTO DE SECTORES SI SE QUIERE AUMENTAR LA PRODUCCION DE CIERTO TIPO DE BIENES Y SERVICIOS?

¿ CUAL SERIA EL IMPACTO DE UN AUMENTO EN LOS PRECIOS DE LOS PRODUCTOS DE UNA RAMA INDUSTRIAL, SOBRE EL NIVEL GENERAL DE LOS PRECIOS?

¿QUE REQUERIMIENTOS DE IMPORTACION MOTIVARIA LA EXPANSION DE LAS EXPORTACIONES DE UNA RAMA INDUSTRIAL DETERMINADA?

¿ANTE ALTERNATIVAS DE PRODUCCION, QUE EFECTOS SOBRE EL EMPLEO EN LA ECONOMIA PUEDEN ESPERARSE?

¿QUE NIVELES DE PRODUCCION DEBE ALCANZAR CADA SECTOR PARA CUMPLIR CON LAS METAS PROPUESTAS DE CONSUMO DE LA POBLACION?

"LAS MATRICES I-O SIRVEN TAMBIEN PARA EXAMINAR LAS REPERCUSIONES QUE EN LA PRODUCCION DE BIENES Y SERVICIOS DE LA ECONOMIA TIENEN POR EJEMPLO, LOS PROGRAMAS Y PROYECTOS DE INVERSION PUBLICA Y - PRIVADA; TAMBIEN PERMITE CONOCER EL IMPACTO DE LOS CAMBIOS TECNO LOGICOS EN EL PROCESO DE PRODUCCION DE BIENES Y SERVICIOS. POR O TRA PARTE POSIBILITA EXAMINAR, POR SEPARADO O EN CONJUNTO, LAS REPERCUSIONES DE LOS INCREMENTOS EN SALARIOS, IMPUESTOS INDIREC- TOS Y SUBSIDIOS"

TODO ELLO, PERMITE DETECTAR A TIEMPO LOS POSIBLES CUELLOS DE BO- TELLA QUE PUDIERAN OBSTACULIZAR EL DESARROLLO ECONOMICO FUTURO, AL TRAVES DE:

1. LA SERIE DE CUENTAS CONSOLIDADES DE LA NACION

   Cuenta de Producto y Gasto Interno Bruto
   Cuenta de Ingreso Nacional Disponible y su Asignación
   Cuenta de Acumulación y Financiamiento del Capital, y:
   Cuenta de Transacciones con el Exterior

2. LA CUENTA DE PRODUCCION, CONSUMO Y ACUMULACION DE CAPITAL POR RAMA DE ACTIVIDAD y:

3. LA MATRIZ I-O

"LA MATRIZ I-O SE PUEDE CONSIDERAR COMO UNA EXTENSION DE LAS CUENTAS DE PRODUCCION, CONSUMO Y FORMACION DE CAPITAL DE LA ECONOMIA, DONDE LA PARTE REFERIDA A LA DEMANDA INTERMEDIA SE DETALLA PARA HACER EXPLICITAS LAS RELACIONES DE ABASTECIMIENTO Y USO DE BIENES Y SERVICIOS QUE SE DAN ENTRE LAS DIFERENTES ACTIVIDADES ECONOMICAS QUE PARTICIPAN EN LA PRODUCCION INTERNA. A SU VEZ, TAMBIEN MUESTRA LA PARTE DE LA PRODUCCION QUE SE DESTINA AL ABASTECIMIENTO DE LA DEMANDA FINAL"

PARA CUMPLIR CON SU PROPOSITO LA MATRIZ I-O SE DISEÑA EN FORMA DE CUADRO DE DOBLE ENTRADA, DONDE LOS CRUCES DE LAS FILAS Y LAS COLUMNAS SIRVEN PARA REGISTRAR EN UN SOLO ASIENTO LAS TRANSACCIONES, DEBIDO A QUE LAS FILAS MUESTRAN EL DESTINO DE LOS BIENES Y SERVICIOS PRODUCIDOS POR UNA ACTIVIDAD ECONOMICA Y LAS COLUMNAS LA COMPOSICION DE LOS COSTOS DE PRODUCCION EN BASE A LAS ACTIVIDADES ECONOMICAS DE LAS CUALES PROVIENEN LOS BIENES Y SERVICIOS UTILIZADOS. PERO VEAMOS UN ESQUEMA SIMPLE:

CUADRO DE RELACIONES INTERSECTORIALES

Composición de insumos / Distribución de la producción	Agric.	Indus.	Serv.	Total de ventas intermediarias	Demanda Final: Total	Demanda Final: Bienes y Serv. de Cons.	Demanda Final: Bienes y Serv. de Capital	V. B. P.
Agricultura	5	30	—	35	65	65	—	100
Industria	10	40	5	55	95	50	45	150
Servicios	10	10	5	25	115	115	—	140
Total Insumos	25	80	10	115				
Salarios	40	40	75					
Intereses	5	5	10					
Ingresos	15	5	5					
Ganancias	15	20	40					
V. A.	75	70	130		275			
V. B. P.	100	150	140					390

EN EL ESQUEMA ANTERIOR SE DISTINGUEN TRES CAMPOS:

EL PRIMERO:(A),PRESENTA EN FORMA INTEGRAL TODA LA PRODUCCION DE BIENES INTERMEDIOS EN LA ECONOMIA. SE HACE NOTAR QUE AQUI SE TORNA CLARO EL FENOMENO GENERICO DE QUE LAS "SALIDAS" DE UN SECTOR CONSTITUYEN "ENTRADAS" DE OTROS (O DEL MISMO SECTOR)

EL SEGUNDO (B),NOS MUESTRA TODOS LOS BIENES FINALES PRODUCIDOS POR EL SISTEMA ECONOMICO EN UN PERIODO DETERMINADO.

Y EN EL CAMPO (C) EN FORMA GENERICA: LOS RENDIMIENTOS QUE SE PAGAN AL TRABAJO Y A LOS PROPIETARIOS DE LOS FACTORES CAPITAL Y RECURSOS NATURALES, etc, PERO AMPLIEMOS LA VISION:

La Matriz de Insumo-Producto

RAMA NUMERO		DEMANDA INTERMEDIA							DEMANDA FINAL						VALOR BRUTO DE PRODUCCION
		SECTORES DE PRODUCCION							INTERNA				EXPORTACIONES	TOTAL	
	SECTORES DE BIENES Y SERVICIOS	1	2	3	......	71	72	TOTAL	CONSUMO PRIVADO	CONSUMO GOBIERNO GENERAL	INVERSION INTERNA	SUBTOTAL			
1	AGRICULTURA														
2	GANADERIA														
3	SILVICULTURA														
4	CAZA Y PESCA														
5	CARBON Y DERIVADOS														
.	.....														
.	.....														
.	.....														
.	.....														
.	.....														
.	.....														
.	.....														
70	SERVICIOS MEDICOS														
71	SERVICIOS DE ESPARCIMIENTO														
72	OTROS SERVICIOS														
	IMPORTACIONES														
	SUBTOTAL	INSUMOS DE BIENES Y SERVICIOS							CONSUMO FINAL		INVERSION BRUTA INTERNA	BIENES Y SERVICIOS DISPONIBLES	EXPORTACIONES	DEMANDA FINAL TOTAL	VALOR BRUTO DE PRODUCCION MAS IMPORTACIONES
	VALOR AGREGADO BRUTO														
1	REMUNERACION DE ASALARIADOS														
2	SUPERAVIT BRUTO DE EXPLOTACION														
3	IMPUESTOS INDIRECTOS NETOS DE SUBSIDIOS														
		VALOR BRUTO DE PRODUCCION													

III. ALGUNOS CONCEPTOS BASICOS

VALOR BRUTO DE LA PRODUCCION: SUMA TOTAL DE LOS VALORES DE LOS BIENES Y SERVICIOS PRODUCIDOS POR UNA SOCIEDAD, INDEPENDIENTEMENTE DE QUE SE TRATE DE Insumos, ES DECIR, BIENES INTERMEDIOS.

