APÊNDICE III - TESTES ESTATÍSTICOS EMPREGADOS E PASSOS DE SELEÇÃO DO MODELO DO CÁLCULO DO FATOR X

Todos os procedimentos econométricos foram realizados utilizando o Software R_Studio, versão 4.4.2.

A modelagem, definida nas Resoluções CMED nº 1/2015 e nº 5/2015, tem uma estrutura de séries temporais e será estimada via método de mínimos quadrados ordinários (MQO). Trata-se de uma abordagem tradicional e conhecida que busca explicar o comportamento de uma determinada variável, no caso a produtividade do trabalho, em relação a variações de outras variáveis. Como todo modelo, é impossível explicar e prever, com total precisão, todas as variações da produtividade. Essa parcela não explicada é chamada de resíduo. O método de MQO consiste num sistema de equações que mensuram a elasticidade de uma determinada variável em relação a outras de forma a minimizar a parcela residual, ou seja, explicando o máximo possível das variações da variável de interesse.

Estudo da estacionariedade das séries

Para que os testes e resultados sejam confiáveis, a abordagem MQO assume o pressuposto de estacionariedade das séries, ou seja, os resíduos devem ser independente e identicamente distribuídos (i.i.d.). A presença de correlação serial entre as observações de uma variável gera um comportamento não estacionário da série temporal. Para testar a estacionariedade, foram realizados os testes de raiz unitária Philips-Perron (PP) e de estacionariedade Kwiatkowski-Philips-Schmidt-Shin (KPSS).

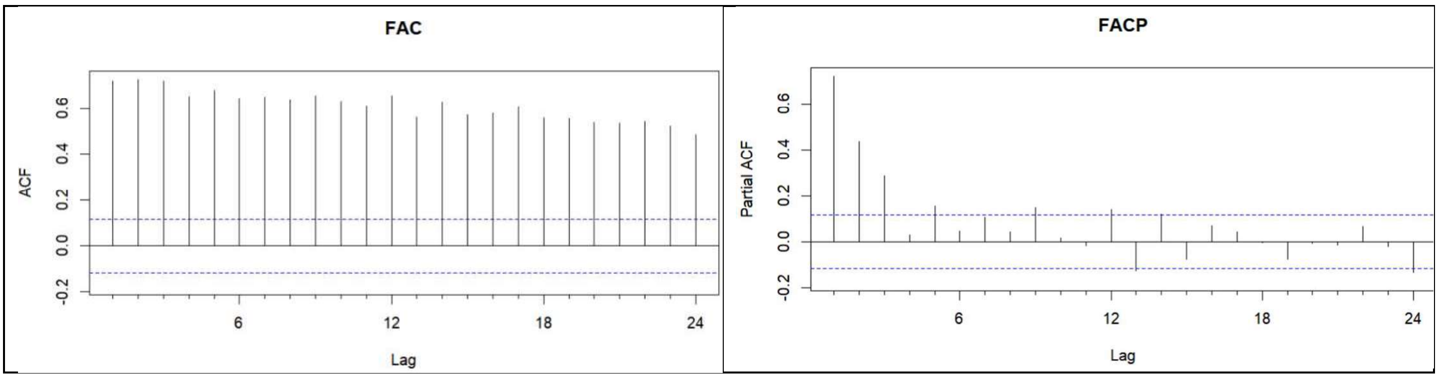
O teste PP é um método não paramétrico para verificar correlação nos resíduos. A hipótese nula testada assume que há presença de raiz unitária, isto é, que a série é não estacionária. Por outro lado, o teste KPSS testa a hipótese nula de que a série é estacionária. Os resultados do teste rejeitam a hipótese nula de estacionariedade da série em nível e assumem a presença de tendência estacionária.

Os resultados do teste de PP realizados indicam a variável dependente IPFF se torna estacionaria em primeira diferença, isto é, I(1). Do mesmo modo, os resultados dos testes para as variáveis independentes lnPIBR, lnCAMBIOR, JUROSR e lnIPCA indicam que as séries passam a ser estacionárias em primeira diferença. Portanto, a modelagem posterior utilizará as séries em primeira diferença para todas as variáveis.

Identificação das ordens apropriadas para os processos AR e MA

Sabe-se que as funções de autocorrelação (AC) e de autocorrelação parcial (PAC) teóricas não são observadas, mas AC e PAC amostrais são conhecidas. Logo, deve-se buscar semelhanças entre as funções de autocorrelação teóricas e amostrais que sejam boas sugestões do processo que melhor explica a dinâmica da série em estudo.

A função de AC amostral estima a relação entre a covariância de k defasagens e a variância amostral de uma determinada série temporal. Dessa forma, é possível identificar o número de defasagens necessárias para que a série se comporte de forma estacionária, ou seja, apresente correlação nula. O correlograma amostral plota o resultado da razão entre a correlação das defasagens e a variância da série em relação ao número de defasagens. Adicionalmente, a função de PAC mostra que a série do índice de produtividade se torna estacionária em primeira diferença.



Após identificar a ordem de estacionariedade da série temporal e verificar a cointegração com as demais séries de variáveis exógenas, segue-se para o modelo econométrico, o qual segue a forma funcional de um modelo ARIMA, conforme definido nas Resoluções CMED nº 1/2015 e nº 5/2015.

O modelo ARIMA (p,d,q) é a agregação de um modelo autorregressivo (AR) com o modelo de médias móveis (MA), em séries cointegradas. Como são estacionárias e cointegradas em primeira diferença, as séries são I(1). A ordem de defasagem tanto do AR(p) quanto da MA(q) é sugerida pelo próprio pacote do R_Studio. O comando *auto.arima* testa todas as possíveis combinações de ordens do ARIMA que sejam factíveis, dado o número de variáveis exógenas, o tamanho da amostra e os graus de liberdade do modelo. A melhor combinação é aquela que minimiza os Critérios de Informação de Akaike (AIC).

O AIC é um teste de robustez que penaliza o uso de regressores no modelo, incluindo o intercepto e os componentes autorregressivos.

Uma das vantagens do AIC é que o teste é valido também para previsões do modelo. Modelos com valores AIC mais baixos são preferíveis.

Foram testados diversos modelos, todos integrados de primeira ordem – I(1), conforme requisito do método MQO, e é apresentado abaixo o modelo mais robusto de acordo com critérios econométricos, sem levantar críticas em relação ao sentido econômico das variáveis escolhidas para explicar o índice de produtividade.

A) Modelo ARIMA (3,1,2)

Tabela 1: Resultados do modelo ARIMA (3,1,2)

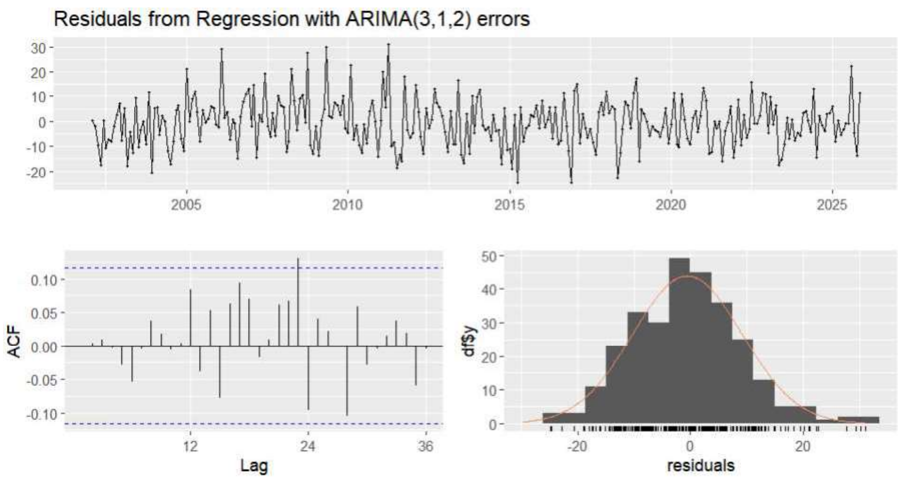
	AR1	AR2	AR3	MA1	MA2	IPCA	CAMBIOR	JUROSR	PIBR
	-0,5219	0,1274	0,1394	-0,1957	-0,5428	243,3474	8,9225	-0,8322	-792.480
s.e.	0,2295	0,0984	0,076	0,2243	0,1757	178,2488	15,7659	0,3025	16,1145

sigma^2 = 96,95: log likelihood = -1052,1

AIC=2124,21 AICc=2125,01 BIC=2160,73

O modelo ARIMA (3,1,2) foi o que apresentou o menor critério de Akaike e o maior número de coeficientes significativos. Todos os coeficientes dos componentes de média móvel foram significativos, para um intervalo de confiança de 90%.

