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A macro-econometric model containing income distribution, price changes and Government financing: Updates and forecasts for the US, 2025-29

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Textos para Discussão

No. 22 – fevereiro, 2025.

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Título

A macro-econometric model containing income distribution, price changes and Government financing: Updates and forecasts for the US, 2025-29

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Resumo:

Este texto contém informações sobre uma pesquisa em andamento que visa fornecer uma breve visão das tendências macroeconômicas futuras nos EUA, com base nas últimas informações disponíveis e em uma ferramenta analítica adequada – o chamado modelo macroeconométrico. Estão incluídas algumas simulações obtidas com este modelo e, na verdade, dois tipos de soluções foram obtidos: uma Solução Básica, derivada do cenário mais provável para as variáveis exógenas; e simulações que resultam de cenários alternativos que exploram, para os próximos cinco anos, possíveis tendências nas decisões de política macroeconômica, bem como mudanças futuras que possam ocorrer no comércio internacional.

Abstract:

This text contains information about ongoing research that aims to provide a brief look at future macroeconomic trends in the US, based on the latest available information and also a suitable analytical tool – the so-called macro-econometric model. Simulations that were obtained with this model are included, and two types of solutions were generated: a Basic Solution, derived from the most probable scenario for the exogenous variables; and simulations that result from alternative scenarios that explore, for the next five years, possible trends in macroeconomic policy decisions, as well as future changes that may occur in international trade.

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(February 2025)

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Introduction

This text contains some information about ongoing research that, to summarize, aims to provide a brief look at future macroeconomic trends in the US, based on the latest available information and also a suitable analytical tool. It is well known that economic systems evolve continuously, so this type of research can only be considered experimental at best. However, the author firmly believes that having some quantitative information on future economic developments, even if limited in scope, is more advantageous than having none at all.

The analytical tool that was actually used – the so-called macro-econometric model – is described in Sections 1 and 2. The following Section presents simulations that were obtained with this model. In fact, two types of solutions were generated: a Basic Solution, derived from the most probable scenario for the exogenous variables; and simulations that result from alternative scenarios that explore, for the next five years, possible trends in macroeconomic policy decisions, as well as future changes that may occur in international trade. At the end of the text, some concluding remarks are included.

1. Main characteristics of the model

This model is made up of 17 equations that can be classified into three different segments (see Section 2). In the first of these segments, there are two equations. The first one establishes the equilibrium aggregate output, which is divided into four productive sectors and the services provided by the Government. The second equation contains a function for total employment in the economy – which is the sum of labor used in the productive sectors and by the Government.

The equations in the second segment, a total of six, can be described as relations to model effective demand and the generation of income – which is divided into labor income and profits (operating surplus).

The set of equations in the first two segments – Items 2.1. a) and 2.1. b) in Section 2 – can be considered a macroeconomic version of Miyazawa's celebrated intersectoral model (Miyazawa, 1976; Sonis & Hewings, 2000). In that model, the total values of sectoral productions are determined by an "exogenous demand" vector, which does not explicitly include aggregate consumption, since the consumption demand of the sectors is explained by

the structure of income distribution. An additional development in the present macro-econometric analysis is that private investment is also excluded from "exogenous demand", i.e. there is no explicit equation for this variable. It deserves mention that the sector formed by manufacturing and construction activities, and public utility services (Y_{MNF}, see Section 2) follows very closely the trend of private investment.

In the third segment – Item 2.1. c) –, the set of equations results from the analysis developed in da Fonseca (2011 and 2017), where the various factors that affect the inflation rate are divided into two parts, one linked to aggregate (nominal) demand and the other that results from general (macroeconomic) cost factors (eq. 14) – which is consistent with the well-known analysis that distinguishes demand inflation from cost inflation.[1] In this analytical development, the pattern of Government expenditures' financing plays a central role, given the relation with the public debt and money supply.

2. Data series and parameter estimations [2]

In this update, the estimates of the parameters of the stochastic equations were revised, incorporating recent data (up to 2024), which proved to be a challenge since the data in the period following the Covid epidemic show significant variations in relation to the historical series.

To this later problem, a more fundamental difficulty in terms of estimation, that results from the limited number of annual observations, is superimposed. On one hand, annual series have the great advantage of not being affected by the most common patterns of seasonality and, therefore, tend to capture longer-term trends more clearly. On the other hand, when older data are used, the problem of structural changes in the economic system prevails.