PRODUCTO INTERNO BRUTO: SUMA DE LOS VALORES MONETARIOS DE LOS BIENES Y SERVICIOS PRODUCIDOS POR UN PAIS EN UN AÑO

Ejemplo:

	Valor de la Venta	Valor Agregado
TRIGO	100	100
HARINA	150	50
PAN	200	50
	450	200
	(VBP)	(PIB)

T A S A - N I V E L

Ejemplo: Crecimiento poblacional. <u>Hipótesis</u>: La Tasa Neta de Crecimiento (TNC) de la población P, es proporcional a ésta

1) $TNC = \frac{dP}{dt} = kP$ o bien: $\frac{dP}{P} = k\,dt$

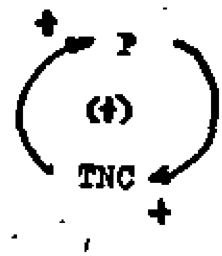
integrando:

2) $\ln P = kt + \ln C \Rightarrow P = C\,e^{kt}$

si $t = 0$, $P = P_o$ y de 2) $C = P_o \Longrightarrow$

3) $P_t = P_o e^{kt}$

Formulación causal del ejemplo anterior:

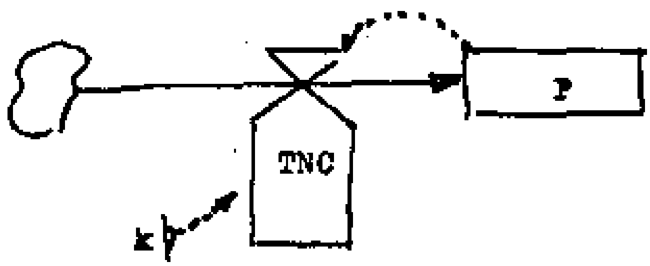


$$P.K = P.J + (DT)(TNC.JK)$$

$$\frac{P.K - P.J}{DT} = TNC.JK$$

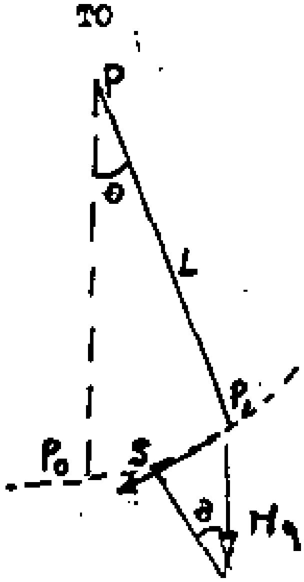
$$\frac{dP}{dt} = TNC_t \quad \text{pero:} \quad TNC = kP \qquad \frac{dP}{dt} = k\,P$$

siguiendo el proceso anterior: $P_t = P_0 e^{kt}$



Hagamos otro ejemplo:

UN PENDULO, DE LONGITUD <u>L</u> Y MASA <u>M</u>, SUSPENDIDO DEL PUNTO <u>P</u> SE MUEVE EN UN PLANO VERTICAL BAJO P. ENCUENTRE LA ECUACION DEL MOVIMIENTO



<u>HIPOTESIS</u>: EL CENTRO DE GRAVEDAD DEL PENDULO SE MUEVE EN FORMA CIRCULAR CON CENTRO <u>P</u> Y CON RADIO <u>L</u>. SEA ϕ EL ANGULO POSITIVO MEDIDO EN SENTIDO CONTRARIO DE LAS MANECILLAS DEL RELOJ Y CUYA MAGNITUD ES FUNCION DEL TIEMPO <u>t</u>. LA UNICA FUERZA ES LA GRAVEDAD (SENTIDO POSITIVO HACIA ABAJO) Y SU COMPONENTE, TANGENTE AL CIRCULO ES: $Mg \operatorname{sen}\phi$. SI <u>S</u> ES IGUAL AL ARCO P_0P_1, ENTONCES $S = L\phi$ Y LA ACELERACION A LO LARGO DEL ARCO ES:

$$\frac{d^2S}{dt^2} = L\,\frac{d^2\phi}{dt^2}$$

$$ML\left(\frac{d^2\phi}{dt^2}\right) = -Mg\,\text{sen}\,\phi \quad\Longrightarrow\quad L\,\frac{d^2\phi}{dt^2} = -g\,\text{sen}\,\phi \quad \ldots.(1)$$

multiplicando por $2\,\frac{d\phi}{dt}$ e integrando:

$$L\left(\frac{d\phi}{dt}\right)^2 = 2g\cos\phi + C_1$$

o bien:
$$\frac{d\phi}{\sqrt{2g\cos\phi + C_1}} = \pm\frac{dt}{\sqrt{L}}$$

cuando ϕ es pequeño, SEN $\phi \doteq \phi$

$$L\,\frac{d^2\phi}{dt^2} + g\,\phi = 0 \qquad \phi = C_1\cos\sqrt{\frac{g}{L}}\,t + C_2\,\text{sen}\sqrt{\frac{g}{L}}\,t$$

O LO QUE ES IGUAL: ES UN EJEMPLO DEL MOVIMIENTO ARMONICO SIMPLE

$$S_t = C_1 L\cos\sqrt{\frac{g}{L}}\,t + C_2 L\,\text{sen}\sqrt{\frac{g}{L}}\,t$$

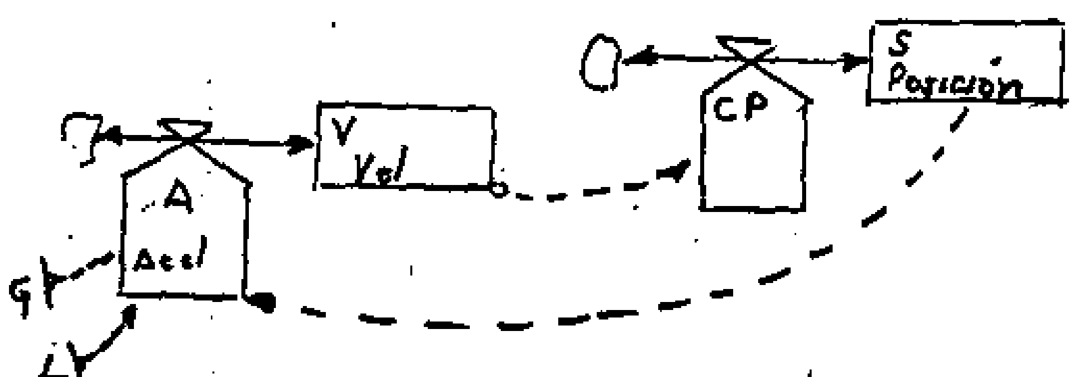
¡ C O N T I N U A N D O !

$A = \frac{G}{L}(-S)$ $\qquad$ $A.KL = \left(\frac{G}{L}\right)(-S.K)$

$V = \int A\,dt$ $\qquad$ $V.K = V.J + (DT)(A.JK)$

$S = \int V\,dt$ $\qquad$ $CP.KL = V.K$

$S.K = P.J + (DT)(PC.JK)$



IV. MANIPULACIONES DE LA MATRIZ I-O

Formulación Estática: COMO HEMOS VISTO, LA MATRIZ I-O NOS DA EL FLUJO DE BIENES Y SERVICIOS QUE SE HA ESTABLECIDO ENTRE LOS DIFERENTES SECTORES DE UNA ECONOMIA DURANTE UN DETERMINADO PERIODO DE TIEMPO, DIGAMOS DE UN AÑO. REPRESENTEMOS UN EJEMPLO MUY SIMPLE CONSTITUIDO POR UNA ECONOMIA TRISECTORIAL:

	S_1	S_2	S_3	VBP
S_1	x_{11}	x_{12}	x_{13}	X_1
S_2	x_{21}	x_{22}	x_{23}	X_2
S_3	x_{31}	x_{32}	x_{33}	X_3

EN QUE:

S_i = SECTOR DE PRODUCCION $\quad i = 1,2,3$

x_{ij} = VENTAS DEL SECTOR S_i AL SECTOR S_j

X_i = VALOR BRUTO DE LA PRODUCCION

AHORA BIEN: $\boxed{\text{SI } x_{ij} = a_{ij} X_j} \Longrightarrow$

$$a_{ij} = \frac{\text{CANTIDAD DE PRODUCCION DEL } S_i \text{ ABSORBIDA POR } S_j}{\text{PRODUCCION DE } S_j}$$

$$= \frac{x_{ij}}{X_j}$$

ES DECIR, a_{ij} = COEFICIENTE TECNICO QUE REPRESENTA LA COMPRA DE PRODUCTOS INTERMEDIOS DEL SECTOR j AL SECTOR i, PARA CONCRETAR UNA UNIDAD DE PRODUCCION BRUTA DEL SECTOR j. POR LO TANTO, LA MATRIZ DE COEFICIENTES TECNICOS SERA:

PARA ESTE EJEMPLO:

	S_1	S_2	S_3	VBP
S_1	$x_{11} = 50$	$x_{12} = 40$	$x_{13} = 110$	200
S_2	$x_{21} = 70$	$x_{22} = 30$	$x_{23} = 150$	250
S_3	$x_{31} = 80$	$x_{32} = 180$	$x_{33} = 40$	300

	S_1	S_2	S_3
S_1	0.25	0.16	0.3666
S_2	0.35	0.12	0.5000
S_3	0.40	0.70	0.1333

a_{13} (0.3666)

a_{32} (0.70)

Y REGRESANDO: SI LA PRODUCCION BRUTA X_j DEL S_j ES IGUAL A SUS VENTAS DE DEMANDA FINAL (Y_j), MAS SUS VENTAS A LOS OTROS SECTORES PRODUCTORES ENTONCES:

$$X_1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + Y_1$$
$$X_2 = a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + Y_2$$
$$X_3 = a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + Y_3$$

- -

$$\begin{array}{lllll} (1 - a_{11})X_1 & -a_{12}X_2 & -a_{13}X_3 & & Y_1 \\ -a_{21}X_1 & +(1 - a_{22})X_2 & -a23X_3 & & Y_2 \\ -a_{31}X_1 & -a_{32}X_2 & +(1-a_{33})X_3 & = & Y_3 \end{array}$$

$$\begin{bmatrix} 1 - a_{11} & -a_{12} & -a_{13} \\ -a_{21} & 1 - a_{22} & -a_{23} \\ -a_{31} & -a_{32} & 1 - a_{33} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix}$$

EXPRESION GENERAL:

$$\left[X_i\right] = \left[a_{ij}\right]^{-1} \left[Y_i\right] = \left[A_{ij}\right] \left[Y_i\right]$$

SI SUPONEMOS CONOCIDAS LAS DEMANDAS FINALES, EL SISTEMA TIENE SOLUCION

LA MATRIZ I-O DINAMICA SE DESARROLLA A PARTIR DE LA ESTATICA DESDE EL MOMENTO EN QUE CONSIDERAMOS QUE LA INTERDEPENDENCIA SECTORIAL PRESENTA DESFASES, O SUPONEMOS QUE LA MISMA EXPERIMENTA VARIACIONES A LO LARGO DEL TIEMPO. LAS RELACIONES ESTRUCTURALES ENTRE LOS STOKS Y LAS CORRIENTES DE BIENES CONSTITUYEN LA BASES TEORICA DEL ENFOQUE I-O DEL ANALISIS EMPIRICO DEL PROCESO DE ACUMULACION Y DE LA PLANEACION DEL DESARROLLO.

EL STOCK DE BIENES PRODUCIDOS POR EL SECTOR i QUE EL SECTOR j DEBE ABSORBER POR unidad DE SU PRODUCTO, CORRESPONDIENTE A LA PLENA CAPACIDAD, ES DENOMINADO COEFICIENTE DE CAPITAL DEL BIEN i EN EL SECTOR j Y ACOSTUMBRA DESIGNARSE POR b_{ij}

EL EQUILIBRIO ENTRE EL PRODUCTO Y LA CAPACIDAD DISPONIBLE DE UN SECTOR CARACTERISTICO, POR EJEMPLO EL i, Y SU UTILIZACION EN UN AÑO PARTICULAR t, PODRIA SER DESCRITO POR LA SIGUIENTE ECUACION LINEAL DIFERENCIAL, QUE IMPLICA LA EXISTENCIA DE INTERRELACIONES ESTRUCTURALES ENTRE LOS INSUMOS Y PRODUCTOS DE LOS DIVERSOS SECTORES Y SUS tasas de cambio, $\dot{X}_1(t)$, $\dot{X}_2(t)$, $\dot{X}_3(t)$,.......

$$X_1(t) - a_{11}X_1(t) - a_{12}X_2(t) - \ldots\ldots\ldots - a_{1n}X_n(t) -$$
$$- b_{11}X_1(t) - b_{12}X_2(t) - \ldots\ldots - b_{1n}X_n(t) = Y_1(t)$$

LA MAYOR PARTE DEL TRABAJO EMPIRICO EN ESTE CAMPO SE LLEVA A CABO EMPLEANDO EL ANALISIS DE PERIODOS DISCRETOS QUE SE FUNDA EN SISTEMAS DE ECUACIONES EN DIFERENCIAS DEL TIPO QUE INDICAMOS A CONTINUACION

$$X_i^t - a_{11}X_1^t - a_{12}X_2^t - \ldots\ldots - a_{1n}X_n^t -$$
$$-b_{11}(X_1^{t+1}-X_1^t) - b_{12}(X_2^{t+1}-X_2^t) - \ldots\ldots\ldots - b_{1n}(X_n^{t+1}-X_n^t) = Y_i^t$$

LA FORMULACION EN DYNAMO SE PRESENTA EN LAS SIGUIENTES HOJAS, PERO PODEMOS AFIRMAR LO SIGUIENTE:

- EN UN MODELO REGIONAL, LAS DEMANDAS FINALES SON TAMBIEN VARIABLES ENDOGENAS Y POR LO TANTO, EXISTE UNA INTERACCION ENTRE LAS VARIABLES RELEVANTES, TAL Y COMO SE PLANTEARA EN LA PROXIMA CONFERENCIA LO ANTERIOR PERMITIRA DESCRIBIR PARA CADA POLITICA, POR EJEMPLO: EL RITMO DEL PIB, NIVEL DE EMPLEO etc., EN CADA DIFERENCIAL DE TIEMPO dt.

- LOS COEFICIENTES TECNICOS Y DE CAPITAL PUEDEN VARIAR INTERNAMENTE A TODO LO LARGO DEL HORIZONTE DE PLANEACION Y PARA CADA SIMULACION A REALIZAR

E J E M P L O S:

ACADEMIA
NACIONAL
DE INGENIERIA, A.C.

México, D.F., mayo, 1983.

Señor (es)
Jorge Silva Midences
División de Estudios de Posgrado
de la Facultad de Ingeniería, UNAM.
Cd. Universitaria, Apdo Postal 70-256
04510 - México, D. F.

Tengo el agrado de informarle(s) que su trabajo: "LA MATRIZ INSUMO-PRODUCTO EN UN MODELO DE SIMULACION DINAMICA PARA EL ANALISIS REGIONAL".

Ha sido aceptado para su presentación ante el IX Congreso de la Academia Nacional de Ingeniería, que tendrá lugar en León, Gto., del 28 al 30 de Septiembre del presente año.

A fin de que dicho trabajo pueda incluirse en las Memorias del Congreso, le(s) ruego escribirlo en las hojas especiales anexas, siguiendo las instrucciones que también se acompañan. Juntamente con el manuscrito, deberá(n) Ud(s) devolver firmada la declaración de no publicación.

Es muy importante que los autores presenten sus trabajos personalmente, por lo que será muy apreciada su participación en el Congreso. En el caso de no poder asistir, le(s) ruego encargar la presentación a un participante que Ud(s) considere(n) capacitado para ello.

Agradeciéndole(s) su colaboración, le(s) saludo atentamente.

POR EL COMITE TECNICO

Presidente del Comite

Dr. Alejandro F. Romero López.

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LA MATRIZ INSUMO-PRODUCTO EN UN MODELO DE SIMULACION DINAMICA PARA EL ANALISIS REGIONAL

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Abstract

This paper is devote of the General System Theory. Hipothesis: the real world can be described by a set of simultaneous differential equations and the model can be simulated on a digital computer with a set of nonsimultaneous difference equations, according with Forrester, by languaje DYNAMO (DYNAmics MOdels).

The purpose is to include the Input-Output (I-O) matrix in a model of dynamics simulation for regional analysis, solving the subsystem I-O by a set of simultaneous difference equations, with the demands (exogenous variable) like endogenous and with no necessarily fixed technical and capital coefficients over the time. This lend us to generate easily alternative sets of projections and to incorporate policies within the framework used for projection so as to test their potential impact in more realistic form.

Resumen

Este documento se apoya en la Teoría General de Sistemas. Hipótesis: el mundo real puede ser representado por un conjunto de ecuaciones diferenciales simultáneas y el modelo puede ser simulado en una computadora digital con un conjunto no simultáneo de ecuaciones de diferencias, de acuerdo a Forrester, por medio del lenguaje DYNAMO (DYNAmics MOdels).