A análise da função de autocorrelação dos resíduos do modelo ARIMA (3,1,2) indica que os mesmos não estão correlacionados entre si, garantido a eficácia dos coeficientes estimados para o seguinte exercício de previsão do Índice de Produtividade do Trabalho do Setor Farmacêutico.



B) Scripts

```
> setwd("F:/SEAE/Saúde/Fator X/Fator X 2024")
> df <- read.csv("BaseR2025.csv", sep = ';', dec = '.')
> View(df)
```

Data	IPCA	CAMBIOR	JUROSR	PIBR	IPFF
2002-01-01	1822,08	2,368797	18,43414	111793,2	107,6637
2002-02-01	1828,64	2,405759	17,9322	110502,3	127,8515
2002-03-01	1839,61	2,325754	16,97704	116708,9	120,5065
2002-04-01	1854,33	2,291747	15,71848	117680	115,7546
2002-05-01	1858,22	2,447424	15,47166	120522,6	101,4687
2002-06-01	1866,02	2,668285	14,72703	119894,3	116,4945
2002-07-01	1888,23	2,857646	13,43957	121778,9	106,1632
2002-08-01	1900,50	3,017396	12,38913	121892,6	105,6215
2002-09-01	1914,18	3,224619	11,63826	118500,4	107,3304
2002-10-01	1939,26	3,632859	11,78725	124433,9	104,3953
2002-11-01	1997,83	3,319154	10,00726	123363,8	118,8541
2002-12-01	2039,78	3,301345	9,330845	115738,8	125,6344
2003-01-01	2085,68	3,075168	22,30807	109256,9	101,6003
2003-02-01	2118,43	3,179167	21,00905	112414,3	116,635
2003-03-01	2144,49	3,019576	20,156	118463,3	91,60108
2003-04-01	2165,29	2,695454	19,00141	118037,8	102,093
2003-05-01	2178,50	2,534891	18,26779	116536,2	95,25519
2003-06-01	2175,23	2,479121	18,23893	114938,4	108,8054
2003-07-01	2179,58	2,479353	17,32335	120279,3	92,49706
2003-08-01	2186,99	2,587481	15,18373	119655,7	99,63265
2003-09-01	2204,05	2,507411	12,0037	123655,7	104,0006
2003-10-01	2210,44	2,445067	10,30728	129851,4	88,31334
2003-11-01	2217,96	2,482669	8,800809	126483,2	115,2412
2003-12-01	2229,49	2,486282	6,962489	121352,7	87,70929
2004-01-01	2246,43	2,415892	15,44264	114947,3	99,66913
2004-02-01	2260,13	2,472662	14,72822	113608,6	108,8883
2004-03-01	2270,75	2,445491	14,07953	128259,6	84,23496
2004-04-01	2279,15	2,440805	13,4305	126546,2	105,2202
2004-05-01	2290,77	2,601981	12,67153	126694,2	100,8263
2004-06-01	2307,03	2,617264	11,90568	127731,6	88,91782
2004-07-01	2328,02	2,519805	10,86957	130977,2	79,88796
2004-08-01	2344,08	2,475906	10,19593	129965,4	85,73319
2004-09-01	2351,82	2,383392	10,04835	130230,5	94,29736
2004-10-01	2362,17	2,353923	9,872581	133821,4	96,55366
2004-11-01	2378,47	2,293724	9,636295	135664,3	87,40229
2004-12-01	2398,92	2,218811	9,200743	131112,1	85,48257
2005-01-01	2412,83	2,184421	17,24995	121437,8	110,7811
2005-02-01	2427,07	2,103561	17,09993	119470,7	97,23395
2005-03-01	2441,87	2,184795	16,87789	132205,1	97,12268
2005-04-01	2463,11	2,071841	16,20569	130933,4	114,1288
2005-05-01	2475,18	1,959654	15,92363	130449,7	103,5659
2005-06-01	2474,68	1,929631	16,08181	131487,1	93,07014
2005-07-01	2480,87	1,904632	15,76097	132739,7	102,547
2005-08-01	2485,09	1,902703	15,59996	136190,2	97,23589
2005-09-01	2493,79	1,868248	15,06494	134087,1	101,555
2005-10-01	2512,49	1,826453	13,86422	139203,6	105,4191

2005-11-01	2526,31	1,770722	12,87627	140933	106,1476
2005-12-01	2535,40	1,824011	11,87435	138046,7	104,3772
2006-01-01	2550,36	1,815034	16,95994	129147,4	101,3895
2006-02-01	2560,82	1,719417	16,11881	125279,5	133,4216
2006-03-01	2571,83	1,706778	15,08281	137842,6	104,2408
2006-04-01	2577,23	1,693668	14,30398	132638,6	115,7062
2006-05-01	2579,81	1,73594	13,71007	139634,6	100,6871
2006-06-01	2574,39	1,800142	13,43313	137061,4	106,8513
2006-07-01	2579,28	1,7591	13,02467	143006,4	103,91
2006-08-01	2580,57	1,739067	12,65475	146665,6	88,20078
2006-09-01	2585,99	1,737163	11,93137	144086,8	106,9084
2006-10-01	2594,52	1,707548	11,35542	153027,8	107,0324
2006-11-01	2602,56	1,710729	10,71603	153910,9	116,1592
2006-12-01	2615,05	1,705481	9,744037	149264,1	126,6994
2007-01-01	2626,56	1,691803	12,63441	142622,4	111,8887
2007-02-01	2638,12	1,657542	11,94489	138486,3	129,6552
2007-03-01	2647,88	1,653999	11,33715	152801,1	94,02641
2007-04-01	2654,50	1,609886	10,90533	149499,2	113,7079
2007-05-01	2661,93	1,572028	10,45289	154940,9	109,9415
2007-06-01	2669,38	1,531848	9,747257	152235,6	130,0023
2007-07-01	2675,79	1,491975	9,196638	156428,7	113,9777
2007-08-01	2688,37	1,551121	8,394942	157712	108,84
2007-09-01	2693,21	1,502358	7,991067	152797,6	120,6735
2007-10-01	2701,29	1,424462	7,628267	164864,3	101,1701
2007-11-01	2711,55	1,405516	7,223455	162623,6	124,2642
2007-12-01	2731,62	1,411966	6,433084	157522,2	126,3711
2008-01-01	2746,37	1,399989	10,58285	153668,3	120,6255
2008-02-01	2759,83	1,359835	10,04652	152365,4	108,6248
2008-03-01	2773,08	1,342371	9,515366	161616,2	102,1801
2008-04-01	2788,33	1,323459	9,100705	164597,7	133,379
2008-05-01	2810,36	1,298633	8,505054	164954,1	126,9973
2008-06-01	2831,16	1,26995	8,153223	166838,5	117,0138
2008-07-01	2846,16	1,250656	7,841444	172778,2	127,3743
2008-08-01	2854,13	1,26167	8,078101	170552,9	132,0406
2008-09-01	2861,55	1,40586	8,237877	172783,8	123,1039
2008-10-01	2874,43	1,675476	8,011023	179670	150,489
2008-11-01	2884,78	1,710422	7,603447	170987	125,7663
2008-12-01	2892,86	1,78725	7,327668	162028,3	118,1736
2009-01-01	2906,74	1,718403	12,77866	152647,9	123,5504
2009-02-01	2922,73	1,719168	11,51143	150394,3	109,5659
2009-03-01	2928,57	1,714862	10,34278	166403,4	112,1501
2009-04-01	2942,63	1,628692	9,231223	162275	127,06
2009-05-01	2956,46	1,516705	7,78865	164765,1	149,8813
2009-06-01	2967,10	1,4474	6,795359	165807,7	132,885
2009-07-01	2974,22	1,42521	6,030542	171533,1	128,225
2009-08-01	2978,68	1,363101	5,51617	171921,9	138,6492
2009-09-01	2985,83	1,343699	5,270807	175371,2	134,5115
2009-10-01	2994,19	1,283828	4,975845	187150,8	130,4363
2009-11-01	3006,47	1,273858	4,541518	185664,2	144,0825
2009-12-01	3017,59	1,287561	4,160675	182254,8	134,5917
2010-01-01	3040,22	1,300369	7,841191	169558,6	132,9864
2010-02-01	3063,93	1,333859	7,002167	167635,5	158,5344

