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288

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IMPLICATIONS OF MARKET AND POLITICAL POWER INTERACTIONS FOR GROWTH AND THE BUSINESS CYCLE I: PRIVATE SECTOR EQUILIBRIUM

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Abstract

In this paper, we develop a two sector DSGE model with market and political power interactions. These interactions are motivated by the politico-economic systems of several South European countries, over the last half century. In these countries the state permits the existence of industries, typically related to the extended public sector, where firms and workers employed therein have market power (insiders), unlike other firms and workers in the economy (outsiders), as insiders, that dominate the major political parties, cooperate to influence government decisions, including those that pertain to the very existence of such a politico-economic system. Consistently with stylized facts of growth and the business cycle of these countries, the model predicts: (i) large negative deviations of per capita GDP from what these countries would have been capable of, if their politico-economic system was not characterized by the above mentioned frictions; and (ii) deeper and longer recessions in response to negative shocks, as their politico-economic system reacts so as to amplify these shocks.

JEL- classification: E20, E32, H42, J51, P16

Keywords: Growth, Business Cycles, Southern European Economies, Insiders-Outsiders, Politico-economic Equilibrium, Amplification Effect

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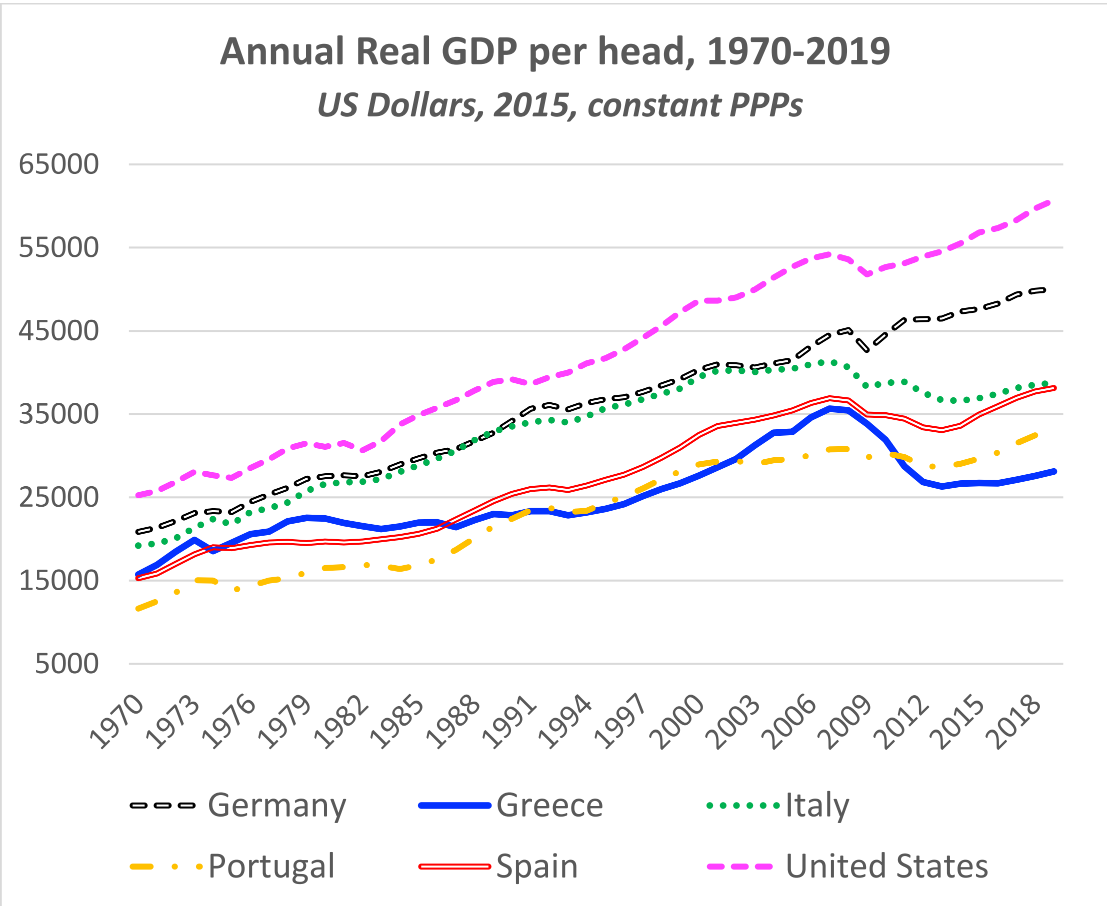
1. Introduction