El propósito de este trabajo es incluir la matriz Insumo-Producto (I-O), en un modelo de simulacion dinámico para el análisis regional, resolviendo el subsistema I-O como un conjunto de ecuaciones de diferencias simultáneas y manipulando las demandas (variable exógenas) como endógenas así como sin tener necesariamente fijos los coeficientes técnicos y de capital a lo largo del tiempo. Lo anterior permite generar fácilmente conjuntos alternos de proyecciones, incorporando políticas y estimando sus impactos potenciales en forma más realista.

Introducción

Las investigaciones científicas son una exposición de la estructura de los sistemas naturales, la tecnología ha producido complejos sistemas de producción, pero aún así a partir de la Teoría General de los Sistemas (1), no hemos entendido completamente sus principios respecto al comportamiento de los Sistemas, aún aceptando el concepto de sistema: "conjunto de partes coordinadas con objeto de lograr un conjunto de metas" (2). Conforme a lo anterior, una componente interactuante del desarrollo nacional, es el desarrollo regional en la cual también existen prácticamente, las mismas variables. Huelga decir la importancia que actualmente cobra en nuestro país el análisis regional, debido a problemas tales como migración, contraste en actividad económica, nivel de infraestructura, contaminación, etc.

Estado del Arte

Ahora bien, dentro de los modelos a gran escala realizados sobre desarrollo regional del tipo base económica, como son los que se han utilizado en Estados Unidos sobre las regiones de San Diego, Nueva York, Cuenca del río Ohio, California o el de la Cuenca Lehigh, todos se han caracterizado por realizar dos proyecciones independientes, población y fuerza laboral (3), manipulando en forma separada la matriz I-O y como variable exógena la demanda. Una excepción en cuanto a proyecciones independientes es el modelo de la Cuenca del río Susquehanna, aunque éste no emplea como instrumento de análisis económico dicha matriz.

El presente trabajo propone una interacción dinámica para la utilización de la matriz I-O en el análisis regional, o bien, a nivel nacional, apoyándose directamente en la conceptualización teórica y matemática de Forrester (4,5), lo cual permite, baja manipulación especial, describir paso a paso las fluctuaciones de cada variable en el tiempo para cada simulación realizada.

El Subsistema I-O Dinámico

"el análisis I-O no es más que una consecuencia práctica de aquella teoría clásica que postula la interdependencia general de las variables económicas. "Considera esta teoría que el conjunto de la economía de una región, un país o el mundo costituye un sistema único, y se esfuerza por expresar la totalidad de sus funciones en términos de sus propiedades estructurales que son susceptibles de cuantificación". (Leontief). La conceptualización de la interacción dinámica representada por el diagrama causal de la fig. 1, se ilustra en la página siguiente. Lo anterior arroja como consecuencia los siguientes aspectos relevantes:

Contribución

- En un modelo regional, las demandas finales son también variables endógenas y por lo tanto, existe una interacción entre todas las variables relevantes (fig2), lo anterior permite describir para cada política asumida, por ejemplo: el ritmo del PIB, empleo, etc., y en cada diferencia del tiempo dt.
- Los coeficientes técnicos y de capital pueden variar internamente a todo lo largo del horizonte de análisis y para cada simulación realizar

-Las entregas que el sector A se hace a sí mismo y a los demás sectores en respuesta a las respectivas necesidades de la capacidad productiva, y de acuerdo a Forrester (4,5), se mide por la diferencia existente entre el nivel de producción del tiempo presente K, y el tiempo pasado J, es decir en cada diferencial de tiempo dt, (6) o bien, como diferencia entre un pronóstico de evento futuro y tiempo presente.

Como ejemplo de cómputo, sea la variable Inventario (I) es como las Tasas de entrada y salida E y S respectivamente:

$$I_{\text{"ahora"}} = I_{\text{"anterior"}} + \int_0^t (E-S)\,dt \text{ ------------ (0)}$$

$$I_k = I_j + (E_{jk} - S_{jk})DT \text{ -------- (0')}$$

en que DT se usa para definir el lapso entre J y K o E y S de acuerdo a la fig. 3

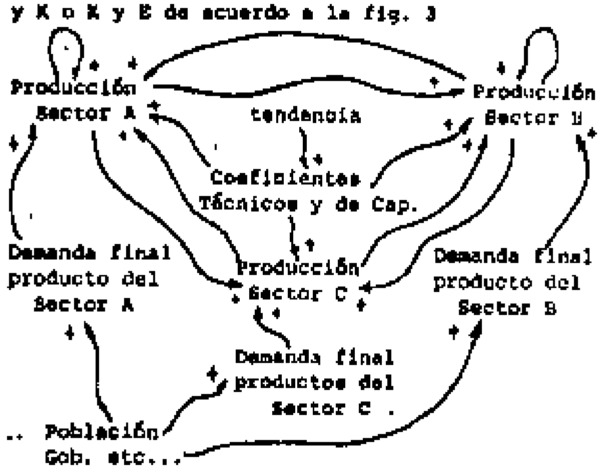

Figura 1

"La descripción analítica general y al mismo tiempo realista de las relaciones I-O de índole dinámica sería utilizando diferentes variables para designar las corrientes de insumo y producción efectuadas o absorbidas por la misma industria en años diferentes. El equilibrio entre lo producido y la capacidad disponible de un sector característico por ejemplo el x_i y su utilización en un año particular t, podría ser descrito por la siguiente ecuación lineal diferencial que implica la existencia de interrelaciones estructurales entre los insumos y su producción de los diversos sectores y sus tasas de cambio: $\dot{x}_1(t), \dot{x}_2(t)$" (7)

$$x_i(t) - a_{i1}x_1(t) - a_{i2}x_2(t) - \ldots - a_{in}x_n(t) - b_{i1}\dot{x}_1(t) - b_{i2}\dot{x}_2(t) - \ldots - b_{in}\dot{x}_n(t) = y_i(t) \text{ ---------------- (1)}$$

$$x_i^t - a_{i1}^t x_1^t - a_{i2}^t x_2^t - \ldots - a_{in}^t x_n^t - b_{i1}^t(x_1^{t+1} - x_1^t) - b_{i2}^t(x_2^{t+1} - x_2^t) - \ldots - b_{in}^t(x_n^{t+1} - x_n^t) = y_i^t \text{ ---------- (2)}$$

en que:

$x_i(t) = x_i^t$ = cantidad de producción del sector del sector i en el sector j, en el tiempo $\underline{t}$

$\dot{x}_i(t)$ = tasa de cambio del sector i en el tiempo $\underline{t}$

a_{ij}^t = coeficiente técnico del producto del sector i en el sector j, en el tiempo $\underline{t}$

b_{ij}^t = coeficiente de capital del bien i en el sector j, en el tiempo $\underline{t}$

$y_i(t) = y_i^t$ = cantidad de la demanda final del producto del sector i en el tiempo $\underline{t}$

t = unidad de tiempo

y la formulación general en lenguaje Dynamo:

$$PT_i.K = PT_i.J + (DT)(1/T)(TX_i.J - PT_j.J) \text{ --- (3)}$$

$$TX_i.K = (1/[1-A_{ii}.K])[STCK_i.K + \sum_{j=1}^{n}((A_{ij}.K)(PT_j.K)) + \sum_{j=1}^{n}((B_{ij}.K)(PT_j.K)) + Y_i.K] \text{ -------- (4)}$$

$$DPROP_i.K = (A_{ii}.K)(PT_i.K) \text{ ó bien ---------- (5)}$$

$$(A_{ii}.K)(TX_i.K) \text{ si } REALS_i.K = f(\text{pronóstico}) \text{ - (5')}$$

$$STCK_i.K = (B_{ii}.K)(REALS_j.K) \text{ ---------------- (6)}$$

$$REALS_i.K = CLIP(IP_i.K, 0, IP_i.K, 0) \text{ ------------ (7)}$$

$$IP_i.K = PT_i.K - A_i.J \text{ ó bien ------------- (8)}$$

$$(\text{Pronósticos})_i.K = TX_i.K \text{ ------------------ (8')}$$

$$A_i.K = A_i.J + (DT)(1/T)(TA_i.J - A_i.J) \text{ ------ (9)}$$

$$PT_i = 0 \text{ ------------------------------ (10)}$$

$$A_i = 0 \text{ ------------------------------ (11)}$$

$$TA_i.K = PT_i.J \text{ ------------------------------ (12)}$$

Si $REALS_i.K$ se define en función de un pronóstico (6), entonces desaparecen las ecuaciones 3), 9), 10), 11) y 12), siendo la notación la siguiente:

$PT_i.K = TX_i.K$ = cantidad de producción del sector i en el tiempo presente K.