2010-03-01	3079,86	1,287162	6,456986	187544	122,3388
2010-04-01	3097,42	1,259218	5,913298	182381,1	137,4323
2010-05-01	3110,74	1,293571	6,120865	184104,6	127,4397
2010-06-01	3110,74	1,28825	6,644679	184455,1	116,7609
2010-07-01	3111,05	1,264157	7,00291	191628,9	124,9046
2010-08-01	3112,29	1,258345	7,291061	193581,7	117,8709
2010-09-01	3126,29	1,225555	6,814672	195201,6	131,1875
2010-10-01	3149,74	1,195655	6,016478	201962,3	136,608
2010-11-01	3175,88	1,209872	5,140143	204576,8	131,6115
2010-12-01	3195,89	1,193098	4,48494	197378,9	122,102
2011-01-01	3222,42	1,174138	9,937519	184274,7	129,874
2011-02-01	3248,20	1,163747	9,37623	185448,3	148,8631
2011-03-01	3273,86	1,154404	8,961343	197452,1	134,8229
2011-04-01	3299,07	1,100502	8,243728	194836,6	168,5664
2011-05-01	3314,58	1,117618	7,916305	201403,4	132,3878
2011-06-01	3319,55	1,097607	7,923366	198665,9	130,4351
2011-07-01	3324,86	1,082725	7,891196	200267,4	119,1639
2011-08-01	3337,16	1,105052	7,661368	203620,4	114,3496
2011-09-01	3354,85	1,207067	6,611413	199978,5	116,4302
2011-10-01	3369,28	1,218456	5,947074	206464,2	139,0685
2011-11-01	3386,80	1,22666	5,124092	209554,3	126,7558
2011-12-01	3403,73	1,252499	4,131455	205297,9	124,4066
2012-01-01	3422,79	1,216814	10,08353	192868	125,1463
2012-02-01	3438,19	1,165639	9,296109	193764,5	139,8828
2012-03-01	3445,41	1,217813	8,496345	209262,7	129,8328
2012-04-01	3467,46	1,252263	7,342692	201724,1	129,7262
2012-05-01	3479,94	1,333299	6,484742	209324,9	116,116
2012-06-01	3482,72	1,373507	5,932369	205782,9	132,1934
2012-07-01	3497,70	1,354396	5,16738	211973,3	123,2114
2012-08-01	3512,04	1,357171	4,526071	216128,4	126,1353
2012-09-01	3532,06	1,354981	3,488484	206650,6	146,4499
2012-10-01	3552,90	1,351865	2,730408	220095,4	134,2753
2012-11-01	3574,22	1,3666	2,028378	216355,9	141,7223
2012-12-01	3602,46	1,362281	1,247166	208159,8	141,9624
2013-01-01	3633,44	1,322915	6,196708	203989,5	128,5562
2013-02-01	3655,24	1,284529	5,568148	197413,3	124,3655
2013-03-01	3672,42	1,281129	5,11085	214527,3	127,4215
2013-04-01	3692,62	1,28384	4,643902	219183,9	120,7437
2013-05-01	3706,28	1,300543	4,412908	215839,6	119,9399
2013-06-01	3715,92	1,388526	4,604944	212073,9	145,3671
2013-07-01	3717,03	1,441534	4,894359	220711,9	113,1135
2013-08-01	3725,95	1,499136	4,853524	220763,6	110,6079
2013-09-01	3738,99	1,44871	4,923403	217070,4	128,5639
2013-10-01	3760,30	1,389332	4,665645	229321,1	105,4692
2013-11-01	3780,61	1,451864	4,287756	225497,6	133,8607
2013-12-01	3815,39	1,473988	3,76735	221987,2	123,5989
2014-01-01	3836,37	1,49248	9,567379	214167,5	129,9794
2014-02-01	3862,84	1,484819	9,07744	213747,1	141,9751
2014-03-01	3898,38	1,438653	8,289293	221887,6	125,2835
2014-04-01	3924,50	1,3743	7,787284	221577,8	127,5838
2014-05-01	3942,55	1,363304	7,326043	221273	125,666
2014-06-01	3958,32	1,368608	6,891566	211253,6	122,7253

2014-07-01	3958,72	1,363328	6,881264	222933,1	122,181
2014-08-01	3968,62	1,386243	6,614113	220963,3	122,184
2014-09-01	3991,24	1,417942	6,012809	223207	121,0823
2014-10-01	4008,00	1,481524	5,587815	230235,8	105,5189
2014-11-01	4028,44	1,531401	5,27562	224328,6	126,5969
2014-12-01	4059,86	1,568971	4,858566	223640,2	111,9677
2015-01-01	4110,20	1,536906	10,45041	209302,1	108,266
2015-02-01	4160,34	1,627544	9,435988	203459,6	103,6451
2015-03-01	4215,26	1,795483	8,427237	221499,4	109,0636
2015-04-01	4245,19	1,72993	7,765876	212270,3	92,59401
2015-05-01	4276,60	1,733363	7,414088	208632,3	112,8284
2015-06-01	4310,39	1,752703	6,979373	206316	104,1019
2015-07-01	4337,11	1,80714	6,421417	212002,5	100,6179
2015-08-01	4346,65	1,966109	6,622455	209026,3	108,3752
2015-09-01	4370,12	2,168887	6,047938	207282	109,9286
2015-10-01	4405,95	2,138878	5,187984	214482,7	109,1937
2015-11-01	4450,45	2,063352	4,132458	209397	117,9654
2015-12-01	4493,17	2,09274	3,144484	207956,2	110,4738
2016-01-01	4550,23	2,162249	12,71848	192207,7	117,7682
2016-02-01	4591,18	2,098597	11,71462	193518	110,7404
2016-03-01	4610,92	1,95382	11,23563	207431,8	104,6803
2016-04-01	4639,05	1,876716	10,5569	203479,6	119,3559
2016-05-01	4675,23	1,852721	9,706872	200129,1	107,1788
2016-06-01	4691,59	1,791324	9,318138	201724,9	115,1399
2016-07-01	4715,99	1,703698	8,755716	200800,6	103,3905
2016-08-01	4736,74	1,665177	8,281161	203020,6	99,6837
2016-09-01	4740,53	1,692487	8,188797	200447,8	119,4949
2016-10-01	4752,86	1,65536	7,818113	205886,3	104,7321
2016-11-01	4761,42	1,735459	7,48325	207742,7	97,34365
2016-12-01	4775,70	1,739985	6,924452	207720,5	82,62049
2017-01-01	4793,85	1,659557	12,74158	194601,1	111,1964
2017-02-01	4809,67	1,608834	12,02463	192335,4	120,0482
2017-03-01	4821,69	1,616323	11,0836	210779,3	91,32621
2017-04-01	4828,44	1,620345	10,37587	201771,9	113,9143
2017-05-01	4843,41	1,651715	9,593768	206047,1	102,8821
2017-06-01	4832,27	1,701054	8,865388	203574,7	98,68507
2017-07-01	4843,87	1,651527	8,459036	205311,3	100,7116
2017-08-01	4853,07	1,626245	7,409959	207659,4	93,39606
2017-09-01	4860,83	1,6236	6,455099	202869,1	89,69832
2017-10-01	4881,25	1,647178	5,674592	211116,7	99,17263
2017-11-01	4894,92	1,682113	4,780488	212496,1	106,535
2017-12-01	4916,46	1,695061	3,933949	213139,5	104,6083
2018-01-01	4930,72	1,655421	6,590886	203356,2	116,182
2018-02-01	4946,50	1,67051	6,072955	197768,8	111,7836
2018-03-01	4950,95	1,688748	5,839126	215730,7	104,768
2018-04-01	4961,84	1,755542	5,430044	214515,1	113,8662
2018-05-01	4981,69	1,870086	5,003454	204609,9	90,0544
2018-06-01	5044,46	1,918188	3,703704	210056,5	90,96432
2018-07-01	5061,11	1,941519	3,361181	212228,6	94,99004
2018-08-01	5056,56	1,998153	3,451629	214764,1	102,7316
2018-09-01	5080,83	2,087395	2,961099	205561,6	112,3408
2018-10-01	5103,69	1,901685	2,494943	217414,5	95,13704

