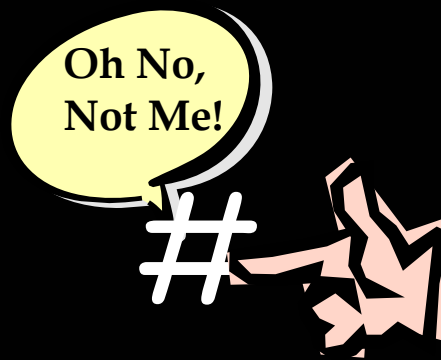


Structure of the Macroeconomic Advisers' Macro Model of the U.S.

Or

How to Make an Honest Living Pushing Around Big Matrices of Helpless Numbers



WUMM

- Quarterly Structural Macro Model
- Roughly 745 Variables
- 134 Estimated Equations
- 201 Exogenous Variables
- Runs on Personal Computers (Since '83)

WUMM (a textbook exposition)

- Dynamic IS/LM Model
 - An Aggregate Production Function
 - A Long-run Vertical Phillips Curve
-
- Keynesian Properties in the Short-Run
 - Neoclassical Growth Model in the L-R

IS/LM w/Aggregate Supply

- Goods Market Equilibrium

$$Q \cong^* C(Q) + I(Q,r) + G_0 + X(Q_f) - IM(Q)$$

- Money/Credit Equilibrium

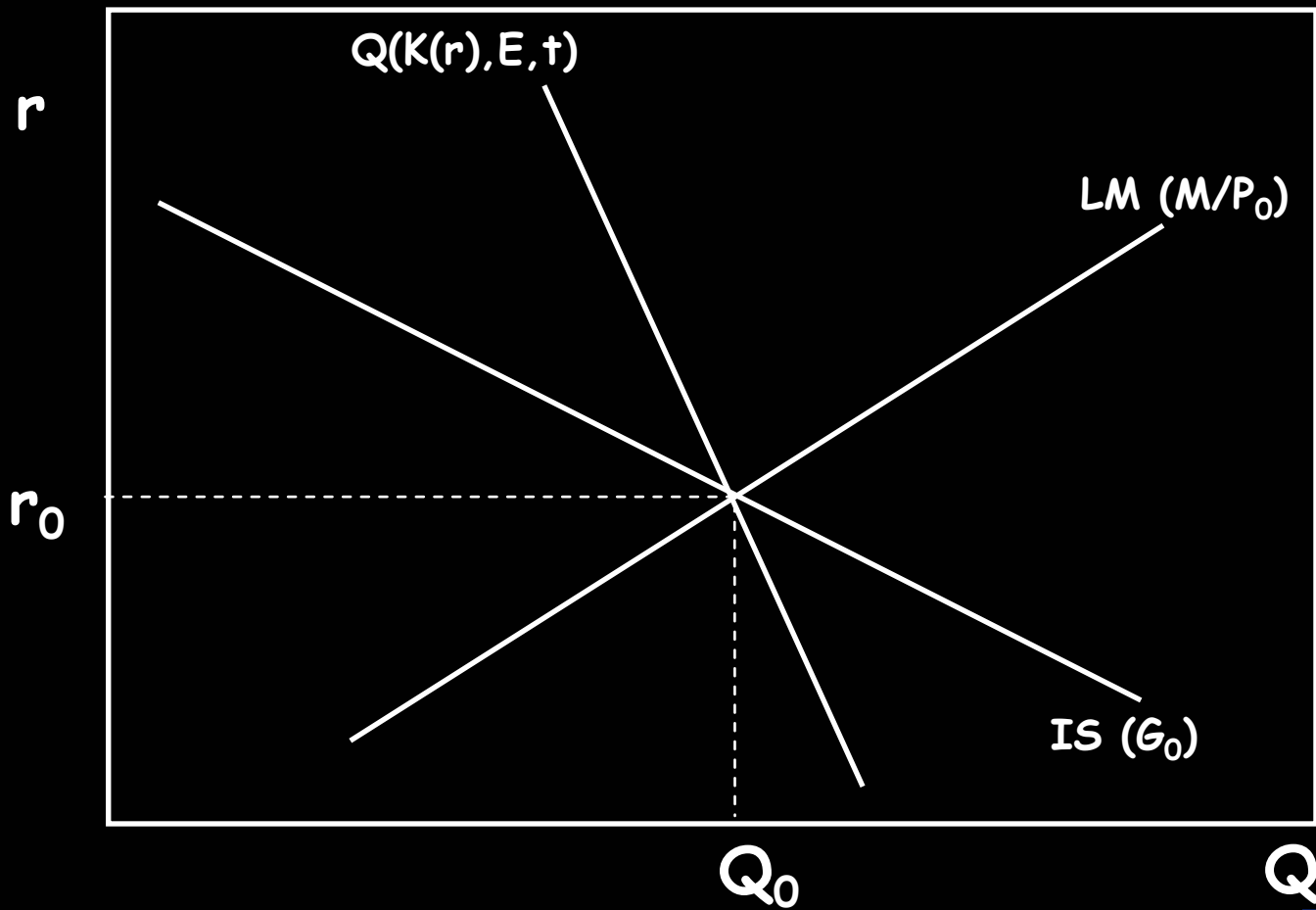
$$M_0/P = L(Q,r)$$

- Aggregate Supply

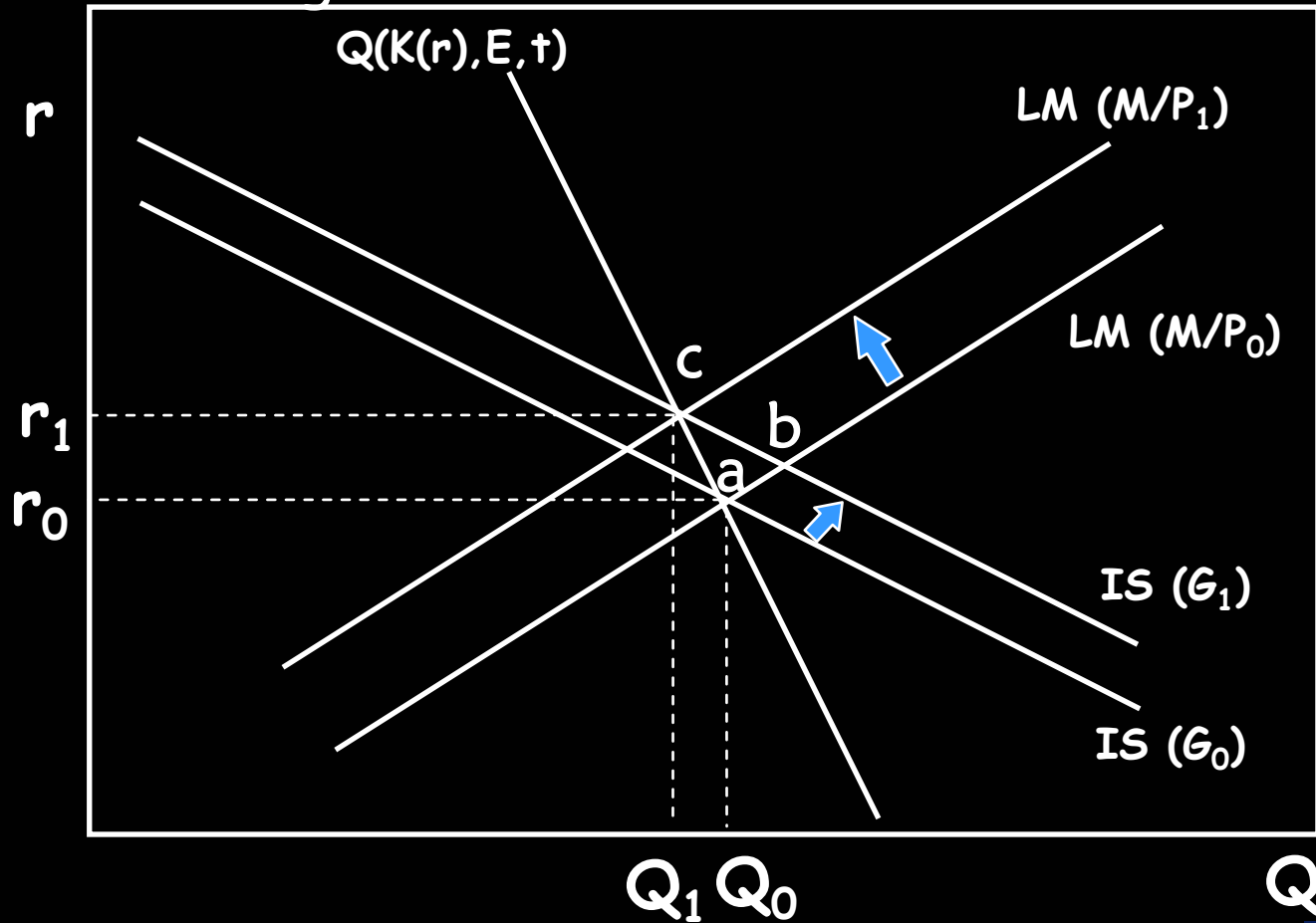
$$Q = Q(K(r), E, t)$$

*Total real output is constructed using chain-type (Fisher) aggregation

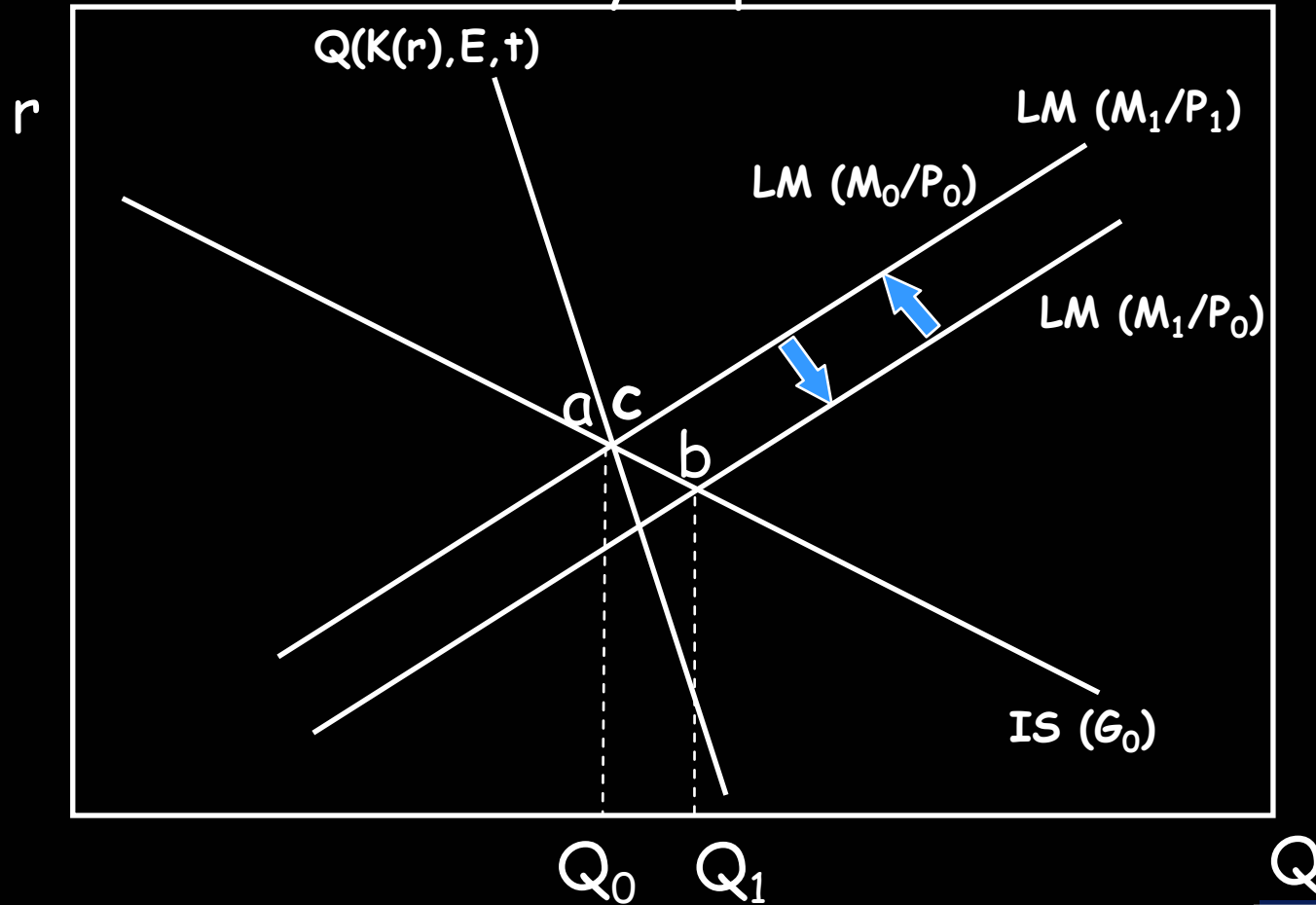
The Basics



Higher Government Purchases



Monetary Expansion



Levers for Fiscal & Monetary Policy

- Fiscal policy
 - 34 levers related to federal outlays
 - 35 levers related to federal taxes
- Monetary Policy
 - 3 regimes based upon a short-term interest rate:
 - Funds rate can be exogenous in nominal terms (RFF) or real terms (RFFREAL).