PT_i = valor de inicialización

$PT_i.J = TX_i.J$ = cantidad de producción del sector i en el tiempo pasado J

DT = diferencial de tiempo

T = tiempo promedio de demora

$A_{ij}.K$ = coeficiente técnico del producto del sector i en el sector j, en el tiempo presente K

$B_{ij}.K$ = coeficiente de capital del bien i en el sector j, en el tiempo presente K

$DPROP_i.K$ = demanda propia del sector i en el tiempo presente K

$STCK_i.K$ = adiciones al stock de capital productivo del sector i en el tiempo presente K

$A_i.K$, A_i, $TA_i.K$, $IP_i.K$ = variables auxiliares

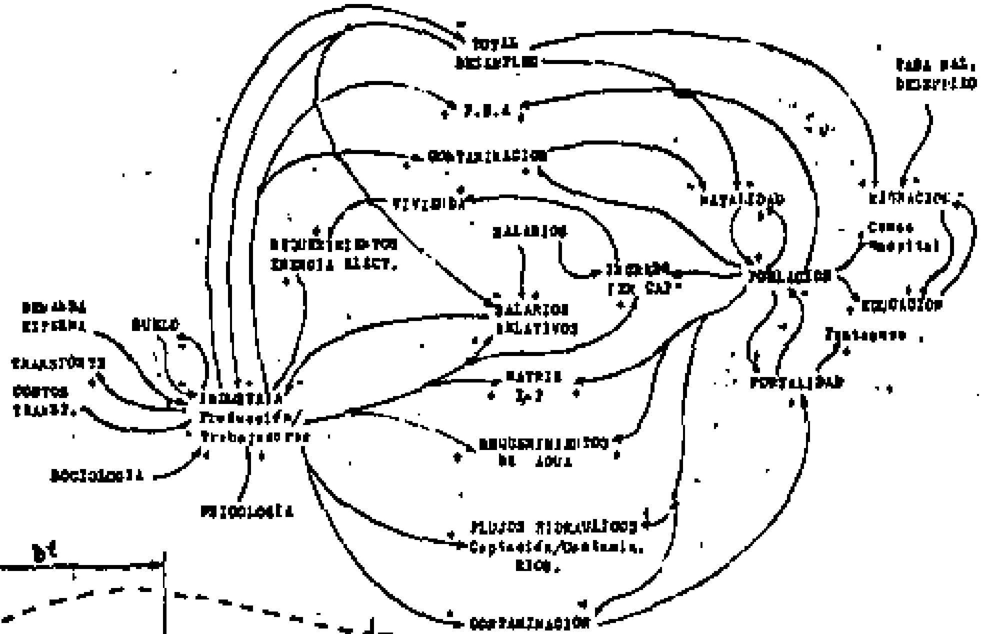

Figura 2

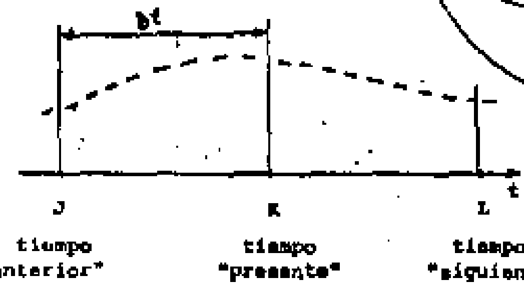

Figura 3

EJEMPLOS

Ejemplo 1: (validación)
En la tabla 1 se presenta un ejemplo sencillo tomado del artículo Análisis I-O, 1965 de Leontief (7) en el cual primero hizo un análisis de consistencia interna, para lo cual mantiene constante las demandas Y_1 y Y_2 (variable exógenas) en 55 Hl de trigo y 30 m^2 de paño. El producto total de trigo se mantiene constante en 100 Hl y el de productos manufacturados en 50 m de paño; es decir, la economía se mantuvo invariable.

TABLA 1 Ejemplo del artículo "Análisis I-O/1965" pg 208, ...(7)

Hacia / A partir	Sect 1 Agric.	Sect 2 Indust	Sect 3 Familias	Output ($)
Sector 1 Agricultura	50	40	110	200
Sector 2:	70	30	150	250
Sector 3:	80	180	40	300
Input Total	200	250	300	

En dynamo, las Listas 1 y 2 se presentan los listados por computadora, en la 3, los valores asumidos por las variables asumidos por las variables. En la fig. 3 se presenta la gráfica por computadora obtenida con una DT=0.125 en que, efectivamente, la economía se mantiene invariable

Lista 1

```
[illegible]

BURROUGHS B6700/B7700 DYNAMO LEVEL [illegible]

INPUT PHASE BEGIN AT [illegible]

DYNAMO [illegible]
RUN   LEONTIEF

        [illegible] DE ANALISIS INPUT/OUTPUT [illegible]
            SECTOR [illegible] AGRICULTURA
[illegible]
```

```
A2.K=A2.J+(DT)(1/T)(Y2(A2,J-A2,J))
A2=0
TA2.K=T12.J                                   Lista F
                                              (cont'n)
Y2=DEMANDA FAMILIAR AL SECTOR (2)

Y2.K=TABHL(Y2T,TIME.K,0,5,.5)
Y2T=0/30/30/30/30/30/30/30/30/30/30

COEFICIENTES TECNICOS = AIJ
COEFICIENTES DE CAPITAL = BIJ
A11=0.25
A12=0.40
A21=0.14
.PAGE.
A22=0.13
B11=0.70
B12=0.05
B21=0.01
B22=0.07

T=0.125
PRINT 1)X1/2)X2/3)...
PRINT 1)...
PLOT  X1=1(0,150)/X2=2(0,150)/Y1=Y(0,75)/Y2=?(0,50)
SPEC  DT=0.125
SPEC  LENGTH=5
SPEC  PRTPER=0.5
SPEC  PLTPER=0.125

INPUT PHASE CONCLUDED AT   2115 35

GENERATION PHASE BEGAN AT  2115 37
RUN PHASE GENERATED AT     2115 42
.PAGE.
PRINT PHASE GENERATED AT   2115 43
PLOT PHASES GENERATED AT   2115 44

ELAPSED COMPILATION TIME     1 48

PLEASE ENTER COMPILE LEONT/D       WITH ALGOL.  THEN
WAIT UNTIL YOUR TERMINAL REPORTS THAT YOUR COMPILATION
IS COMPLETE.  AFTER GOOD COMPILATION ENTER  EXECUTE
LEONT/D

COMPILE LEONT/D WITH ALGOL
                                              Lista G

PAGE  2     LEONTI

      STARTED PRINTING AT  2116.40..., 14 JULY 1983
```

TIME					Y1 / Y2	
E+00	E+00 E+00	E+00 E+00	E+00 E+00	E+00 E+00	E+00 E+00	E+00 E+00
0.0000	0.000 0.000	0.0000 0.00000	0.000 0.0000	0.00000 0.00000	0.000 0.000	0.00 0.000
0.5000	18.424 10.430	5.5404 0.67234	13.718 4.1104	0.67234 0.74120	55.000 30.000	74.70 34.245
1.0000	25.185 14.104	0.0000 0.00000	20.170 4.0511	0.00000 0.00000	55.000 30.000	100.74 50.424
1.5000	25.001 14.001	0.0000 0.00000	20.001 4.0004	0.00000 0.00000	55.000 30.000	100.01 50.001
2.0000	25.000 14.000	0.0000 0.00000	20.000 4.0000	0.00000 0.00000	55.000 30.000	100.00 50.000
2.5000	25.000 14.000	0.0000 0.00000	20.000 4.0000	0.00000 0.00000	55.000 30.000	100.00 50.000
3.0000	25.000 14.000	0.0000 0.00000	20.000 4.0000	0.00000 0.00000	55.000 30.000	100.00 50.000
3.5000	25.000 14.000	0.0000 0.00000	20.000 4.0000	0.00000 0.00000	55.000 30.000	100.00 50.000
4.0000	25.000 14.000	0.0000 0.00000	20.000 4.0000	0.00000 0.00000	55.000 30.000	100.00 50.000
4.5000	25.000 14.000	0.0000 0.00000	20.000 4.0000	0.00000 0.00000	55.000 30.000	100.00 50.000

En la fig. 4, una nueva gráfica computarizada, pero ahora incrementando la demanda Y_1 y decrementando la Y_2. Lo anterior permite visualizar la cantidad y capacidad de respuesta del sistema.