2018-11-01	5092,97	1,918637	2,712617	216251,3	112,7629
2018-12-01	5100,61	1,966901	2,554217	213353,3	123,3695
2019-01-01	5116,93	1,886759	6,060606	205089,8	93,02076
2019-02-01	5138,93	1,875204	5,60794	203407,4	111,2236
2019-03-01	5177,47	1,929958	4,817259	210740,6	108,4253
2019-04-01	5206,98	1,951127	4,221765	213446,7	104,6025
2019-05-01	5213,75	2,001759	4,089219	214197,6	101,4862
2019-06-01	5214,27	1,929543	4,079037	207717,1	103,0386
2019-07-01	5224,18	1,890552	3,88596	219414,4	96,19195
2019-08-01	5229,93	2,010605	3,27677	218474	99,39274
2019-09-01	5227,84	2,065375	3,14177	214242,3	97,31856
2019-10-01	5233,07	2,051822	2,709552	224939,3	93,97231
2019-11-01	5259,76	2,081374	1,726144	219771,4	108,785
2019-12-01	5320,25	2,040952	0,268431	217065,7	97,20324
2020-01-01	5331,42	2,060455	4,181219	208996,2	98,0283
2020-02-01	5344,75	2,151203	3,712921	209742,4	111,7617
2020-03-01	5348,49	2,407583	3,40197	215188,6	91,55286
2020-04-01	5331,91	2,612711	3,422471	193199	98,05826
2020-05-01	5311,65	2,776753	3,17508	196833,6	106,4429
2020-06-01	5325,46	2,562574	2,477522	206826	96,3208
2020-07-01	5344,63	2,607687	1,682262	218437	90,67424
2020-08-01	5357,46	2,700667	1,23138	215609,2	92,07786
2020-09-01	5391,75	2,660138	0,552595	217852,3	97,78481
2020-10-01	5438,12	2,75141	-0,31305	224722,5	101,401
2020-11-01	5486,52	2,632271	-1,19267	224596,4	95,63012
2020-12-01	5560,59	2,477378	-2,5067	229966,8	101,1713
2021-01-01	5574,49	2,578235	1,645885	221048,2	111,8842
2021-02-01	5622,43	2,594226	0,781327	227979,7	109,3819
2021-03-01	5674,72	2,692238	0,176384	245872,4	87,65928
2021-04-01	5692,31	2,661734	0,273518	234911,3	91,66224
2021-05-01	5739,56	2,527896	0,067816	231037,1	98,93758
2021-06-01	5769,98	2,411962	-0,00964	230709	93,45238
2021-07-01	5825,37	2,45959	-0,58228	238248,9	95,85199
2021-08-01	5876,05	2,490538	-0,62459	236835,4	82,62564
2021-09-01	5944,21	2,485906	-1,37512	232500,1	92,19378
2021-10-01	6018,51	2,600598	-1,79231	232705,8	94,81011
2021-11-01	6075,69	2,605437	-1,47355	235175,7	97,34297
2021-12-01	6120,04	2,649153	-1,18117	235484,4	81,13635
2022-01-01	6153,09	2,596271	8,563756	213224,8	81,6765
2022-02-01	6215,24	2,43048	8,792832	219745,1	96,22983
2022-03-01	6315,93	2,310336	7,703488	241727,4	76,23292
2022-04-01	6382,88	2,197772	7,057244	236342	94,85546
2022-05-01	6412,88	2,299567	7,377362	237949,7	83,58838
2022-06-01	6455,85	2,357794	7,014883	236812,7	85,22037
2022-07-01	6411,95	2,52276	7,998473	245714,3	98,62167
2022-08-01	6388,87	2,42766	8,803525	247970,4	86,48852
2022-09-01	6370,34	2,489657	9,18436	244143	90,39289
2022-10-01	6407,93	2,494381	8,548233	249090,9	93,71731
2022-11-01	6434,20	2,501848	8,104252	248132,7	102,543
2022-12-01	6474,09	2,472033	7,429814	246427,8	107,5219
2023-01-01	6508,40	2,452893	13,05083	226063,4	94,92978
2023-02-01	6563,07	2,427107	12,11404	229231,1	106,4465