 - Nominal effective funds rate (RFFEFF) can be determined by a "reaction function" with targets for inflation, real growth, & unemployment
 - 3 regimes target monetary aggregates
 - Nonborrowed reserves (MRNB\$), nominal M1 (M1\$), or real M1 (M1)



Other Exogenous Parameters in WUMM

- Farm & energy prices
- Demographic variables
- Rate of exogenous technological advance outside the computer-producing sector

Major Sectors in WUMM

- Aggregate demand
- Financial
- Labor input & productivity
- Wages & prices
- Income determination
- Foreign economic activity

Aggregate Demand

- Real GDP (GDP) aggregated from 38 components of real spending
- Chain-Aggregation of Prices and Real Quantities
 - Consistent with procedures used by Commerce Department
 - We do all the hard work so you don't need to

Aggregate Demand: Consumption

- A Life-Cycle Model of Consumption
 - Labor Income
 - Wealth: Split between Equity & Other
 - Demographic Adj. to MPC Wealth
 - Demographic Adj. to MPC Labor Income
 - Cyclical Term (Employment Ratio)
 - Transfer Income
- "Stock Adjustment" Eq's for Durables

Aggregate Demand: Consumption

Personal Consumption Expenditures (EC)

Durable Goods (ECD)

Motor Vehicles and Parts* (ECDMV)

Other* (ECDO)

Nondurable Goods* (ECND)