In the estimation with annual series, these limiting factors make the adoption of more advanced methods virtually unfeasible. In other words, the most appropriate alternative is the traditional ordinary least squares (OLS) estimator, including procedures to reduce the effects of breaks in the patterns that one seeks to capture – which certainly occurred in the 2008-9 crisis, and in 2020 (Covid). Examples of these procedures are indicator ("dummy") variables – applied in this case on the slope – and estimation with restrictions on the parameters (non-sample information). In relation to this point, the author's experience indicates that the OLS method is not necessarily inferior when systemic results, i.e. simulations through a model, are prioritized.

When the estimated equations are included in a simulation model, the efficiency that is pursued in terms of prediction is that of the systemic form, and not in terms of isolated variables. That is, an equation considered independently can provide satisfactory results in econometric terms, but the trajectory of the variable in model simulations may be inadequate. To put it in another way, in the evaluation of a model, what matters is the systemic performance of the equations, and ad hoc adjustments in the original estimations may be made with this objective in mind.

[1] Simonsen (1980) contains an earlier discussion on this topic.
[2] For the sources of the model's data bank, see da Fonseca (2022).

2.1. Model equations [3]

Notes: The list of endogenous and exogenous variables is included in Table 1. Symbols ε represent stochastic errors in the corresponding equations. Data series for the period 1981-2023 (43 observations) were used in OLS estimation; in eq. (14), the period was 1971-2023; standard errors are in parentheses. The symbol (*) indicates the number is a restricted (non-sample) coefficient.

2.1. a) Equilibrium output and aggregate production function (inverse function for labor)

$$Y = Y_{AGR} + Y_{MNF} + Y_{TRD} + Y_{SRV} + Govt\text{-}sector \tag{1}$$

$$L = a_{w1}\, Y_{AGR} + a_{w2}\, Y_{MNF} + a_{w3}\, Y_{TRD} + a_{w4}\, Y_{SRV} + L\text{-}Gov \tag{2}$$

Description of variables and data:

- Y: Gross National Product; billions of 2017 dollars.
- Y_{AGR}: Real value added; agriculture (including forestry, fishing and hunting) and mining; billions of 2017 dollars.
- Y_{MNF}: Real value added; utilities, construction and manufacturing; billions of 2017 dollars.
- Y_{TRD}: Real value added; trade (wholesale and retail) and transportation (includes warehousing); billions of 2017 dollars.
- Y_{SRV}: Real value added; services (all types, non-government); billions of 2017 dollars.
- Govt-sector: Real value added by government (federal, state and local); billions of 2017 dollars.
- L: Total employment (private and in government); thousands of employees.
- L-Gov: Government employees; thousands.

Note: The symbols a_w in eq. (2) represent employment coefficients, as defined in input-output analysis. These coefficients are calculated for each year.

2.1. b) Effective demand and income generation

$$\begin{aligned} Y_{MNF} = {} & 916{,}37 + 0{,}1245\, Y_{-1} + 0{,}1022\, \Delta(\Pi/P - T_{\Pi}) + 0{,}4650\, \Delta G - 15{,}514\, r \\ & (247{,}69)\ (0{,}01211) \qquad (0{,}1789) \qquad\quad (0{,}4463) \qquad (23{,}094) \\ & + 0{,}20^{*}\, \Delta(EX\text{–}IM) - 0{,}2^{*}\, Dummy + \varepsilon_3 \end{aligned} \tag{3}$$

$$\begin{aligned} Y_{TRD} = {} & -235{,}07 + 0{,}1629\, Y_{-1} + 0{,}2808\, \Delta(wL/P - Tw) - 6{,}3540\, r + 0{,}11^{*}\, \Delta G \\ & (200{,}55)\ (0{,}00970) \qquad (0{,}1111) \qquad\quad (19{,}179) \\ & - 0{,}20^{*}\, \Delta(EX\text{–}IM) - 0{,}21^{*}\, Dummy + \varepsilon_4 \end{aligned} \tag{4}$$

$$\begin{aligned} Y_{SRV} = {} & -472{,}33 + 0{,}5706\, Y_{-1} + 0{,}2^{*}\, \Delta(wL/P - Tw) - 64{,}0^{*}\, r + \varepsilon_5 \\ & (467{,}83)\ \ (0{,}02211) \end{aligned} \tag{5}$$

$$\begin{aligned} r = {} & 5{,}9365 - 0{,}00133\, M/P + 0{,}00065\, \Delta Y + \varepsilon_6 \\ & (0{,}6907)\ (0{,}00032) \qquad (0{,}00117) \end{aligned} \tag{6}$$