2023-03-01	6609,67	2,42989	11,32334	257609,1	89,10708
2023-04-01	6649,99	2,335631	10,64058	247990,1	106,5413
2023-05-01	6665,28	2,316639	10,39339	248144,7	82,13887
2023-06-01	6659,95	2,263266	10,47925	246407,6	76,53034
2023-07-01	6667,94	2,240677	10,35052	250498,7	79,59204
2023-08-01	6683,28	2,294779	9,648358	252901,9	87,05241
2023-09-01	6700,66	2,31377	9,149758	247663,8	83,59611
2023-10-01	6716,74	2,370139	8,578313	257286,5	84,48576
2023-11-01	6735,55	2,289037	7,814302	258796,7	80,26038
2023-12-01	6773,27	2,280565	6,929841	254312	83,06421
2024-01-01	6801,72	2,28682	11,18303	237647,3	81,68265
2024-02-01	6858,17	2,300157	9,777778	238711	88,19628
2024-03-01	6869,14	2,311784	9,445869	255948,1	83,66424
2024-04-01	6895,24	2,378854	8,693517	261061,5	85,3617
2024-05-01	6926,96	2,370701	8,008214	252737,2	85,89433
2024-06-01	6941,51	2,483661	7,728337	254830,4	97,91802
2024-07-01	6967,89	2,548048	7,319918	264993,1	71,88412
2024-08-01	6966,50	2,558032	7,340788	261194,2	86,32456
2024-09-01	6997,15	2,547607	6,959636	257359,6	86,55733
2024-10-01	7036,33	2,576964	6,517135	269283,4	76,48915
2024-11-01	7063,77	2,65792	6,472337	261554,7	90,78775
2024-12-01	7100,50	2,78631	6,620242	270055,3	85,46893
2025-01-01	7111,86	2,760374	11,97085	276671,6	84,87578
2025-02-01	7205,03	2,614378	11,51079	283450,1	79,87925
2025-03-01	7245,38	2,590044	11,29949	290394,6	83,874
2025-04-01	7276,54	2,601247	11,38759	297509,3	78,58934
2025-05-01	7295,46	2,54438	11,48418	304798,3	77,18607
2025-06-01	7312,97	2,491532	11,40887	312265,8	80,35392
2025-07-01	7331,98	2,481608	11,27252	319916,3	79,13556
2025-08-01	7323,91	2,457031	11,39118	327754,3	101,9556
2025-09-01	7359,06	2,417082	10,86453	335784,3	83,16555
2025-10-01	7365,68	2,425531	10,76834	344011	70,61755

```
> library(tseries)
> library(urca)
> library(forecast)
> library(fpp)
> library(expsmooth)
> library(lmtest)
> library(zoo)
> library(vars)
> library(tidyverse)
> str(df)
'data.frame':	287 obs. of  6 variables:
 $ data   : chr  "2002-01-01" "2002-02-01" "2002-03-01" "2002-04-01" ...
 $ IPCA   : num  1822 1829 1840 1854 1858 ...
```

```
 $ CAMBIOR: num  2.37 2.41 2.33 2.29 2.45 ...
 $ JUROSR : num  18.4 17.9 17 15.7 15.5 ...
 $ PIBR   : num  111793 110502 116709 117680 120523 ...
 $ IPFF   : num  108 128 121 116 101 ...
```

```
> df$Data <-as.Date(df$Data)
> x=ur.pp(df$IPFF, type = c("Z-tau"), model = c("constant"))
> summary(x)
```

```
##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept


Call:
lm(formula = y ~ y.l1)

Residuals:
    Min      1Q  Median      3Q     Max 
-29.593  -7.925  -1.350   7.694  41.222 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 30.16914    4.52068   6.674 1.31e-10 ***
y.l1         0.72076    0.04123  17.483  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 12.37 on 284 degrees of freedom
Multiple R-squared:  0.5184,   Adjusted R-squared:  0.51 
F-statistic: 305.6 on 1 and 284 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -6.5666 

         aux. Z statistics
Z-tau-mu            6.4692

Critical values for Z statistics: 
                     1pct      5pct     10pct
critical values -3.454833 -2.871776 -2.572183
```

```
> x=ur.pp(df$IPFF, type = c("Z-tau"), model = c("trend"))
> summary(x)
```

```
##################################
# Phillips-Perron Unit Root Test #
##################################
```

```
Test regression with intercept and trend


Call:
lm(formula = y ~ y.l1 + trend)

Residuals:
    Min      1Q  Median      3Q     Max
-30.871  -7.300  -0.945   7.975  41.950

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 37.597162   4.918928   7.643  3.3e-13 ***
y.l1         0.652270   0.044952  14.510  < 2e-16 ***
trend       -0.033700   0.009659  -3.489 0.000562 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 12.13 on 283 degrees of freedom
Multiple R-squared:  0.5382,   Adjusted R-squared:  0.535
F-statistic: 164.9 on 2 and 283 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -7.8769

           aux. Z statistics
Z-tau-mu              7.0917
Z-tau-beta           -3.5363

Critical values for Z statistics:
                     1pct     5pct     10pct
critical values -3.993586 -3.42694 -3.136447



 > x=ur.kpss(df$IPFF, type = c("mu"))
 >  summary(x)

#######################
# KPSS Unit Root Test #
#######################

Test is of type: mu with 5 lags.

Value of test-statistic is: 1.988

Critical value for a significance level of:
                10pct  5pct 2.5pct  1pct
critical values 0.347 0.463  0.574 0.739


 > x=ur.kpss(df$IPFF, type = c("tau"))
 > summary(x)

#######################
```

```
# KPSS Unit Root Test #
#######################

Test is of type: tau with 5 lags.

Value of test-statistic is: 0.8963

Critical value for a significance level of:
                10pct  5pct 2.5pct  1pct
critical values 0.119 0.146  0.176 0.216


> > #IPCA
> > # nível (log)
> > x=ur.pp(log(df$IPCA), type = "Z-tau", model = "trend")
> > summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept and trend


Call:
lm(formula = y ~ y.l1 + trend)

Residuals:
       Min         1Q     Median         3Q        Max
-0.0100260 -0.0023240 -0.0004422  0.0017074  0.0223214

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 2.251e-01  7.376e-02   3.052  0.00249 **
y.l1        9.733e-01  8.936e-03 108.915  < 2e-16 ***
trend       1.180e-04  4.215e-05   2.800  0.00545 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.003826 on 283 degrees of freedom
Multiple R-squared:  0.9999,  Adjusted R-squared:  0.9999
F-statistic: 1.476e+06 on 2 and 283 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -3.1981

           aux. Z statistics
Z-tau-mu              0.3337
Z-tau-beta            3.2735

Critical values for Z statistics:
                     1pct     5pct     10pct
critical values -3.993586 -3.42694 -3.136447

>
```

```
> > x=ur.pp(log(df$IPCA), type = c("Z-tau"), model = c("constant"))
> > summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept


Call:
lm(formula = y ~ y.l1)

Residuals:
       Min         1Q     Median         3Q        Max
-0.0108310 -0.0023357 -0.0005855  0.0017597  0.0236931

Coefficients:
             Estimate Std. Error  t value Pr(>|t|)
(Intercept) 0.0189921  0.0048594    3.908 0.000116 ***
y.l1        0.9982919  0.0005879 1697.957  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.003872 on 284 degrees of freedom
Multiple R-squared:  0.9999,  Adjusted R-squared:  0.9999
F-statistic: 2.883e+06 on 1 and 284 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -1.7858

         aux. Z statistics
Z-tau-mu            2.3694

Critical values for Z statistics:
                     1pct      5pct     10pct
critical values -3.454833 -2.871776 -2.572183

>
>
> > ur.kpss(log(df$IPCA), type = "tau")

#######################################
# KPSS Unit Root / Cointegration Test #
#######################################

The value of the test statistic is: 0.1482

> >
> > ur.kpss(log(df$IPCA), type = c("mu"))

#######################################
# KPSS Unit Root / Cointegration Test #
#######################################
```

```
The value of the test statistic is: 4.8689

>
> > # primeira diferença do log
> > x= ur.pp(diff(log(df$IPCA)), type = "Z-tau", model = "constant")
> > summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept


Call:
lm(formula = y ~ y.l1)

Residuals:
       Min         1Q     Median         3Q        Max
-0.0128414 -0.0015216 -0.0001354  0.0014136  0.0197302

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.0017969  0.0002895   6.208 1.91e-09 ***
y.l1        0.6320886  0.0461321  13.702  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.003051 on 283 degrees of freedom
Multiple R-squared:  0.3988,	Adjusted R-squared:  0.3967
F-statistic: 187.7 on 1 and 283 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -8.1031

         aux. Z statistics
Z-tau-mu             6.308

Critical values for Z statistics:
                     1pct      5pct     10pct
critical values -3.454909 -2.87181 -2.572201

> >
> > x=ur.pp(diff(log(df$IPCA)), type = "Z-tau", model = "trend")
> > summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept and trend


Call:
lm(formula = y ~ y.l1 + trend)
```

```
Residuals:
       Min         1Q     Median         3Q        Max
-0.0125051 -0.0015138 -0.0001581  0.0014917  0.0193947

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.848e-03  2.913e-04   6.346  8.8e-10 ***
y.l1         6.219e-01  4.662e-02  13.341  < 2e-16 ***
trend       -3.120e-06  2.220e-06  -1.405    0.161
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.003046 on 282 degrees of freedom
Multiple R-squared:  0.403,   Adjusted R-squared:  0.3988
F-statistic: 95.18 on 2 and 282 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -8.2393

           aux. Z statistics
Z-tau-mu              5.9334
Z-tau-beta           -1.4214

Critical values for Z statistics:
                     1pct      5pct     10pct
critical values -3.993693 -3.426991 -3.136478

> > ur.kpss(diff(log(df$IPCA)), type = "mu")

#######################################
# KPSS Unit Root / Cointegration Test #
#######################################

The value of the test statistic is: 0.2643


> > ur.kpss(diff(log(df$IPCA)), type = "tau")

#######################################
# KPSS Unit Root / Cointegration Test #
#######################################

The value of the test statistic is: 0.097


> > #PIB EM LOG
> > x=ur.pp(log(df$PIBR), type = "Z-tau", model = "trend")
> > summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################
```

```
Test regression with intercept and trend


Call:
lm(formula = y ~ y.l1 + trend)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.119090 -0.022915 -0.001885  0.022724  0.109092 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 9.629e-01  2.928e-01   3.289  0.00113 ** 
y.l1        9.211e-01  2.410e-02  38.226  < 2e-16 ***
trend       2.304e-04  7.336e-05   3.140  0.00187 ** 
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03737 on 283 degrees of freedom
Multiple R-squared:  0.9783,	Adjusted R-squared:  0.9781 
F-statistic:  6366 on 2 and 283 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -2.6273 

           aux. Z statistics
Z-tau-mu              5.3945
Z-tau-beta            2.1562

Critical values for Z statistics: 
                     1pct     5pct     10pct
critical values -3.993586 -3.42694 -3.136447


> > x= ur.pp(log(df$PIBR), type = "Z-tau", model = "constant")
> > summary(x)

################################## 