Services (ECS)

Housing Services* (ECSH)

Medical* (ECSM)

Other* (ECSO)

* Denotes estimated equation

Consumption: MPCs

	Durables		Nondurables	Services			TOTAL
	MV&P	Other		Housing	Medical	Other	
Labor Income							
short-run	0.05	0.03	0.14	0.00	0.06	0.19	0.47
long-run	0.10	0.15	0.14	0.05	0.11	0.19	0.69
Med. & H.I. Trans.							
short-run	0	0	0	0	0.66	0	0.66
long-run	0	0	0	0	0.66	0	0.66
Other Transfers							
short-run	0.04	0.03	0.15	0.00	0	0.24	0.47
long-run	0.08	0.12	0.61	0.05	0	0.91	1.72
Equity Net Worth							
short-run	0	0.001	0.003	0.000	0	0.010	0.014
long-run	0.001	0.006	0.005	0.001	0	0.018	0.029
Other Net Worth							
short-run	0	0	0.025	0	0	0.014	0.039
long-run	0	0	0.025	0	0.022	0.014	0.061



Aggregate Demand: BFI

- Neoclassical Investment Model for Nonfarm Business
- Assume Capital is Putty-Clay
- Carefully Constructed User Costs of Capital
 - Weighted Debt & Equity Cost of Finance
 - Many Tax Levers: ITC, Acc. Dep., Indexing...
 - Relative Price of Investment Goods
 - Depreciation
- Elasticity of Capital Stock w.r.t. user cost = 1 - 1.4



Aggregate Demand: BFI

Nonresidential Fixed Investment (EFINR)

Producers Structures* (EPS)

Producers Durable Equipment & Software (EPD)

PDE Exc. Computers & Software* (EPDO)

PDE New Autos & Trucks* (EPDMV)