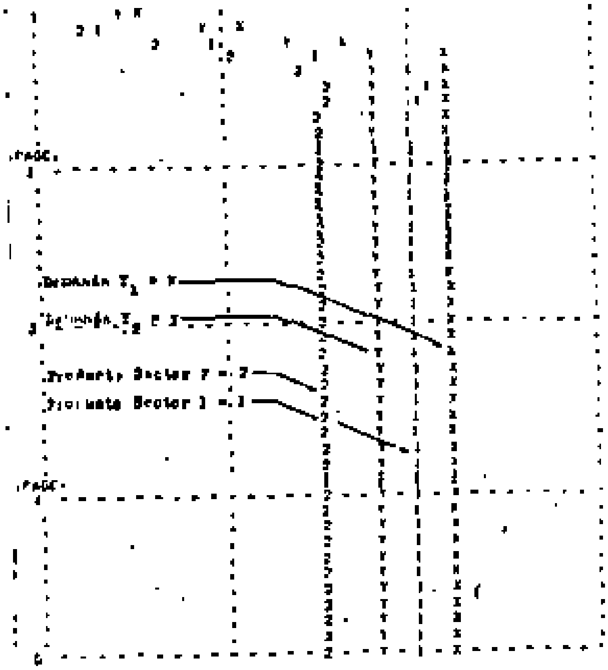

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Figura 3

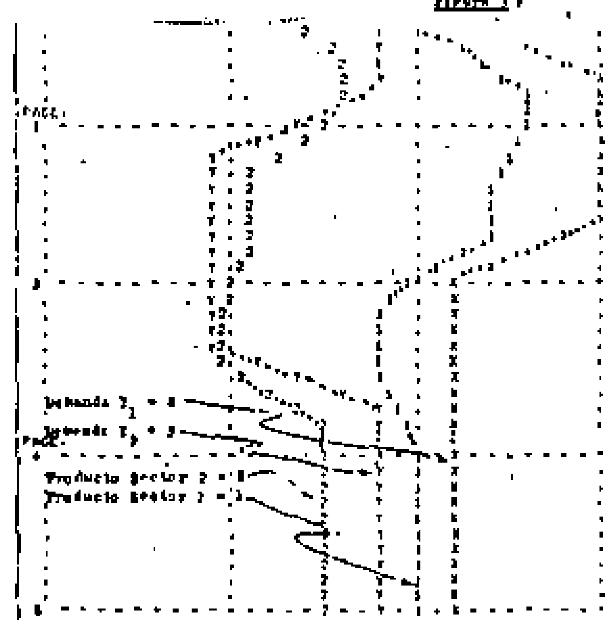

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Figura 4

En la fig. 5 se realiza otra simulación, ahora con una DT=0.0625 año

Ejemplo 2:

Dentro del análisis regional (8), un diagrama causal general puede ser como el de la fig 2 anterior, y cuyos resultados se visualizan en las gráficas por computadora de las figs. 6 y 7 y se puede apreciar las fluctuaciones de algunas de las 72 variables consideradas.

Agradecimientos

Este trabajo fue posible gracias a la beca otor

gada por la ex-Secretaría de Asentamientos Humanos y Obras Públicas, siendo Subsecretario el Ing. Rodolfo Félix Valdes, así como por la asesoría del Dr. José de Jesús Acosta Flores, Subjefe de Ingeniería de Sistemas de la DEPFI, UNAM.

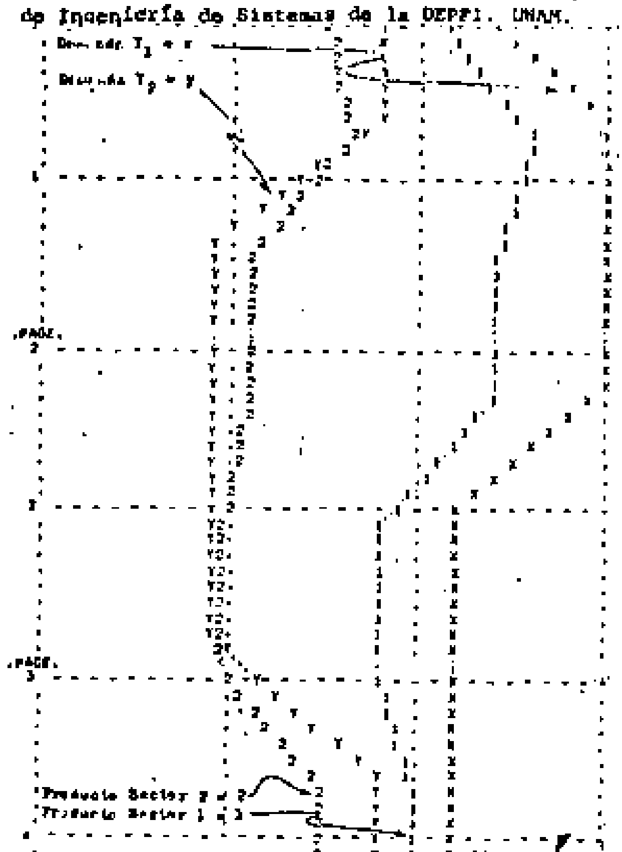


Figura 5

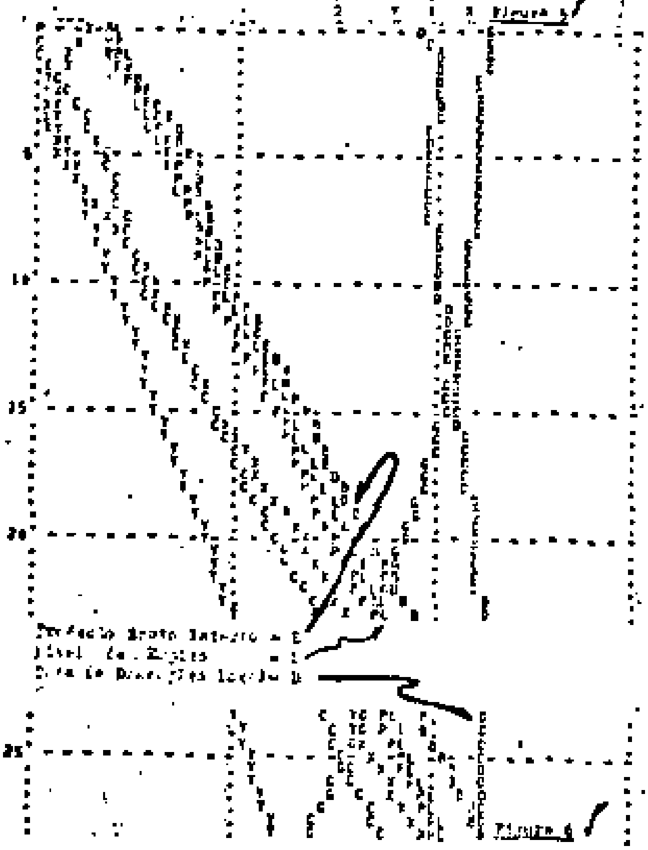
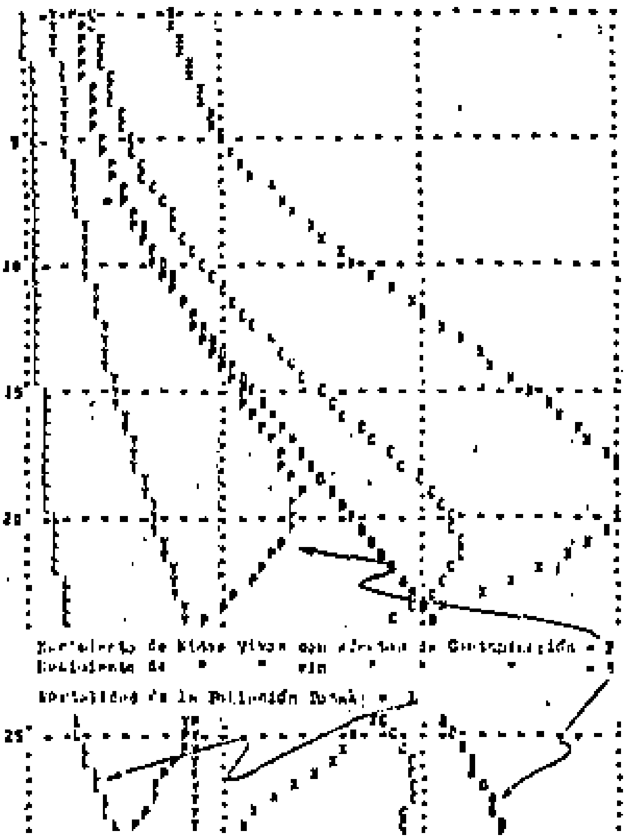