# Phillips-Perron Unit Root Test # 
################################## 


Test regression with intercept 


Call:
lm(formula = y ~ y.l1)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.11072 -0.02225 -0.00187  0.02376  0.11432 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 0.106911   0.108491   0.985    0.325    
```

```
y.l1        0.991532   0.008927 111.077   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03794 on 284 degrees of freedom
Multiple R-squared:  0.9775,  Adjusted R-squared:  0.9774
F-statistic: 1.234e+04 on 1 and 284 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -0.4312

         aux. Z statistics
Z-tau-mu             0.484

Critical values for Z statistics:
                     1pct      5pct     10pct
critical values -3.454833 -2.871776 -2.572183


> ur.kpss(log(df$PIBR), type = "tau")

#######################################
# KPSS Unit Root / Cointegration Test #
#######################################


The value of the test statistic is: 0.7592



> ur.kpss(log(df$PIBR), type = "mu")

#######################################
# KPSS Unit Root / Cointegration Test #
#######################################

The value of the test statistic is: 4.2602


> # primeira diferença do log
> x=ur.pp(diff(log(df$PIBR)), type = "Z-tau", model = "constant")
> summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept


Call:
lm(formula = y ~ y.l1)

Residuals:
     Min       1Q   Median       3Q      Max
```

```
-0.10911 -0.02240 -0.00151  0.02271  0.11524

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.004571   0.002248   2.033    0.043 *
y.l1        -0.127058   0.058974  -2.154    0.032 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03775 on 283 degrees of freedom
Multiple R-squared:  0.01614, Adjusted R-squared:  0.01266
F-statistic: 4.642 on 1 and 283 DF,  p-value: 0.03205


Value of test-statistic, type: Z-tau  is: -20.7288

         aux. Z statistics
Z-tau-mu            2.2034

Critical values for Z statistics:
                     1pct      5pct     10pct
critical values -3.454909 -2.87181 -2.572201


> x=ur.pp(diff(log(df$PIBR)), type = "Z-tau", model = "trend")
> summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept and trend


Call:
lm(formula = y ~ y.l1 + trend)

Residuals:
      Min        1Q    Median        3Q       Max
-0.109572 -0.022394 -0.001281  0.021865  0.115971

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.568e-03  2.252e-03   2.028   0.0435 *
y.l1        -1.272e-01  5.908e-02  -2.153   0.0321 *
trend        6.232e-06  2.723e-05   0.229   0.8191
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03782 on 282 degrees of freedom
Multiple R-squared:  0.01632, Adjusted R-squared:  0.009344
F-statistic: 2.339 on 2 and 282 DF,  p-value: 0.09826


Value of test-statistic, type: Z-tau  is: -20.6954
```

```
            aux. Z statistics
Z-tau-mu                3.3037
Z-tau-beta              0.2445

Critical values for Z statistics:
                     1pct      5pct     10pct
critical values -3.993693 -3.426991 -3.136478

> ur.kpss(diff(log(df$PIBR)), type = "mu")

#######################################
# KPSS Unit Root / Cointegration Test #
#######################################

The value of the test statistic is: 0.105

> ur.kpss(diff(log(df$PIBR)), type = "tau")

#######################################
# KPSS Unit Root / Cointegration Test #
#######################################

The value of the test statistic is: 0.1065


> #CAMBIO EM LOG
> x=ur.pp(log(df$CAMBIOR), type = "Z-tau", model = "trend")
> summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept and trend


Call:
lm(formula = y ~ y.l1 + trend)

Residuals:
      Min         1Q     Median         3Q        Max
-0.101866 -0.023333 -0.004331  0.021110  0.174760

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 7.686e-03  5.600e-03   1.372   0.1710
y.l1        9.878e-01  8.235e-03 119.951   <2e-16 ***
trend       4.558e-05  2.756e-05   1.654   0.0993 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03739 on 283 degrees of freedom
Multiple R-squared:  0.9819,  Adjusted R-squared:  0.9818
F-statistic:  7673 on 2 and 283 DF,  p-value: < 2.2e-16
```

```
Value of test-statistic, type: Z-tau  is: -1.7461

           aux. Z statistics
Z-tau-mu              0.5381
Z-tau-beta            1.4458

Critical values for Z statistics:
                     1pct     5pct     10pct
critical values -3.993586 -3.42694 -3.136447

> x=ur.pp(log(df$CAMBIOR), type = "Z-tau", model = "constant")
> summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept


Call:
lm(formula = y ~ y.l1)

Residuals:
      Min        1Q    Median        3Q       Max
-0.109271 -0.023370 -0.003292  0.020153  0.172830

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.005691   0.005485   1.038      0.3
y.l1        0.990979   0.008024 123.495   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.0375 on 284 degrees of freedom
Multiple R-squared:  0.9817,  Adjusted R-squared:  0.9817
F-statistic: 1.525e+04 on 1 and 284 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -1.4606

         aux. Z statistics
Z-tau-mu            1.3431

Critical values for Z statistics:
                     1pct      5pct     10pct
critical values -3.454833 -2.871776 -2.572183

>
> ur.kpss(log(df$CAMBIOR), type = "tau")

#######################################
# KPSS Unit Root / Cointegration Test #
```

```
########################################

The value of the test statistic is: 0.9653

> ur.kpss(log(df$CAMBIOR), type = "mu")

########################################
# KPSS Unit Root / Cointegration Test #
########################################

The value of the test statistic is: 1.297


> # primeira diferença do log
> x=ur.pp(diff(log(df$CAMBIOR)), type = "Z-tau", model = "constant")
> summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept


Call:
lm(formula = y ~ y.l1)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.12713 -0.02283 -0.00064  0.01948  0.14203 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -2.887e-05  2.120e-03  -0.014    0.989    
y.l1         3.091e-01  5.652e-02   5.469 9.94e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.0358 on 283 degrees of freedom
Multiple R-squared:  0.0956,  Adjusted R-squared:  0.0924 
F-statistic: 29.91 on 1 and 283 DF,  p-value: 9.938e-08


Value of test-statistic, type: Z-tau  is: -12.1782 

         aux. Z statistics
Z-tau-mu           -0.0138

Critical values for Z statistics: 
                     1pct      5pct     10pct
critical values -3.454909 -2.87181 -2.572201


> x=ur.pp(diff(log(df$CAMBIOR)), type = "Z-tau", model = "trend")
> summary(x)
```

```
###################################
# Phillips-Perron Unit Root Test #
###################################

Test regression with intercept and trend


Call:
lm(formula = y ~ y.l1 + trend)

Residuals:
     Min       1Q   Median       3Q      Max
-0.12308 -0.02244 -0.00033  0.01948  0.14417

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -4.155e-05  2.120e-03  -0.020    0.984
y.l1         3.045e-01  5.670e-02   5.370 1.65e-07 ***
trend        2.614e-05  2.586e-05   1.011    0.313
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03579 on 282 degrees of freedom
Multiple R-squared:  0.09886, Adjusted R-squared:  0.09247
F-statistic: 15.47 on 2 and 282 DF,  p-value: 4.221e-07


Value of test-statistic, type: Z-tau  is: -12.2029

           aux. Z statistics
Z-tau-mu              -0.020
Z-tau-beta             1.006

Critical values for Z statistics:
                     1pct      5pct     10pct
critical values -3.993693 -3.426991 -3.136478

>
>
> ur.kpss(diff(log(df$CAMBIOR)), type = "mu")

########################################
# KPSS Unit Root / Cointegration Test #
########################################

The value of the test statistic is: 0.2054

> ur.kpss(diff(log(df$CAMBIOR)), type = "tau")

########################################
# KPSS Unit Root / Cointegration Test #
########################################

The value of the test statistic is: 0.0624
```

```
> x=ur.pp((df$JUROSR), type = c("Z-tau"), model = c("constant"))
> summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept


Call:
lm(formula = y ~ y.l1)

Residuals:
    Min      1Q  Median      3Q     Max 
-2.4583 -0.7363 -0.4250  0.0167 13.1138 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.79630    0.23096   3.448 0.000651 ***
y.l1         0.90002    0.02465  36.509  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.859 on 284 degrees of freedom
Multiple R-squared:  0.8244,	Adjusted R-squared:  0.8237 
F-statistic:  1333 on 1 and 284 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -3.7589 

         aux. Z statistics
Z-tau-mu             3.173

Critical values for Z statistics: 
                     1pct      5pct     10pct
critical values -3.454833 -2.871776 -2.572183

> 
> x=ur.pp((df$JUROSR), type = c("Z-tau"), model = c("trend"))
> summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept and trend


Call:
lm(formula = y ~ y.l1 + trend)

Residuals:
    Min      1Q  Median      3Q     Max 
```

```
-2.6083 -0.8109 -0.4140  0.0341 12.7847

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)  1.019050   0.263365   3.869 0.000136 ***
y.l1         0.873155   0.029017  30.091  < 2e-16 ***
trend       -0.002726   0.001567  -1.740 0.083033 .  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.852 on 283 degrees of freedom
Multiple R-squared:  0.8262,	Adjusted R-squared:  0.825 
F-statistic: 672.7 on 2 and 283 DF,  p-value: < 2.2e-16


Value of test-statistic, type: Z-tau  is: -4.1269 

           aux. Z statistics
Z-tau-mu              4.6211
Z-tau-beta           -1.5825

Critical values for Z statistics: 
                     1pct      5pct     10pct
critical values -3.993586 -3.42694 -3.136447

> x=ur.kpss((df$JUROSR), type = c("mu"))
> summary(x)

####################### 
# KPSS Unit Root Test # 
####################### 

Test is of type: mu with 5 lags. 

Value of test-statistic is: 1.9964 

Critical value for a significance level of: 
                10pct  5pct 2.5pct  1pct
critical values 0.347 0.463  0.574 0.739


> x=ur.kpss((df$JUROSR), type = c("tau"))
> summary(x)

####################### 
# KPSS Unit Root Test # 
####################### 

Test is of type: tau with 5 lags. 

Value of test-statistic is: 0.5072 

Critical value for a significance level of: 
                10pct  5pct 2.5pct  1pct
critical values 0.119 0.146  0.176 0.216
```