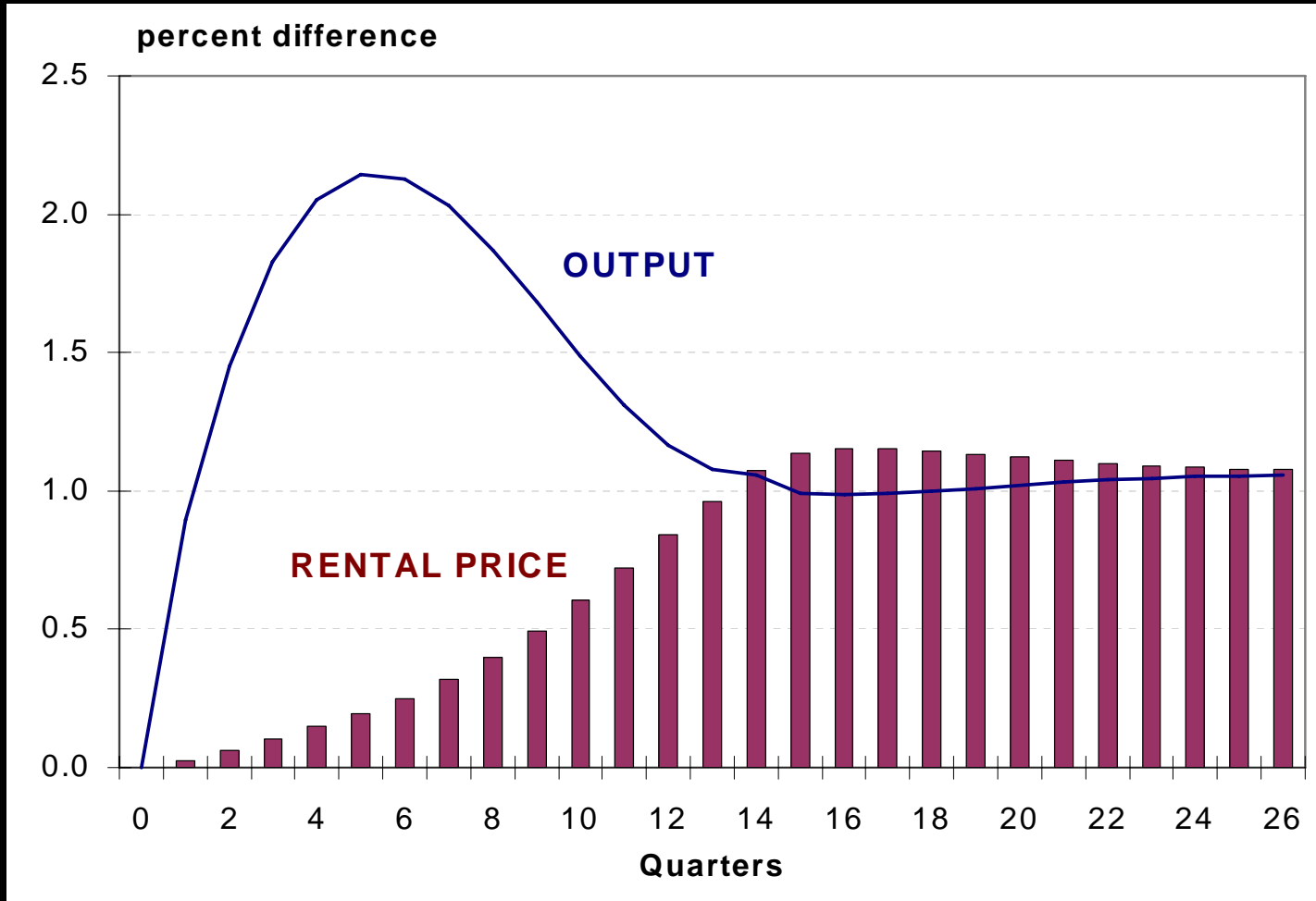
PDE Computers & Software* (EPDC)

Corresponding Stocks:

KPS, KPDO, KPDC, KPD

* Denotes estimated equation

Responses* of EPDO to 1% changes in Output & Rental Price



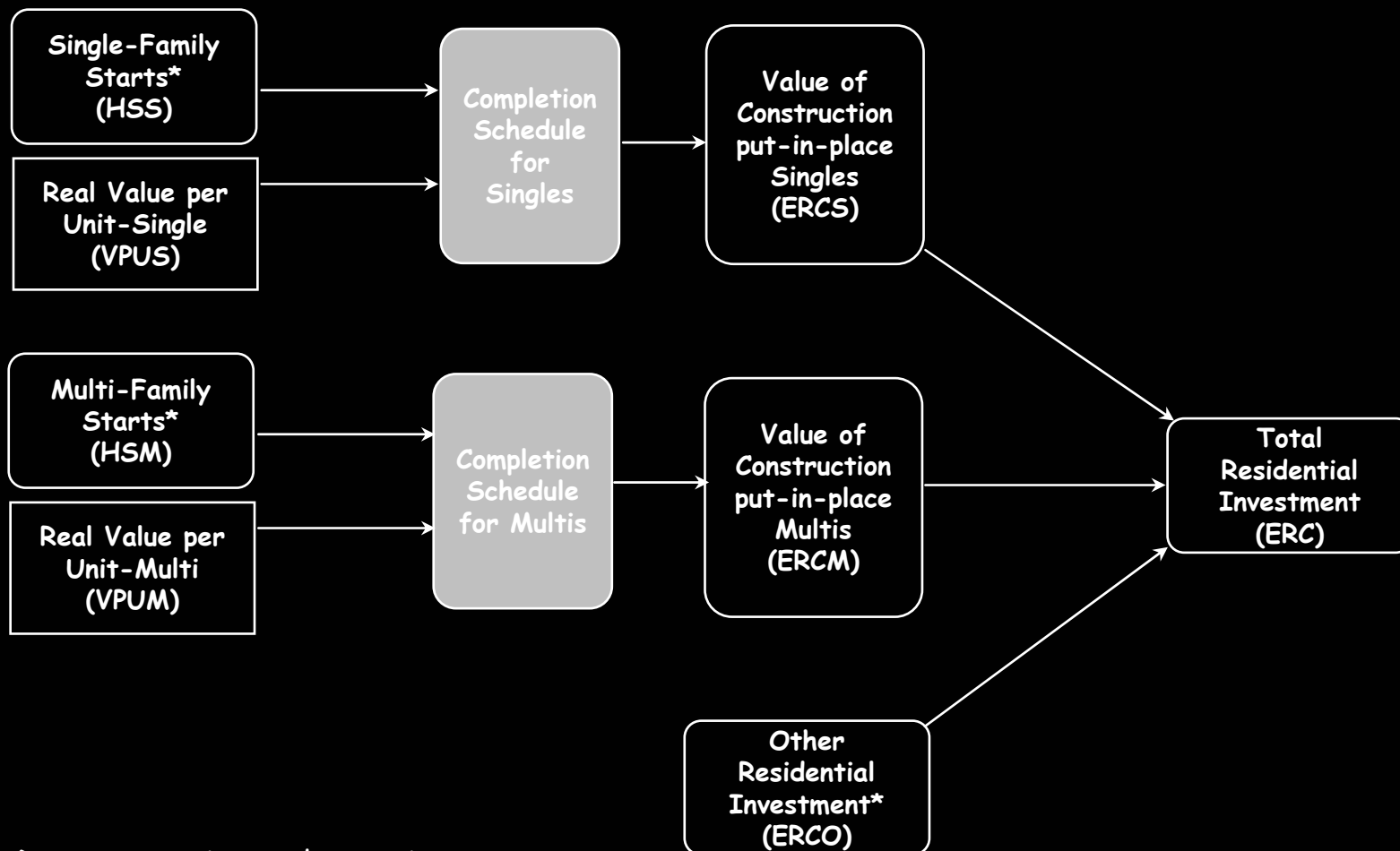
*Partial Responses

Aggregate Demand: Residential Investment

- Households $H = hN$: h =headship rate; N =population
- $H = h'N + (h-h')N$: h' demographic portion of headship rate
- Non-demographic portion $(h-h')$ depends on economics
($h-h'$) = $f(Y/H, R, W/H)$; h income, rental price, h wealth
- $H = h'N + f(y/H, R, W/H)N$
- Starts = $\Delta H + \delta K_{-1}$
- Starts = $\Delta(h'N) + f(\cdot)\Delta N + Nf_y\Delta(Y/H) + Nf_r\Delta R + Nf_w\Delta(W/H) + \delta K_{-1}$
 - the change in adjusted households
 - the change in population
 - the change in income per household
 - the change in the rental price of housing
 - the change in wealth per household
 - the lagged stock (replacement)



Aggregate Demand: Residential Investment



* Denotes estimated equation

Aggregate Demand: Residential Investment

Residential Fixed Investment (ERC)

Residential Investment, Single-Family (ERCS)

Residential Investment, Multi-Family (ERCM)

Residential Investment, Other* (ERCO)

Corresponding Stocks: KH¹, KHS², KHM²

* Denotes estimated equation

¹ Denominated in Chain-type 2000 dollars

² Denominated in millions of units

Aggregate Demand: Inventory Investment

Inventory Investment (EI)

Nonfarm Inventory Investment (EINF)

Motor Vehicles & Parts* (EINFMV)

Other* (EINFO)

Farm Inventory Investment (EIEIO**)

Corresponding Stocks: KI, KIF, KINF, KINFO, KINFMV

* Denotes estimated equation

** Just kidding, EIF

Aggregate Demand: Exports

The basic set-up:

$$\ln X = a_0 + a_1 \ln Q_F - a_2 \ln(P_x \$ / P_F) + a_3 \ln Q_{PDDGS}$$

The degree of disaggregation:

Total Exports (EX)

Merchandise Exports (EXM)

Nonag Merch. Exports* (EXMNAG)

Agricultural Exports* (EXMAG)

Service Exports* (EXS)

* Denotes estimated equation

Aggregate Demand: Imports

The basic set-up:

$$\ln M = b_0 + b_1 \ln Q_{\text{PDDGS}} - b_2 \ln(P_M/P) + b_3 \text{Trend}$$

The degree of disaggregation:

Total Imports (EM)

Merchandise Imports (EMM)

Non-petro Imports* (EMMNP)

Petroleum Imports* (EMMP)

Service Imports* (EMS)

* Denotes estimated equation

Aggregate Demand: Net Export Elasticities

	"Income"		Exchange Rate		Trend (%-point contribution to growth)
	Foreign	Domestic	Short run	Long run	
Total Exports	1.2	0.2	-0.09	-1.0	...
Nonag Merchandise	1.0	0.4	-0.14	-1.2	...
Agricultural	0.4	...	-0.08	-1.0	...
Services	1.7	-0.5	...
Total Imports	...	1.2	-0.19	-0.7	1.2
Nonpetro Merchandise	...	1.2	-0.19	-0.8	1.5
Petro & Products	...	1.0	-0.7
Services	...	1.4	-0.31	-0.9	...

Foreign Economic Activity

- Broad, trade-weighted index of dollar on FX markets (PFXB)
 - ... based on exchange rates against the currencies of 36 countries
- Trade-weighted aggregates for foreign concepts:
 - GDP (GDPFB)
 - Producer-type prices (PPIFB & PPIFN)
 - Consumer prices (PCPIFB)
 - Government bond yields (RGBFN)

Aggregate Demand: Gov't CGI (Defense)

Federal CGI (EGFCGI)

Defense (EGFDCGI)

Consumption (EGFDC)

Cons of Fixed Capital (EGFDCFC)

Compensation of Employees... (EGFDCE)

Intermediate G&S purchased* (EGFDIGS)

Less own-account investment* (EGFDCEF)

Less sales to other sectors* (EGFDSOS)

Gross Investment... (EGFDGI)

* Denotes exogenous component; exogenous in either real or nominal terms

... Denotes more underlying detail

Aggregate Demand: Gov't CGI (Nondefense)

Nondefense (EGFNCGI)

Consumption (EGFNCGI)

Cons of Fixed Capital (EGFNCGI)

Compensation of Employees (EGFNCGI)

Intermediate G&S purchased (EGFNCGI)

Commodity Credit Corp (EGFNCGI)

Other* (EGFNCGI)

Less own-account investment* (EGFNCGI)

Less sales to other sectors* (EGFNCGI)

Gross Investment... (EGFNCGI)