Plotted in Figure A.1 are the paths of annual real per capita GDP of four Southern European countries, Portugal, Spain, Italy and Greece, along with that of the United States and Germany, from 1970 to 2019.[1] As is evident to the naked eye, the real per capita GDP paths of the United States and Germany on the one hand and that of the Southern European countries on the other hand do not seem to converge. This characteristic is surprising on at least two counts. First, as these are countries with similar institutions and, on a per capita basis, similar resources, standard growth theory would have predicted that, over this half a century long period, the real per capita GDP of the Southern European countries would have converged to a large extent to those of the United States and Germany.

Figure A.1

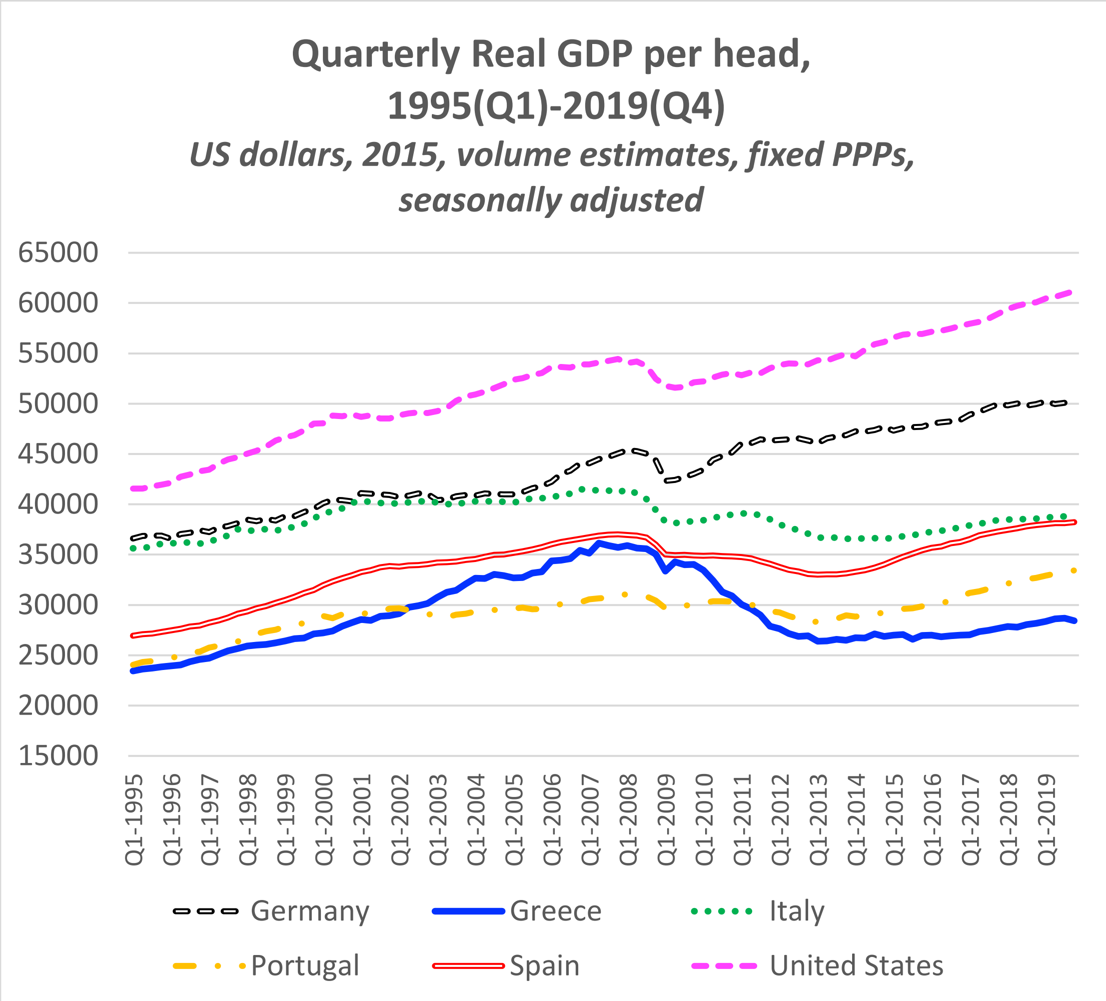


Second, the apparent non convergence to Germany is even more problematic, as the European Investment and Structural Fund programs transferred relatively large amounts of

[1] All data used in Figures 1 and 2 and Table A.1 are from OECD National Accounts.

financial capital from the richer European countries, such as Germany, to the poorer Southern European countries.[2] And, economic policy consensus behind the design of these European Investment and Structural Fund programs, was that they would help the convergence with the richer European countries, such as Germany.