[3] In addition to the ones that have been included in this section, there are two further equations for the variables Total Profits and Wages net of taxes ($\Pi/P - T_{\Pi}$ and $wL/P - Tw$).

$$wL/P = (w\ L\ Kw)\ /\ P \tag{7}$$

$$\Pi/P = \ Y - IndTax - wL/P \tag{8}$$

Description of variables and data:

Π: Profits (gross operating surplus); billions of dollars.
P: GDP price index; 2017=100.
T_Π: Taxes on Π (estimated as a proportion of total real taxes); billions of 2017 dollars.
G: Government purchases (including public investment); billions of 2017 dollars.
r: Average corporate bond yield, Moody's Aaa rating, deflated by P; %.
EX–IM: Net exports (trade deficit); billions of 2017 dollars.
Dummy: Indicator variable: 1 for 2009 and 2020, 0 for other periods.[4]
wL: Compensation of employees; billions of dollars.
Tw: Taxes on wL (estimated as a proportion of total real taxes); billions of 2017 dollars.
M: M1; billions of dollars in December.
w: Average earnings of non-supervisory employees; dollars per hour.
IndTax: Taxes on production and imports less subsidies; billions of 2017 dollars.

Note: The symbol Kw in eq. (7) represents the ratio between the average annual labor income and w/P. This ratio is calculated for each year.

2.1. c) Nominal variables and price changes

Notes: The symbol μ (eq. 9) represents the M1 multiplier over B. The symbol α (eq. 10) represents the share of B in the sum (B + Debt). The symbol V in eq. (14) represents the M1 income velocity. These parameters are calculated for each year.

$$M = \ \mu\ B \tag{9}$$

$$B = \ \alpha\ (B + Debt) \tag{10}$$

$$B + Debt = (B + Debt)_{-1} + G\ P + Interest + Subsids - T\ P \tag{11}$$

$$Interest = \left[\left(\frac{P}{P_{-1}}\right)\left(1 + \frac{r}{100}\right) - 1\right] Debt_{-1} \tag{12}$$

$$Debt = \ (1 - \alpha)\ (B + Debt) \tag{13}$$

$$\ln P = \ln P_{-1} + \underset{(0,0580)}{0,1944}\ [\Delta \ln (M\ V) - \Delta \ln Y] + \underset{(0,0672)}{0,5412}\ \Delta \ln w + \underset{(0,0274)}{0,1589}\ \Delta \ln Inputs$$

$$+ \underset{(0,0214)}{0,02508}\ \Delta \ln e + \varepsilon_{14} \tag{14}$$

$$\ln w = \ \ln w_{-1} + \underset{(0,0517)}{1,0096}\ \Delta \ln P_{-1} + \varepsilon_{15} \tag{15}$$

Description of variables and data:

B: Monetary base; billions of dollars in December.

[4] Estimation for slope indicator, variable $\Delta\ (\Pi/P - T_\Pi)$ or $\Delta\ (wL/P - Tw)$.

Debt: Total federal debt; billions of dollars in December
Subsids: Subsidies (federal Government); billions of dollars.
T: Total real taxes; billions of 2017 dollars.
Interest: Federal Government interest payments; billions of dollars.
Inputs: Producer price index: All commodities; 1982=100.
e: Trade weighted U.S. dollar index; 1973=100.

The multipliers that were included in the model equations (Item 2.1. c) ultimately derive from decisions made by private agents, especially in the case of money demand – the M1 multiplier (μ), and income velocity (V). There are also coefficients that reflect technological patterns prevailing in the production sectors (employment coefficients).

3. Solution of the model [5]

In this update of the macro-econometric model described in Sections 1 and 2, two types of solutions were obtained: [6] a) A basic solution that implements, from the available historical record, the most probable hypotheses for the trajectory of exogenous variables in the next five years; and b) Solutions that result from scenarios that seek to explore alternative trends in macroeconomic policy decisions, as well as possible future developments in international trade. Table 1 contains an overview of the first type of solution. The columns in that Table include information on the endogenous and exogenous variables of the model. Additionally, the paths for the endogenous variables are also included in Figure 1.