* Denotes exogenous component; exogenous in either real or nominal terms

... Denotes more underlying detail

Aggregate Demand: Gov't CGI

State & Local CGI (EGSCGI)

Consumption (EGSC)

Cons of Fixed Capital (EGSCFC)

Compensation of Employees (EGSCE)

Intermediate G&S purchased* (EGSIGS)

Less: Own account investment* (EGSCEF)

Less: Sales to other sectors* (EGSSOS)

Gross Investment ... (EGSGI)

* Denotes exogenous component; Can be exogenous in either real or nominal terms

... Denotes more underlying detail

For both Federal and State & Local CGI, see the GDP grid for additional details on the structure of these components

The Foreign Sector

- Six Foreign Trade-Weighted Series
 - G-36 exchange rate* (PFXB)
 - GDP* (GDPFB)
 - Foreign producer price* (PPIFB, PPIFN)
 - Foreign consumer price* (PCPIFB)
 - Real Government bond yield* (RGBFN)
- The exchange rate equation combines notions of L-R PPP, S-R interest arbitrage, relative growth effects, and CAB effects.
- Foreign growth and inflation are predominantly determined by their own past history and U.S. growth and inflation.
- Foreign Rates adjust gradually to U.S. rates

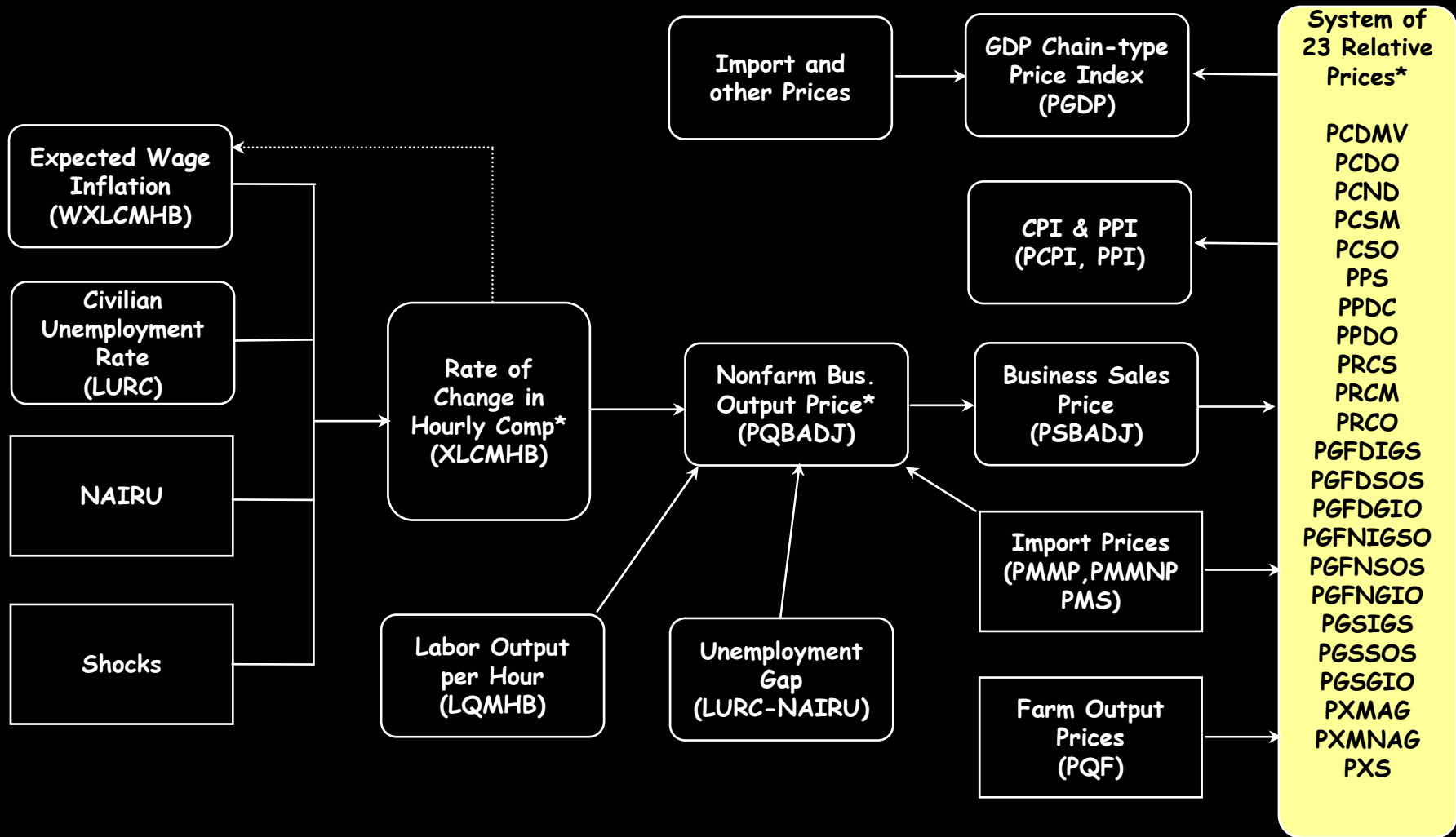
* Denotes estimated equation

The Determination of Prices

- A wage-wage long-run vertical Phillips Curve
 - Expected wage inflation modeled adaptively
 - A linear unemployment gap term
 - Shock terms for min wage, payroll taxes, oil prices
- An aggregate (nonfarm business) price markup-equation
 - Full L-R pass-thru of unit labor costs
 - Smoothed adjustment to comp per hour
 - Smoothed adjustment to productivity
- A system of 23 relative prices for GDP exp. components



The Determination of Prices



The Determination of Interest Rates

Six "Monetary Regimes" are available --- pick one

Set Money Stock, Invert. Money Demand Determines Rates

- M1 Money Stock Exogenous (M1\$)
- Real M1 Exogenous (M1)

Set Rates, Money Demand Determines Money Stock

- Nonborrowed Reserves Exogenous (MRNB\$)
- Fed funds rate exogenous (RFF)
- Real Fed funds rate exogenous (RFFREAL)
- Fed Reaction Function: ΔRFF depends on
 - Target inflation, target growth
 - Unemployment gap

Expectations term structure determines L-T yields (RGB10)

Labor Demand & Productivity

- The long-run relationship between labor and output suggested by the production function is:

$$\Delta \ln(Q) = \gamma + \alpha \Delta \ln K + (1 - \alpha) \Delta \ln L$$

where: γ is the growth of total factor productivity.