Figure A.2



Now, plotted in Figure A.2 are the quarterly real per capita GDP of the abovementioned countries, from 1995Q1 to 2019Q4. Focusing on the second part of this period, it is evident that the Great Recession lasted considerably more and was deeper in Portugal, Spain, Italy and Greece, than in Germany and the United States.[3] Specifically, as the fourth row of Table A.1 indicates, it took 12 and 23 months for the real per capita GDP of Germany and the United

[2] See, e.g, the European Commission, European Structural & Investment Funds website for information on benefits from ESIF funding over the period 2014-20 (https://cohesiondata.ec.europa.eu/countries).

[3] By Great Recession, here, we mean the sharp decline in the level of economic activity that occurred in 2008 and 2009 in the USA and spread out to most of the rest of the world, thereafter.

States, respectively, to equal or surpass the level it reached prior to the beginning of the Great Recession. But it took Portugal and Spain 37 and 39 months, respectively, to see their per capita GDP return to its pre Great Recession level. Even, more strikingly, in Greece and Italy real per capita GDP had not returned to its pre Great Recession level by the end of 2019. That is, 141 months after the beginning of this recession. Moreover, as the fifth row of Table 2 indicates, from peak to trough real per capita GDP lost 7% and 5% in Germany and the United States, respectively. But, it lost 27, 12, 9 and 11 percentage points in Greece, Italy, Portugal and Spain, respectively.

TABLE A.1: BUSINESS CYCLE FACTS OF THE GREAT RECESSION:
Quarterly Real GDP per head: 2007(IV) -2019(IV)

	Germany	**Greece**	**Italy**	**Portugal**	**Spain**	**USA**
peak quarter	2008(I)	2008(I)	2008(I)	2007(IV)	2007(IV)	2007(IV)
back to previous peak quarter	2011(I)	x*	x*	2017(I)	2017(III)	2013(III)
quarters from peak to peak	12	> 49**	> 49**	37	39	23
trough quarter	2009(I)	2013(I)	2014(IV)	2012(IV)	2013(I)	2009(II)
change from peak to trough	-7%	-27%	-12%	-9%	-11%	-5%

Notes: * Real GDP per head did not return to its previous peak quarter level, before the end of 2019; ** More than 49 quarters

There is no doubt that there are many contributors to these dismal economic growth and business cycle facts; especially, if we examine independently any particular Southern European country. And, there is also no doubt that these facts have grave implications for society and European cohesion.[4] For, they make clear that countries with different politico-economic structure have different propagation mechanisms such that shocks, brought about by common monetary and or fiscal policies, will not, in general, have the same effects across the Euro area countries.

[4] These implications are highlighted in the literature on European integration (see, e.g., Blanchard (2004), Alesina and Giavazzi (2004)).

In this paper we focus on a potential contributor that is not usually mentioned as such in the growth and business cycle literatures – the market and political power interactions that characterize the politico-economic system of Southern European countries. In particular, in this paper, based on Kollintzas et al. (2018a), we introduce market and political power interactions, that resemble the politico-economic structure of these South European countries, in a dynamic stochastic general equilibrium model (DSGE), to investigate the effects of these interactions on economic growth and the business cycle.