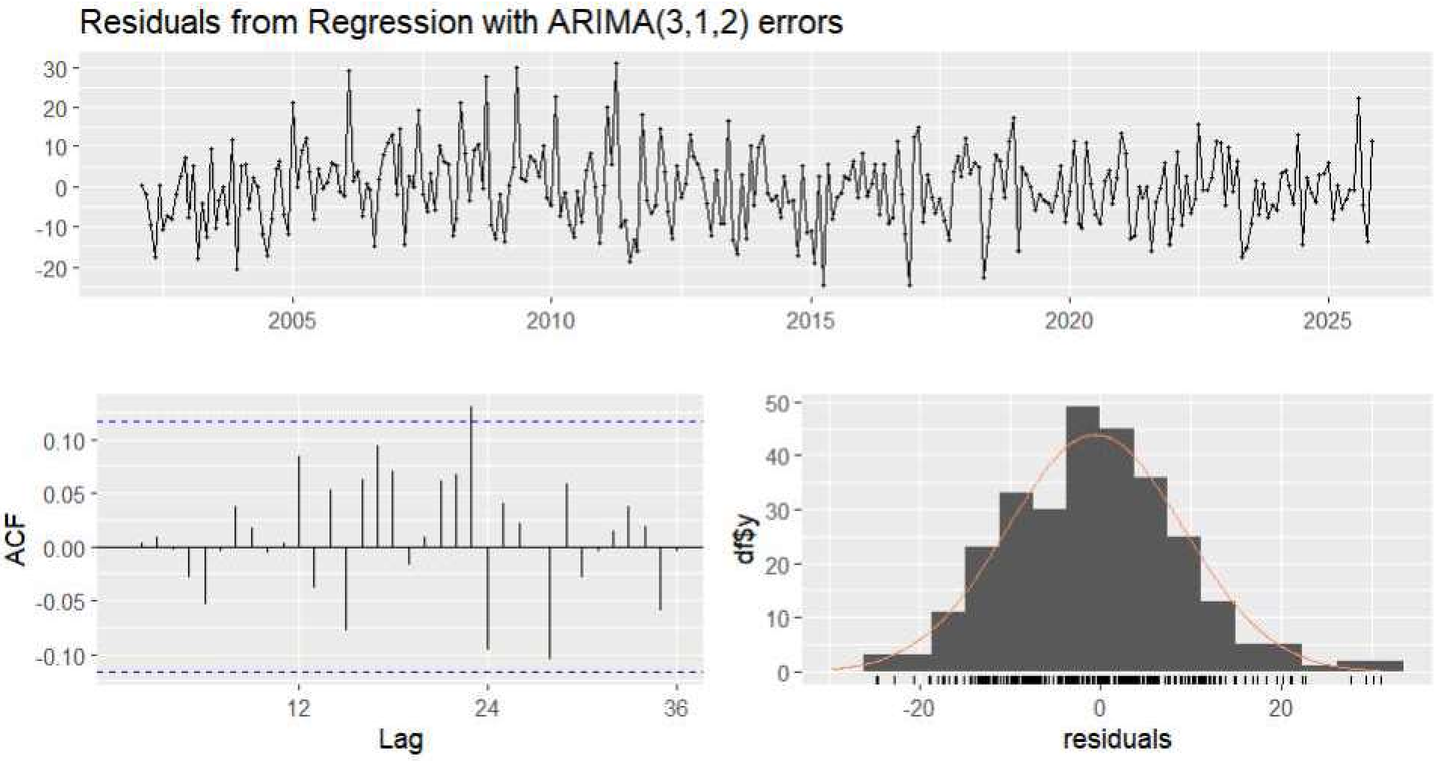
```
> ####primeira diferenças do juros real
> x=ur.pp(diff(df$JUROSR), type = c("Z-tau"), model = c("constant"))
> summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept


Call:
lm(formula = y ~ y.l1)

Residuals:
    Min      1Q  Median      3Q     Max 
-3.3409 -0.7627 -0.4425 -0.1145 12.9457 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.02822    0.11299  -0.250    0.803
y.l1        -0.08839    0.05921  -1.493    0.137

Residual standard error: 1.907 on 283 degrees of freedom
Multiple R-squared:  0.007814,	Adjusted R-squared:  0.004308 
F-statistic: 2.229 on 1 and 283 DF,  p-value: 0.1366


Value of test-statistic, type: Z-tau  is: -19.0192 

         aux. Z statistics
Z-tau-mu           -0.2586

Critical values for Z statistics: 
                     1pct      5pct     10pct
critical values -3.454909 -2.87181 -2.572201

> 
> x=ur.pp(diff(df$JUROSR), type = c("Z-tau"), model = c("trend"))
> summary(x)

##################################
# Phillips-Perron Unit Root Test #
##################################

Test regression with intercept and trend


Call:
lm(formula = y ~ y.l1 + trend)

Residuals:
    Min      1Q  Median      3Q     Max 
-3.2230 -0.7670 -0.4711 -0.1374 13.0739 
```

```
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.028761   0.113095  -0.254    0.799
y.l1        -0.090106   0.059306  -1.519    0.130
trend        0.000980   0.001376   0.712    0.477

Residual standard error: 1.909 on 282 degrees of freedom
Multiple R-squared:  0.009596,     Adjusted R-squared:  0.002572
F-statistic: 1.366 on 2 and 282 DF,  p-value: 0.2568


Value of test-statistic, type: Z-tau  is: -19.0433

             aux. Z statistics
Z-tau-mu              -0.3542
Z-tau-beta             0.7389

Critical values for Z statistics:
                      1pct      5pct     10pct
critical values -3.993693 -3.426991 -3.136478

>
>
> ####KPSS Unit Root Test
> x=ur.kpss(diff(df$JUROSR), type = c("mu"))
> summary(x)

#######################
# KPSS Unit Root Test #
#######################

Test is of type: mu with 5 lags.

Value of test-statistic is: 0.0862

Critical value for a significance level of:
                10pct  5pct 2.5pct  1pct
critical values 0.347 0.463  0.574 0.739

>
> x=ur.kpss(diff(df$JUROSR), type = c("tau"))
> summary(x)

#######################
# KPSS Unit Root Test #
#######################

Test is of type: tau with 5 lags.

Value of test-statistic is: 0.0162

Critical value for a significance level of:
                10pct  5pct 2.5pct  1pct
critical values 0.119 0.146  0.176 0.216
```

```
> ####GRÁFICOS SEÇÃO "Identificação das ordens apropriadas para os
 processos AR e MA"
> acf(na.omit(IPFF), main="FAC")
> pacf(na.omit(IPFF), main="FACP")


> df$dlnIPCA    <- c(NA, diff(log(df$IPCA)))
> df$dlnPIBR    <- c(NA, diff(log(df$PIBR)))
> df$dlnCAMBIOR <- c(NA, diff(log(df$CAMBIOR)))
> df$dJUROSR    <- c(NA, diff(df$JUROSR))
>
> xreg <- cbind(
>   ipca    = df$dlnIPCA,
>   cambior = df$dlnCAMBIOR,
>   jurosr  = df$dJUROSR,
>   pibr    = df$dlnPIBR
> )
>
> ok <- complete.cases(df$IPFF, xreg)
> y_level <- df$IPFF[ok]
> xreg_use <- xreg[ok, , drop=FALSE]
> dates_use <- df$Data[ok]
>
>
> IPFF<-ts(df$IPFF,start=c(2002,2),freq=12)

> Acf(IPFF,main="FAC")
> Pacf(IPFF,main="FACP")
> ggtsdisplay(df$IPFF,main="IPFF")
> ggtsdisplay(diff(df$IPFF),main="DIFFIPFF")

> IPFF_lm <- lm(IPFF~IPFF_time)
> summary(IPFF_lm)


Call:
lm(formula = IPFF ~ IPFF_time)

Residuals:
    Min      1Q  Median      3Q     Max 
-38.881 -12.034  -1.703  11.577  57.402 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 2377.1992   275.3012   8.635 4.24e-16 ***
IPFF_time     -1.1266     0.1367  -8.242 6.24e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 15.99 on 285 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.1925,	Adjusted R-squared:  0.1896 
F-statistic: 67.93 on 1 and 285 DF,  p-value: 6.241e-15
```

```
> library(BETS)
> ok <- complete.cases(df$IPFF, xreg)
> > y_level <- df$IPFF[ok]
> > xreg_use <- xreg[ok, , drop=FALSE]
> > dates_use <- df$Data[ok]
> >
> > # ts mensal só para dar calendário (não muda valores)
> > start_y <- as.integer(format(min(dates_use), "%Y"))
> > start_m <- as.integer(format(min(dates_use), "%m"))
> > y_ts <- ts(y_level, start=c(start_y, start_m), frequency=12)
> >
> > # reestimar em nível
> > modArima <- auto.arima(
> +   y_ts,
> +   xreg = xreg_use,
> +   stepwise = FALSE,
> +   trace = TRUE,
> +   seasonal = FALSE
> + )
>
>  Fitting models using approximations to speed things up...
>
>  Regression with ARIMA(0,1,0)            errors : 2226.966
>  Regression with ARIMA(0,1,0)            errors : 2229.033
>  Regression with ARIMA(0,1,1)            errors : 2118.845
>  Regression with ARIMA(0,1,1)            errors : 2120.329
>  Regression with ARIMA(0,1,2)            errors : 2120.286
>  Regression with ARIMA(0,1,2)            errors : 2121.717
>  Regression with ARIMA(0,1,3)            errors : 2122.372
>  Regression with ARIMA(0,1,3)            errors : 2123.804
>  Regression with ARIMA(0,1,4)            errors : 2120.55
>  Regression with ARIMA(0,1,4)            errors : 2121.88
>  Regression with ARIMA(0,1,5)            errors : 2122.376
>  Regression with ARIMA(0,1,5)            errors : 2123.733
>  Regression with ARIMA(1,1,0)            errors : 2167.216
>  Regression with ARIMA(1,1,0)            errors : 2169.233
>  Regression with ARIMA(1,1,1)            errors : 2119.774
>  Regression with ARIMA(1,1,1)            errors : 2121.276
>  Regression with ARIMA(1,1,2)            errors : 2120.884
>  Regression with ARIMA(1,1,2)            errors : 2122.405
>  Regression with ARIMA(1,1,3)            errors : 2123.01
>  Regression with ARIMA(1,1,3)            errors : 2124.551
>  Regression with ARIMA(1,1,4)            errors : 2121.924
>  Regression with ARIMA(1,1,4)            errors : 2123.339
>  Regression with ARIMA(2,1,0)            errors : 2137.104
>  Regression with ARIMA(2,1,0)            errors : 2139.084
>  Regression with ARIMA(2,1,1)            errors : 2116.77
>  Regression with ARIMA(2,1,1)            errors : 2118.43
>  Regression with ARIMA(2,1,2)            errors : 2117.01
>  Regression with ARIMA(2,1,2)            errors : 2118.854
>  Regression with ARIMA(2,1,3)            errors : 2118.752
>  Regression with ARIMA(2,1,3)            errors : 2120.66
>  Regression with ARIMA(3,1,0)            errors : 2133.869
>  Regression with ARIMA(3,1,0)            errors : 2135.911
>  Regression with ARIMA(3,1,1)            errors : 2116.822
```

```
>  Regression with ARIMA(3,1,1)            errors : 2118.761
>  Regression with ARIMA(3,1,2)            errors : 2115.129
>  Regression with ARIMA(3,1,2)            errors : 2116.963
>  Regression with ARIMA(4,1,0)            errors : 2130.08
>  Regression with ARIMA(4,1,0)            errors : 2132.087
>  Regression with ARIMA(4,1,1)            errors : 2119.595
>  Regression with ARIMA(4,1,1)            errors : 2121.232
>  Regression with ARIMA(5,1,0)            errors : 2130.948
>  Regression with ARIMA(5,1,0)            errors : 2132.994
>
>  Now re-fitting the best model(s) without approximations...
>
>
>
>
>  Best model: Regression with ARIMA(3,1,2)            errors
>
> >
> > summary(modArima)
> Series: y_ts
> Regression with ARIMA(3,1,2) errors
>
> Coefficients:
>           ar1     ar2     ar3      ma1      ma2      ipca  cambior   juros
 r
>       -0.5219  0.1274  0.1394  -0.1957  -0.5428  243.3474   8.9225  -0.832
 2
> s.e.   0.2295  0.0984  0.0760   0.2243   0.1757  178.2488  15.7659   0.302
 5
>          pibr
>      -79.2480
> s.e.   16.1145
>
> sigma^2 = 96.95:  log likelihood = -1052.1
> AIC=2124.21   AICc=2125.01   BIC=2160.73
>
> Training set error measures:
>                      ME     RMSE     MAE       MPE     MAPE      MASE
 ACF1
> Training set -0.5813905 9.672545 7.56493 -1.271905 7.093288 0.6961435 -0.0
 01880218
 >
 > autoplot(residuals(modArima))
```




```
> #Inlcuir os valores das projeções das variáves dependentes
> proj <- data.frame(
+   Data = as.Date(c("2025-12-01","2026-01-01","2026-02-01","2026-03-01","2026-04-01","2026-05-01","2026-06-01")),
+   IPCA   = c(7403.29, 7427.72, 7452.23, 7476.82, 7501.50, 7526.25, 7551.09),
+   CAMBIOR= c(2.453515558, 2.537841048, 2.602393728, 2.668588373, 2.73646675, 2.806071685, 2.877447096),
+   JUROSR = c(10.20525609, 10.10967102, 11.18526807, 11.44018125, 11.55132948, 11.47351561, 11.37353308),
+   PIBR   = c(361073.9963, 369920.3092, 378983.3568, 388268.449, 397781.026, 407526.6611, 417511.0643)
+ )
>
> # âncoras (último observado da amostra usada)
> last_IPCA   <- tail(df$IPCA[ok], 1)
> last_CAMBIO <- tail(df$CAMBIOR[ok], 1)
> last_JUROSR <- tail(df$JUROSR[ok], 1)
> last_PIBR   <- tail(df$PIBR[ok], 1)
>
> # transformar cenário para o xreg do modelo
> ipca_f    <- diff(log(c(last_IPCA,   proj$IPCA)))
> cambior_f <- diff(log(c(last_CAMBIO, proj$CAMBIOR)))
> jurosr_f  <- diff(c(last_JUROSR, proj$JUROSR))
> pibr_f    <- diff(log(c(last_PIBR,   proj$PIBR)))
```

```
>
> expected_modArima <- cbind(
+   ipca     = ipca_f,
+   cambior = cambior_f,
+   jurosr  = jurosr_f,
+   pibr    = pibr_f
+ )
> view(expected_modArima)
```