Q is output

K is capital services

L is labor hours

α is capital's share of gross output

Labor Demand & Productivity

- Equation becomes:

$$\begin{aligned} \% \Delta LMHB = & [-\gamma + \% \Delta QB - \alpha XCS] / (1 - \alpha) \\ & - \sum \beta_i [\% \Delta QB - \% \Delta QB_{-1}] / (1 - \alpha) \\ & - \sum \theta_i \Delta \ln((1 - LURC) / (1 - NAIRU)) \end{aligned}$$

where: XCS is the growth of capital services

and: $\gamma = c[U\text{PPDC}_{-1}/U\text{PPDC} - 1] + (1-c)W\text{XPROD}$

UPPDC is the relative price of computers & software

c is the nominal computer share of nonfarm bus. output

WXPROD is TFP growth outside of the comp. producing sector

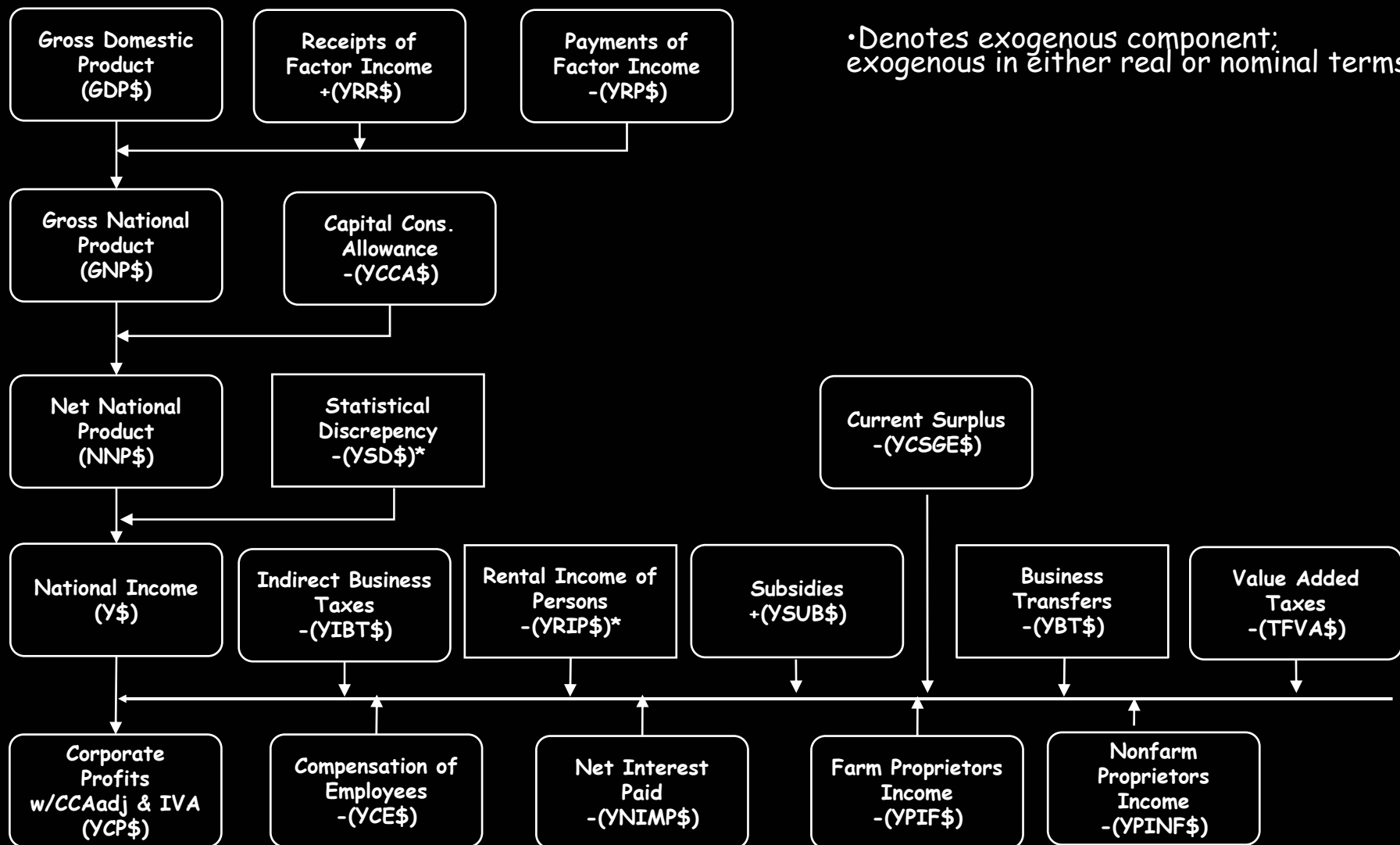
UPPDC and WXPROD are both exogenous



Equity Valuations

- Household Equity Wealth (NWEQ\$)
 - Measured in Flow-of-Funds
 - Closest market index is Wilshire 5000
- Modeled with a dividend-discount model adjusted for
 - Taxes (on dividends, interest, and capital gains)
 - Expected growth of capital services
 - Risk premium (inflation proxy)
 - Changes in share of income paid to capital

The Determination of Corporate Profits



Corporate Profits Determined Residually

Profits are what is left over from national income after payments to workers and proprietors, and for rental income and net interest:

	Y\$	(national income)
-	YCE\$	(NIPA employee compensation)
-	YPI\$	(proprietors' income; split into farm & nonfarm)
-	YRIP\$	(rental income of persons)
-	YNIMP\$	(net interest paid)
-	YIBT\$	(indirect business taxes)
-	YBT\$	(business transfers)
-	YCSGE\$	(current surplus)
-	TFVA\$	(value added taxes)
+	YSUB\$	(government subsidies)

=	YCP\$	(corporate profits with inventory valuation and capital consumption adjustments, a.k.a. "economic profits")



GDP to National Income

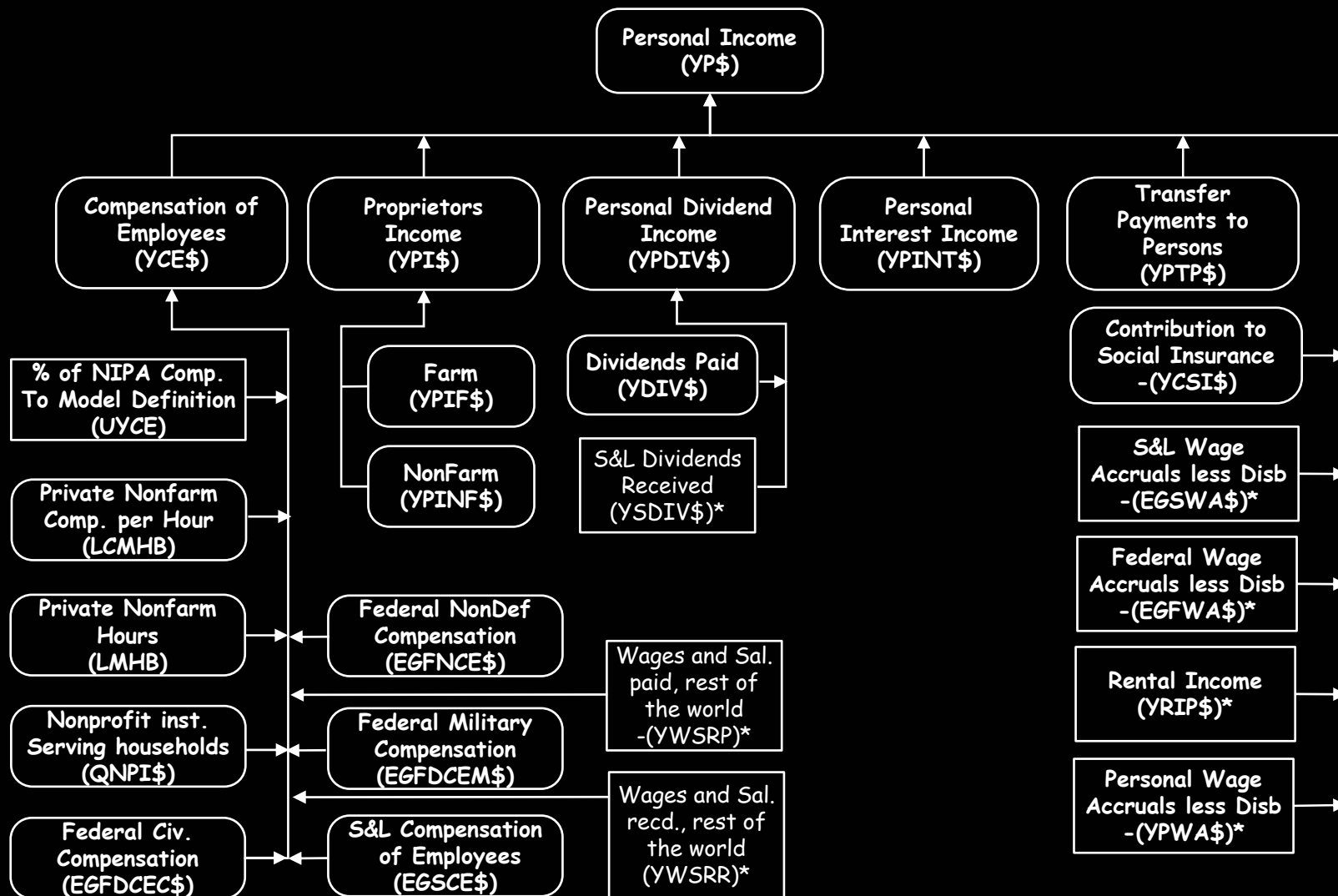
	GDP\$	(gross domestic product)
+	YRR\$	(factor receipts)
-	YRP\$	(factor payments)

=	GNP\$	(gross national product)
-	YCCA\$	(capital consumption allowance)

=	NNP\$	(net national product)
-	YSD\$	(statistical discrepancy)

=	Y\$	(national income)

The Determination of Personal Income



* Denotes exogenous component; exogenous in either real or nominal terms



Personal Income

YCE\$	(NIPA employee compensation)
+ YPI\$	(proprietors' income; split into farm & nonfarm)
+ YRIP\$	(rental income of persons)
+ YPDIV\$	(personal dividend income)
+ YPINT\$	(personal interest income)
+ YPTP\$	(transfer payments to persons)
- YCSI\$	(contributions for social insurance)
- YPWA\$	(priv. wage accruals in excess of disbursements)
-EGFWA\$	(Federal wage accruals in excess of disbursements)
-EGSWA\$	(State & Local wage accruals in excess of disbursements)

= YP\$	(personal income)

How to Learn More About WUMM

- Talk with any of MA's economists
- Download the latest edition of the WUMM model book at www.macroadvisers.com
 - All equations
 - Detailed theoretical underpinnings
 - More simulation properties
 - ... See especially appendices on wealth effects & interest-rate channels in WUMM
 - Searchable
- Play with the model
 - ... *Feel the power at your fingertips! It's Easy!! And FUN!!!*