The last column of Table 1 contains two types of forecasts. On the bottom half, there are projected values for the exogenous variables and varying coefficients used in the model. On the top half, in turn, solutions obtained from the model – that are derived from the values for the exogenous components – are included. For the periods specified in Table 1, all the information appear either as annual growth rates (geometric averages), or as sample (arithmetic) averages.

Considering the model's exogenous variables, it can be perceived from Table 1 that, as a rule, the forecasts for the next five years are predominantly based on the recent patterns for these variables. In this sense, these forecasts can be considered "neutral", or "midpoint" estimates.

In relation to the alternative solutions, they were generated from scenarios for the exogenous variables that were treated independently – with the exception of the fourth one, in which there is some overlapping with Scenario 3. These scenarios are listed below; a general overview of these solutions, along with the assumptions used, is included in Table 2.

Alternative scenarios:

1. Reduction of government expenditures and public employment.
2. Reduction of taxation.
3. Increase in the federal Government's interest expenses.

[5] System's solutions including simultaneously the variables Interest, P, r and Debt proved to be unstable. Therefore, in the simulations described in this Section, eq. (12) was excluded, i.e. Interest was treated as an exogenous variable.
[6] For a general description of solution methods for nonlinear systems of equations, see da Fonseca (2022).

4. Reduction of trade deficits, accompanied by increases in commodity prices – due to higher tariffs and, possibly, to international disputes –, a trend that was also accompanied by higher interest payments.

In contrast to the Basic Solution, the simulation for Scenario 1, which – for the five years starting in 2025 – includes negative growth rates for total government expenditures (variable G) and employment in public administration (L-Gov), shows lower aggregate output growth, and reduced average annual inflation (see Table 2). These trends are accompanied by smaller expansions of total employment (L), real income of wage earners (wL/P), and gross operating surplus (Π/P). On the other hand, in this Scenario, there is a more favorable fiscal situation, with lower growth of the Federal Government's debt (variable Debt).

In the case of Scenario 2, which considers a trend of reduced taxation (variables T and IndTax with negative rates of change), and in relation to the Basic Solution, the simulation points to higher aggregate output and average inflation, as well as aggregate income and total employment. As expected, there is also a deterioration in the government's fiscal situation, with more debt and higher money supply. It also deserves mention that, in relation to the greater expansion of aggregate income, the effect on profits (increase of 0.91 percentage point in the average annual change) is much more pronounced than on real wages (plus 0.14 percentage point). This macro-econometric model, therefore, is entirely consistent with the widely held view that inflation works more in favor of operating surpluses (profits), in comparison to total wages.

In relation to Scenario 3, which contemplates a sharper growth in the federal Government's expenditures with interest – average annual rate of change moving up from 6% (Basic Solution) to 12% –, there are no significant differences in the trajectory of aggregate output and income. In contrast to the Basic Solution, there is a somewhat higher average inflation rate, accompanied by a deterioration in the fiscal situation, albeit moderately.

Similarly, in Scenario 4, which explores the likely consequences of a reduction in the trade deficit, accompanied by a higher rise in commodity prices, there are virtually no changes in aggregate output and income. The differences in relation to the Basic Solution are the higher average inflation rate (sharper than in Scenario 3), and some fiscal deterioration, but quite limited.

Table 1. Basic Solution.

Rates of Growth -- Annual Averages (%)