Our motivation to construct such a model in order to characterize the growth and business cycle behavior of the South European economies, is based on several facts as well as the political science literature. First, it is well documented that Southern European countries feature not only a relatively large public sector, but also a large part of their GDP is produced by firms that are allowed to possess considerable market power.[5] Notable examples are energy utilities, water and sewage utilities, phone networks, garbage disposal utilities, road networks, road, rail and sea transport companies, airports and seaports, oil refineries, natural gas networks, banks and insurance companies. Second, the industries these firms operate are not only non-competitive in their output market, but they are also non-competitive in their labor market, where employees are organized in powerful labor unions. The latter, typically, bargain directly or indirectly with the firms in the corresponding industry for wages, employment, and an assortment of benefits for their members, including job protection. What is important here is that these bargaining agreements are made independently of each other and for that matter do not internalize the profound adverse effects for the economy as a whole.[6] For example, relatively high wages in the energy sector tend to increase costs for the competitive as well as the uncompetitive industries, affecting total factor productivity and overall competitiveness. [7] It is worth noting that such a strategic interdependence does not happen in Anglo-Saxon countries, because, there, unions have little market power. And, does not happen in the Scandinavian countries and Germany, where, although strong, unions and associated business interests work together, thereby taking account of possible negative effects of their decisions on the rest of society. This inefficient type of capitalism survives for

[5] See, e.g., Chapter 1 of the "Industrial Relations in Europe 2012" – an extensive report of the European Commission (2013) - that places the Southern European countries in the industrial relations system cluster, referred to as "state-centered." And, in Chapter 3, the same cluster of countries is identified when it comes to public sector industrial relations.

[6] See, e.g., Sections 3.5.2 and 3.9 in European Commission (2013), European Commission (2014), and Visser (2013).

[7] Kollintzas et al. (2018b) present evidence that in South Europe public sector wage are high relative to a representative group of OECD countries and that these premia have a negative effect on growth and the business cycle, that works through total factor productivity.

it is in a symbiotic relation with the political system. For, in South Europe, the powerful unions and their strategic business allies cooperate in the major political parties and government so as maintain and promote this arrangement.[8] This can also explain the relatively high levels of government spending and financial needs, observed in these countries. This kind of interaction between market and political powers has been emphasized in the political science literature. Schmitter (1977), Sargent (1985), and Cawson (1986) introduced the concept of a "neo-corporatist" state, whereby there is an institutional complementarity between market organizations, where wage premia favour individual groups of society and the political system, where these groups influence government, for their collective benefit. And, more important for our purposes, is the realization, also in the political science literature, that in South Europe, this complementarity is related to the protected greater public sector (e.g., Molina and Rhodes (2007)).[9]

Thus motivated, we construct a model that synthesises the insiders-outsiders labor market of Lindbeck and Snower (2001) and the political economy concept of a hybrid government (Person and Tabellini (2002)), that to a varying degree is influenced by the labor market insiders. The underlying model we use to carry out this synthesis, is similar to Cole and Ohanian (2004). Their model is a two sector DSGE model – a cartel sector and a competitive sector coupled with a non-competitive and a competitive labor market, respectively. In their seminal paper, they showed that the New Deal policies, put in place as a response to the Great Depression in the United States, that allowed for workers to bargain for higher wages and non-competitive firms to have higher markups, deepened and prolonged the Great Recession in the United States, considerably. Like Cole and Ohanian (2004), our model features a non-competitive sector coupled with a non-competitive labor market and a competitive sector coupled with a competitive labor market. In particular, outsiders form a group of workers that supply labor to the industries of a competitive sector. And, insiders are workers organized in independent unions that supply labor to a number of monopolistic industries that constitute the insiders' sector. In both models, prices, output and capital in insiders' industries is determined by a Nash bargaining contract. And, in both models there is complete household insurance. In Cole and Ohanian (2004), the share of non-competitive industries in the economy is fixed and the number of insiders is characterized by a trade-off

[8] Kollintzas et al. (2018b), examining the effects of a comprehensive list of factors that characterize state protection and collective bargaining on public sector wage premia, find that the degree of state protection and the degree of independence in wage setting agreements correlate positively with public sector wage premia.

[9] This literature relates to the so called "Varieties of Capitalism" literature, pioneered by Esping-Andersen (1990) and Hall and Soskice (2001).

between higher wages and higher unemployment (i.e., search equilibrium). In this case, the fraction of insiders' industries is decided by government, given the behavior of all agents in the economy. That is, the share of insiders' industries in the economy is part of the Ramsey allocation, under the assumption, as already mentioned, of the Person and Tabellini (2002) hybrid government objective function. This particular function reflects median voter preferences, as well as the preferences of all insiders' unions. Our conjecture is that the solution to the problem of the Ramsey planner, called politico-economic equilibrium, will be characterized by a greater share of insiders' industries compared to the politico-economic equilibrium corresponding to the standard median voter case, that would not have permitted any insiders.[10] We take the view that Southern European economies operate in such a politico-economic equilibrium. The investigation of the workings of this equilibrium is the subject of a companion paper. In this paper we carry out the tasks necessary to set the stage for a well-defined, suitable Ramsey government problem.