Figura 6



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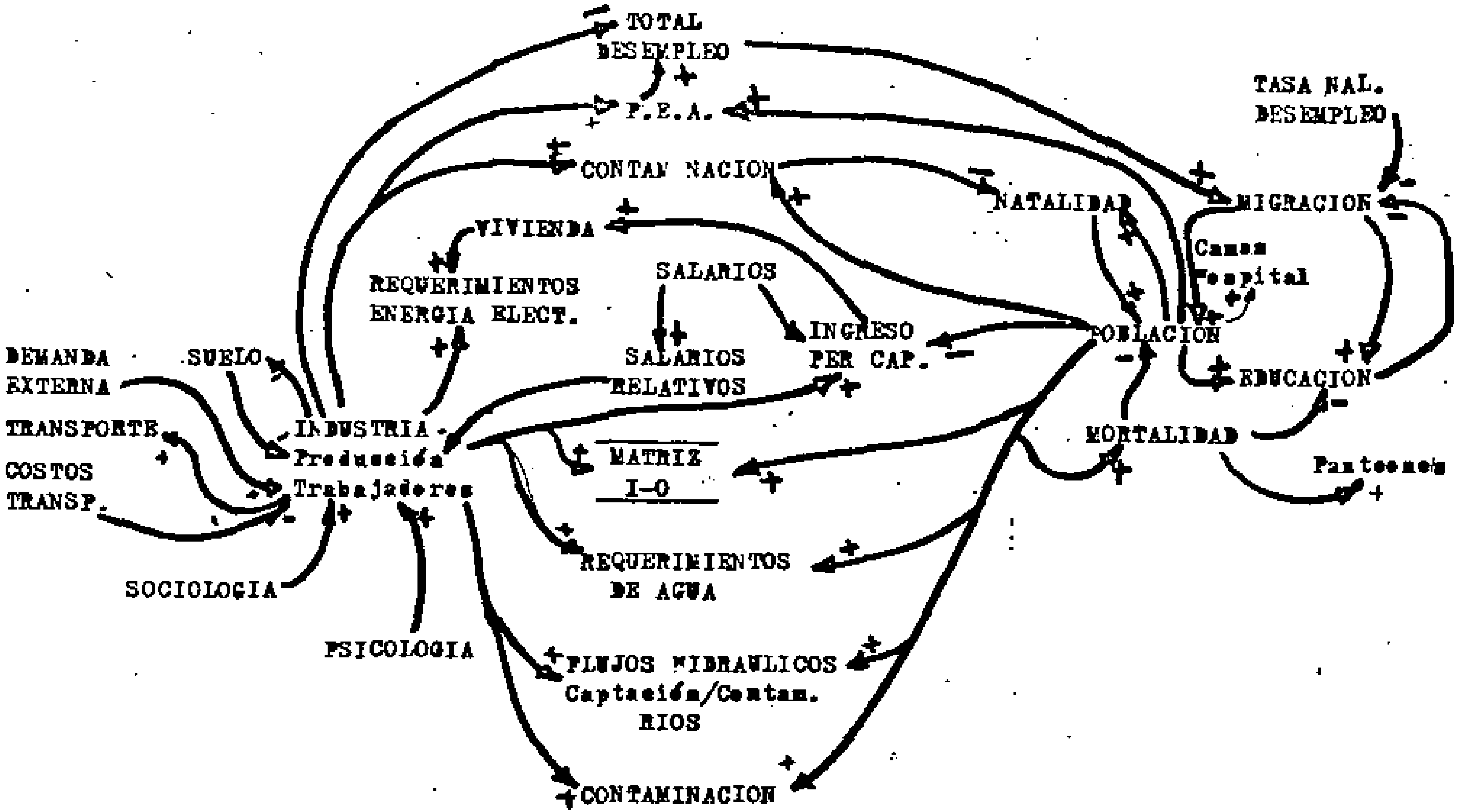
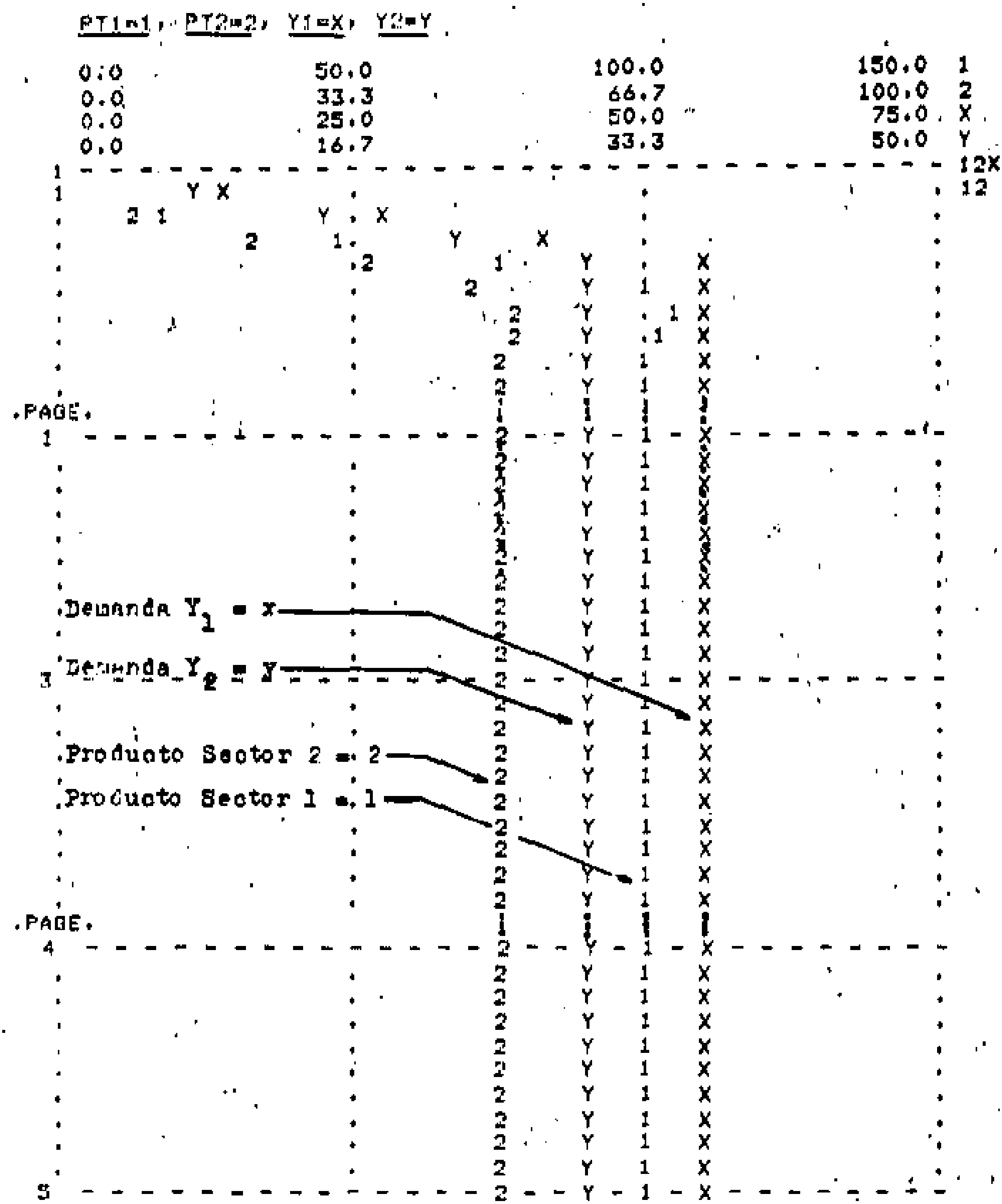