		1971-80	1981-90	1991-00	2001-09	2010-19	2020-24	2025-29
Endogenous variables								
Y		3,22	3,24	3,41	1,74	2,42	1,80	1,88
Y_{MNF}		1,30	2,68	3,20	-0,24	2,07	1,00	1,39
Y_{TRD}		3,72	4,14	5,40	0,90	3,01	1,32	2,11
Y_{SRV}		5,22	3,70	3,85	2,68	2,85	3,36	2,22
r	#	1,60	6,61	5,38	3,51	2,37	0,05	0,96
P		6,91	4,18	2,06	2,21	1,62	3,79	3,69
M		6,66	7,22	2,81	5,00	8,90	2,03	5,95
B		7,27	6,79	6,62	14,52	5,39	10,34	5,95
Debt		9,11	13,72	5,34	9,01	6,54	10,03	5,95
w		7,24	4,07	3,23	3,20	2,37	5,08	4,75
L		2,12	1,75	1,64	-0,10	1,40	0,70	1,75
wL/P		- -	3,18	3,62	0,96	2,31	1,33	2,79
Π/P		- -	3,34	3,20	2,63	2,49	3,69	1,26
Exogenous variables/Changing parameters								
Y_{AGR}		-2,81	3,10	1,63	3,53	2,36	2,36	2,20
G		0,98	3,22	1,15	2,44	0,16	1,82	1,50
EX-IM	#	-41	-91	-127	-567	-448	-922	-977
T		3,66	3,00	3,64	0,26	2,37	0,71	1,40
IndTax		- -	3,22	3,11	2,05	2,54	0,99	0,80
Subsids		13,93	6,77	6,08	8,20	3,45	7,09	2,00
μ	#	2,63	2,78	2,43	1,57	0,92	0,81	0,80
α	#	0,16	0,11	0,08	0,10	0,15	0,16	0,15
V	#	4,12	4,88	5,25	6,67	4,58	4,26	4,60
Inputs		9,30	2,62	1,33	2,98	1,46	4,96	2,80
e	#	101	108	92	88	83	95	98
Govt sector		2,16	2,66	1,28	1,18	0,38	1,03	0,70
L-Gov		1,22	1,25	0,57	0,87	0,04	0,03	0,20
a_{w1}	#	12,62	12,95	8,41	5,57	5,01	4,04	3,76
a_{w2}	#	16,63	14,50	10,97	7,48	6,17	6,08	6,21
a_{w3}	#	27,96	25,38	17,81	10,74	9,47	8,90	8,92
a_{w4}	#	8,25	7,91	8,35	8,51	7,54	6,60	6,53
Kw	#	2346	2627	2935	3089	3097	3106	3040

Sample averages.

Note: For descriptions of the variables and data, see Section 2.