	IPCA	CAMMBIOR	JUROSR	PIBR
1	0.003294499	0.02056673	-0.36056377	0.02420469
2	0.003294452	0.03379182	-0.09558507	0.02420469
3	0.003294369	0.02511795	1.07559705	0.02420469
4	0.003294251	0.02511795	0.25491318	0.02420469
5	0.003295433	0.02511795	0.11114823	0.02420469
6	0.003293909	0.02511795	-0.07781387	0.02420469
7	0.003295014	0.02511795	-0.09998253	0.02420469

```
> myforecast=forecast(modArima,xreg=expected_modArima,level=c(95),h=7)
> print(summary(myforecast))

Forecast method: Regression with ARIMA(3,1,2) errors

Model Information:
Series: y_ts
Regression with ARIMA(3,1,2) errors

Coefficients:
          ar1     ar2     ar3      ma1      ma2      ipca   cambior
jurosr
      -0.5219  0.1274  0.1394  -0.1957  -0.5428  243.3474    8.9225  -
0.8322
s.e.   0.2295  0.0984  0.0760   0.2243   0.1757  178.2488   15.7659
0.3025
          pibr
      -79.2480
s.e.   16.1145

sigma^2 = 96.95:  log likelihood = -1052.1
AIC=2124.21   AICc=2125.01   BIC=2160.73

Error measures:
                         ME      RMSE      MAE        MPE      MAPE       MASE
ACF1
```

```
Training set -0.5813905 9.672545 7.56493 -1.271905 7.093288 0.6961435 -
0.001880218

Forecasts:
         Point Forecast     Lo 95    Hi 95
Dec 2025       83.69506 64.39684 102.9933
Jan 2026       84.60799 64.55516 104.6608
Feb 2026       84.84980 64.26275 105.4368
Mar 2026       83.42695 61.98410 104.8698
Apr 2026       84.95220 63.26168 106.6427
May 2026       84.28782 62.08264 106.4930
Jun 2026       84.62064 62.08975 107.1515
```

```
> autoplot(myforecast)
```