UN MODELO REGIONAL

BEGAN PLOTTING AT 7:18.1825, 16 JULY 1983

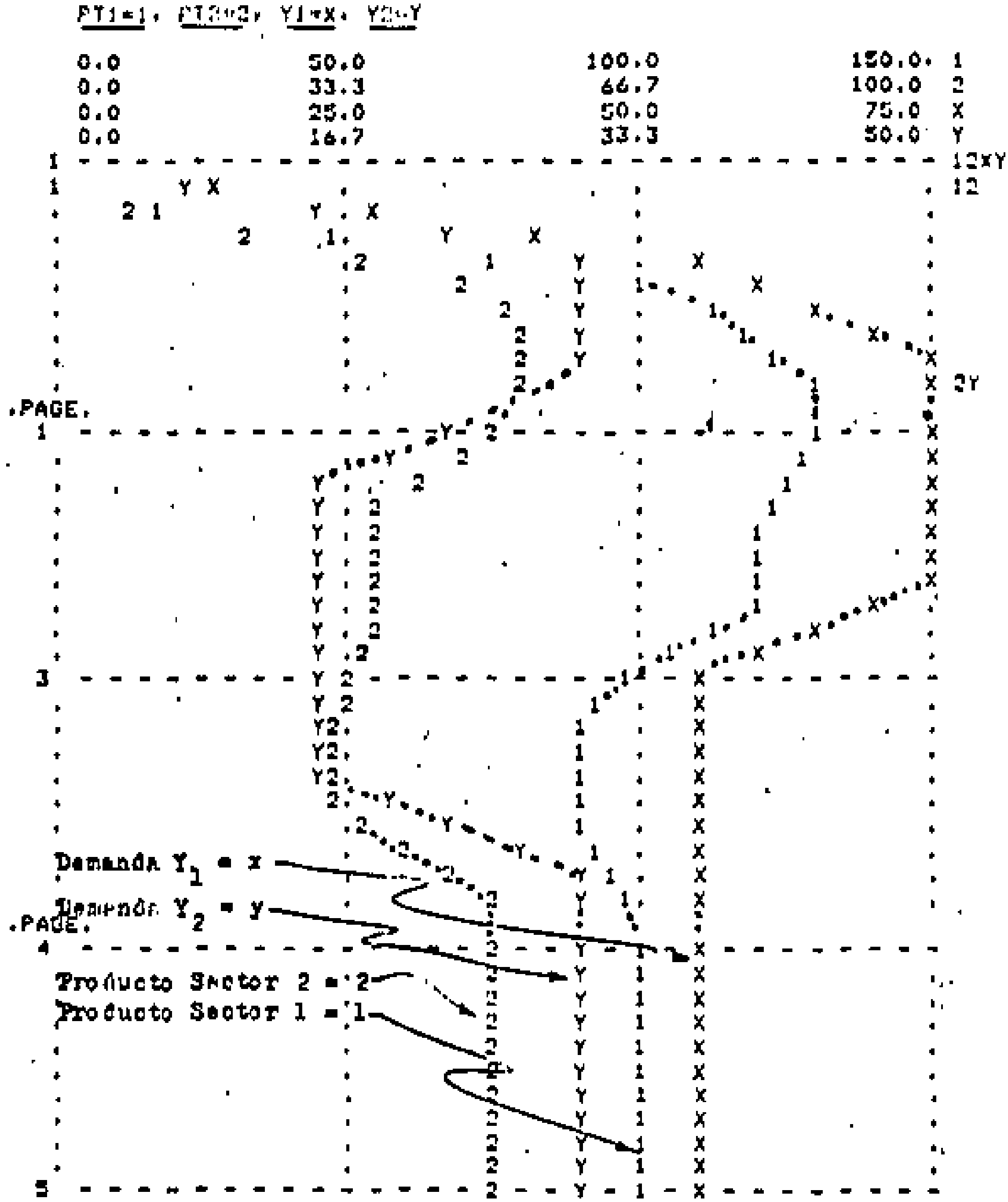


FINISHED RUN NUMBER LEONTI AT 7:20.0956, 16 JULY 1983
#ET=3:27.2 PT=0.8 IO=1.6

Figura 3

GET DYNAMOINPUT

BEGAN PLOTTING AT 7120.0231, 16 JULY 1983



FINISHED RUN NUMBER LEONTI AT 7129.9806, 16 JULY 1983
#ET=3:30.2 PT=0.8 IO=1.6

Figura 4

SA
#UPDATING
#WORKSOURCE DYNAMOINPUT SAVED; OLD SOURCE REMOVED

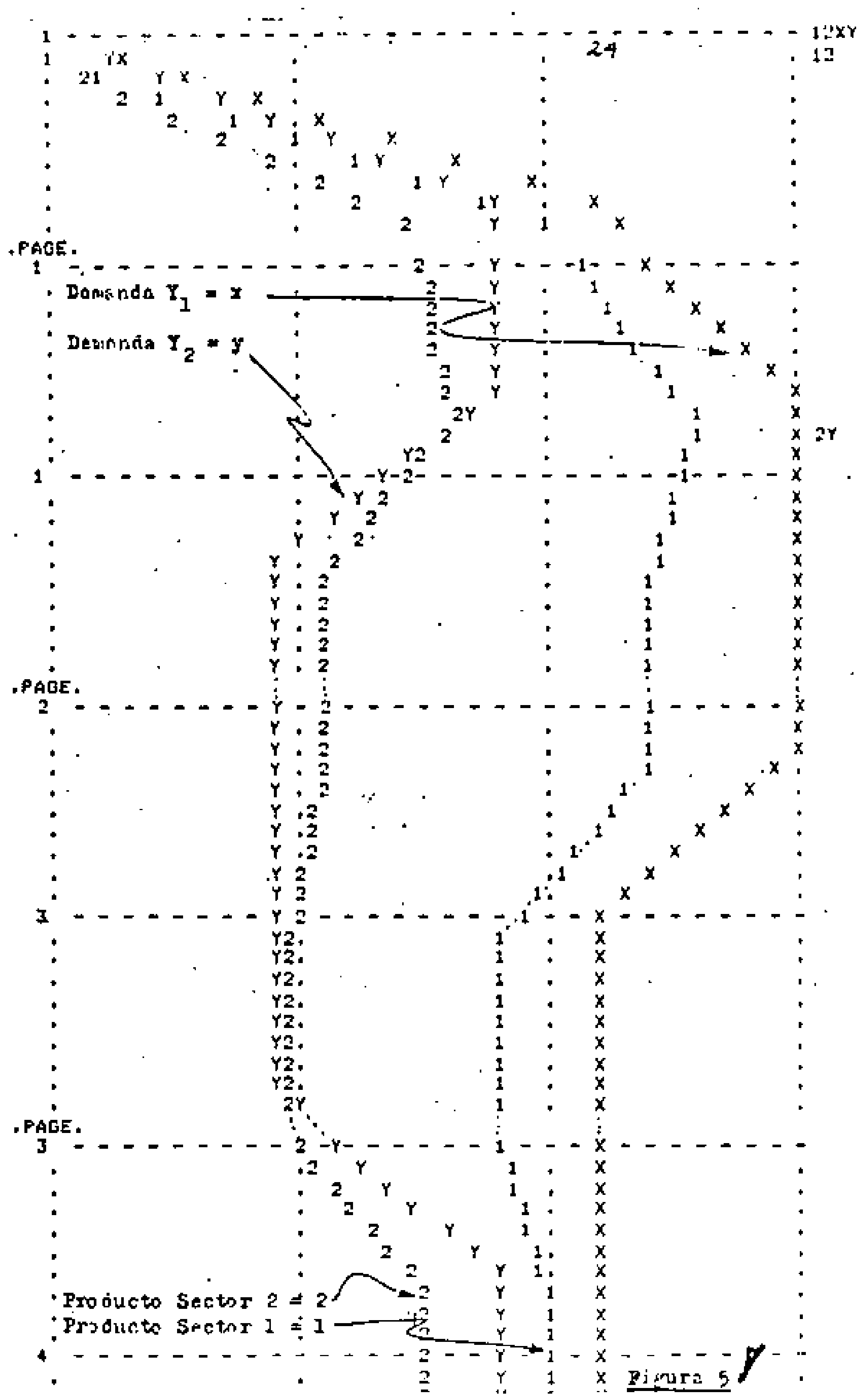

24
12XY
12
.PAGE.
Demanda Y_1 = x
Demanda Y_2 = y
.PAGE.
.PAGE.
Producto Sector 2 = 2
Producto Sector 1 = 1

Figura 5

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