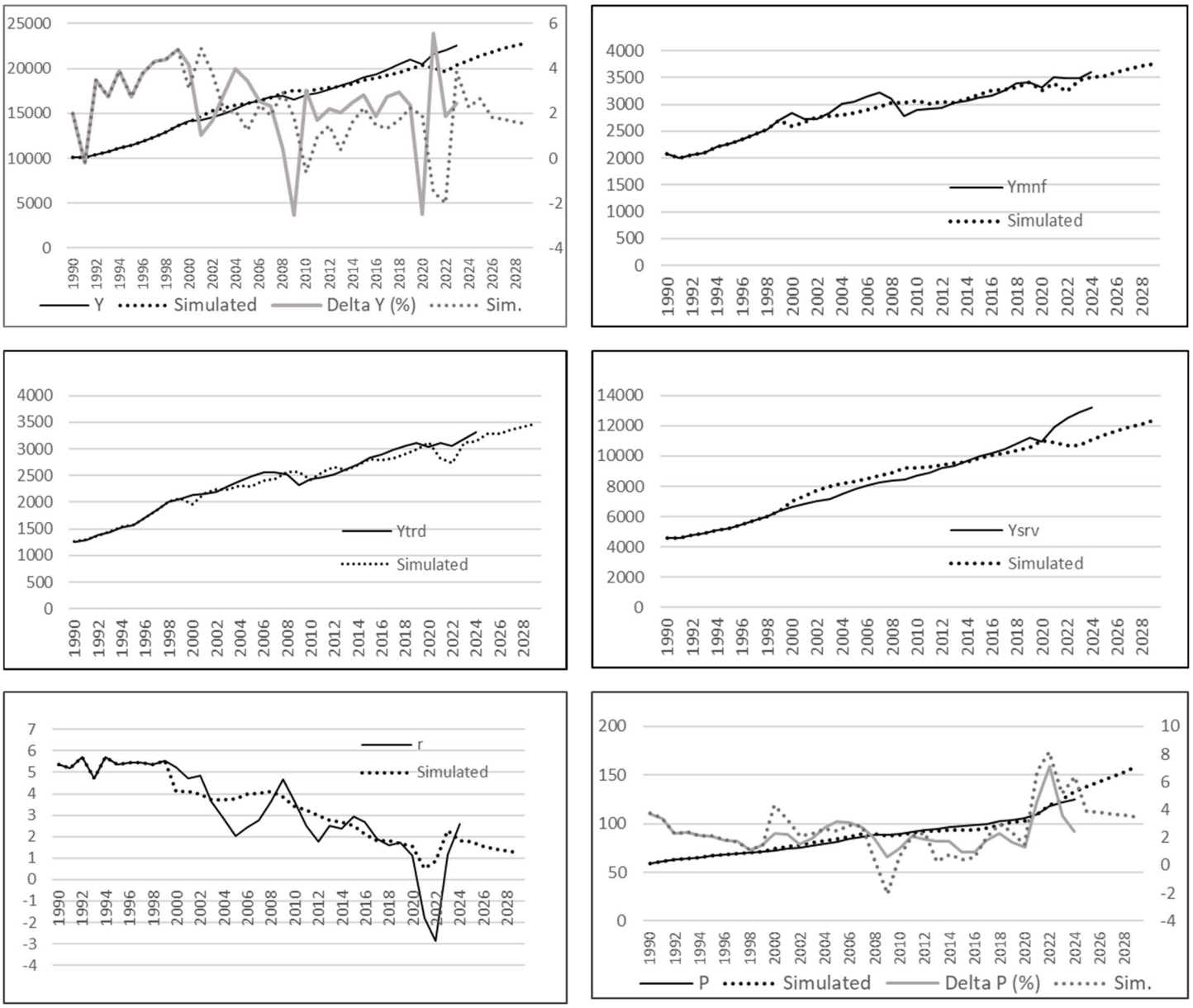

Figure 1. Endogenous variables – Basic Solution.

Notes: The initial solution period is 2000 – that is, 1999 is the last year with historical data in the model for the endogenous variables. For descriptions of the variables and data, see Section 2.

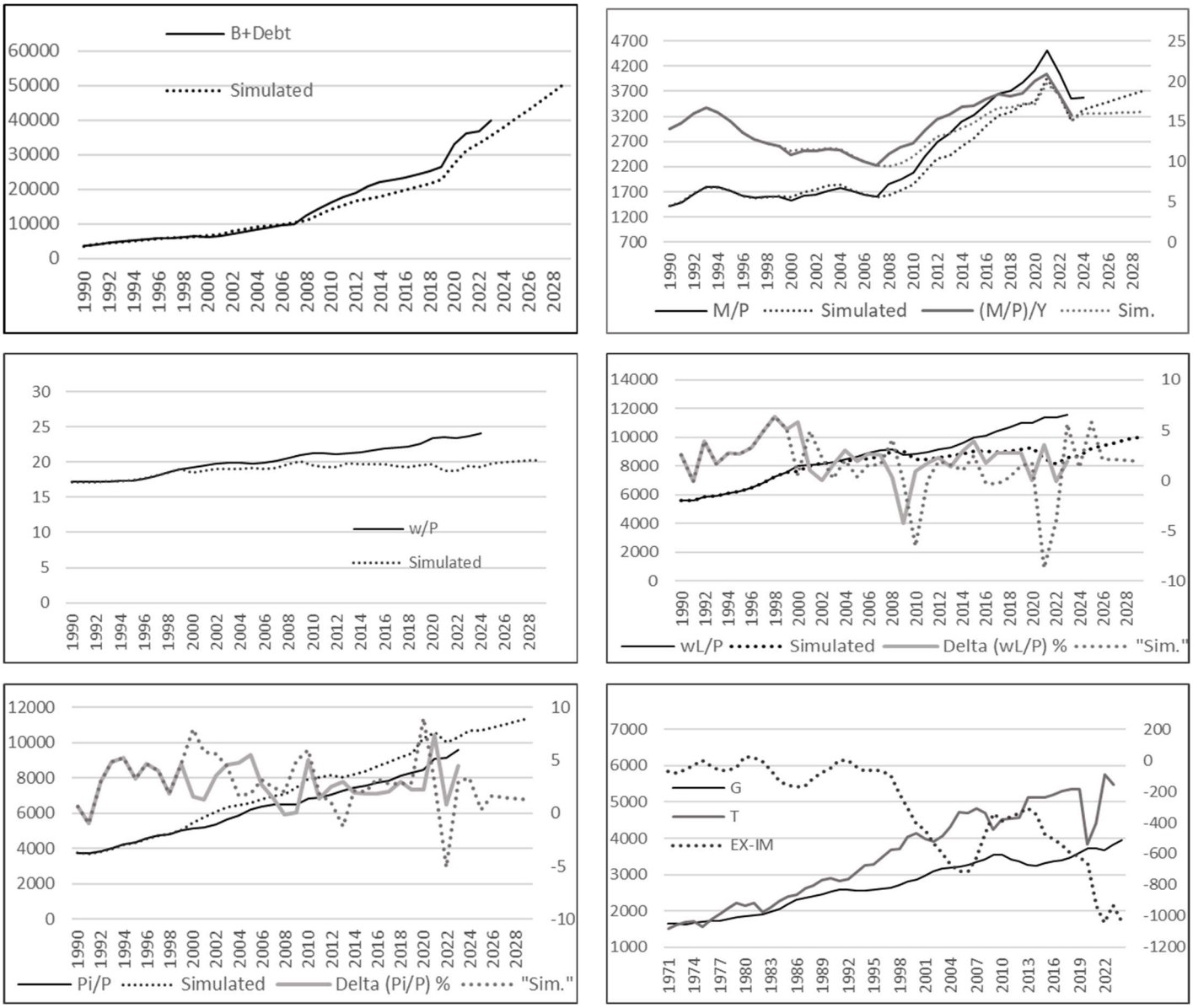

Figure 1. Endogenous variables – Basic Solution (cont.)

Note: The last Graph contains data for three exogenous variables.

Table 2 – Solutions based on alternative scenarios

Rates of Growth -- Annual Averages (%), 2025-29

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Basic Solution
Endogenous variables					
Y	1,24	2,21	1,88	1,86	1,88
Y_{MNF}	0,35	1,74	1,41	1,44	1,39
Y_{TRD}	1,28	2,64	2,10	2,01	2,11
Y_{SRV}	1,59	2,59	2,22	2,19	2,22
r #	0,96	0,71	0,80	0,87	0,96
P	3,13	4,33	3,89	4,04	3,69
M	3,68	8,08	6,50	6,09	5,95
B	3,68	8,08	6,50	6,09	5,95
Debt	3,68	8,08	6,50	6,09	5,95
w	4,40	5,20	4,89	5,04	4,75
L	0,79	2,08	1,75	1,72	1,75
wL/P	2,03	2,93	2,73	2,70	2,79
Π/P	0,67	2,17	1,34	1,32	1,26
Exogenous variables/Changing parameters					
Yagr	2,20	2,20	2,20	2,20	2,20
G	-5,00	1,50	1,50	1,50	1,50
EX-IM #	-977	-977	-977	-654	-977
T	1,40	-3,00	1,40	1,40	1,40
IndTax	0,80	-2,00	0,80	0,80	0,80
Subsids	2,00	2,00	2,00	2,00	2,00
μ	0,80	0,80	0,80	0,80	0,80
α	0,15	0,15	0,15	0,15	0,15
V	4,60	4,60	4,60	4,60	4,60
Inputs	2,80	2,80	2,80	3,80	2,80
e	98	98	98	98	98
Govt sector	0,70	0,70	0,70	0,70	0,70
L-Gov	-2,00	0,20	0,20	0,20	0,20
aw1	3,76	3,76	3,76	3,76	3,76
aw2	6,21	6,21	6,21	6,21	6,21
aw3	8,92	8,92	8,92	8,92	8,92
aw4	6,53	6,53	6,53	6,53	6,53
Kw	3040	3040	3040	3040	3040

Sample averages.

Note: The change introduced in Scenario 3 – increase in the Federal Government's interest expenditures – is not displayed in the Table (exogenous variables). In this case, the (constant) annual growth rate for these expenditures was increased from 6% (Basic Solution) to 12% (see Footnote 5).

4. Concluding remarks

In general terms, the forecasts that were obtained with the macro-econometric model described in Sections 1 and 2, based on the most likely scenario for the exogenous variables (Basic Solution), indicate that the next five years will be marked by trajectories not very much different from the ones that prevailed in the last five years. In comparison to the period 2020-4, the simulations indicate moderately higher growth of aggregate product and income (annual averages), and slightly reduced average inflation. The model's solutions also point to more robust employment growth, which leads to gains in the increase of labor income at the expense of operational surplus (profits) increments.

Considering the disaggregation between the production sectors, economic growth is expected to be stronger in commercial activity (including transport), and in the service sector, with a lower average increase in the manufacturing and construction segment. These results for the endogenous variables of the model derive from projections for the future path of exogenous components based on relatively "neutral" hypotheses – reflecting the trajectories in the last five years.

The macro-econometric model was also used in simulations that result from scenarios that explore, for the next five years, alternative trends in macroeconomic policy decisions, as well as future changes that may occur in international trade.

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