The private sector equilibrium, given government policy, including the share of insiders' industries in the economy, is characterized by an output price markup and a wage premium for insiders over outsiders, in all insiders' industries. This implies lower output and lower capital and labor inputs than what would have been the case if insiders' industries were competitive. As different industry outputs are partial complements, the lower output in all insiders' industries lowers the demand for the output of all outsiders' industries, lowering aggregate output. Furthermore, any strictly positive share of insiders' industries in the economy results in a higher output share of government spending, reflecting the costly adjustment and maintenance of the politico-economic system, further increasing misallocation vis a vis a politico-economic system with no insiders. The combined political, misallocation, and fiscal distortion effects imply that steady state GDP per head of the model economy will be lower than what would had been the case without the underlying frictions. This is what explains the relatively low growth rate of the South European economies.

The relatively low per capita GDP along the steady states implied by the private sector equilibrium (PSE), given policy, along with the fact that the larger the three effects mentioned above the lower the steady state per capita GDP, can also explain the deeper and longer recessions associated with a greater share of insiders' industries, along the lines suggested by

[10] Strictly speaking the term Ramsey allocation characterizes the solution to a social planner's problem that seeks to maximize the welfare of households. In our set up, the planner is a government that its objective function is a hybrid of the welfare of households and the sum of the objective functions of all insiders' unions. For that matter, it seems more appropriate to use the term politico-economic equilibrium.

Cole and Ohanian (2004). In addition, the frictions associated with market and political power interactions should affect the economy's shock propagation mechanism. Finally, the shock propagation mechanism of the politico-economic equilibrium, where the share of insiders' industries is endogenous will be most likely different than the private sector equilibrium given policy, as insiders try to avoid painful adjustments. In this paper, we shall limit our analysis to the first two reasons the economy's shock propagation mechanism may give deeper and longer recessions.[11]

The plan of this paper has as follows: In Section B we present the model. This is a two sector DSGE model to which we refer as the detailed economy. In addition to distortionary taxation, the model involves three more frictions: (a) monopolistic producers in insiders' industries, (b) Nash bargaining between the union and the corresponding producer in each one of the insiders' industries, and (c) resources are required to maintain and adjust the fraction of insiders' industries in the economy. This section is divided in four parts. In Part B.I we characterize the preferences, constraints and behavior of economic agents. Also, in this section we characterize the Nash bargaining contract between unions and firms in insiders' industries. In Part B.II, we characterize the private sector equilibrium (PSE), given policy (i.e., share of insiders' industries, capital and labor taxes and the share of government expenditures). It is shown that the PSE can be characterized solely in terms of the aggregate economy variables (i.e., no need for the industry/sector variables). Also, in this part we characterize analytically the steady state of the PSE. In Section B.III, we follow the Chari – Kehoe - McGrattan methodology in showing that the model economy (or detailed economy) corresponds to a prototype economy (i.e., the canonical RBC economy with distortionary capital and labor taxation), with equilibrium conditions being distorted by four wedges. Then, we show that under a particular set of restrictions, these wedges imply distortions that increase with the share of insiders' industries. In addition, in this part, we discuss the static and dynamic efficiency implications of the wedges. Section C, has three parts. In Part C.I we assign parameter values. The assigned parameter values and the values for the policy instruments correspond to standard values used in the DSGE and RBC literature. We think of USA as a benchmark for the parametrization of the prototype model while Southern European countries serve as our reference point for the parameterization of the detailed economy. In Part C.II, we compute steady state values. We compare the steady state of the prototype economy and that of the detailed economy and investigate the sensitivity of the latter for three different values of

[11] The last reason for deeper and longer recessions is currently being investigated in a companion paper.

the share of insiders' industries. There are important differences in these steady states, especially with respect to aggregate employment. These differences are relatively sensitive to the share of insiders' industries. We also compute the steady state values of the four wedges. The steady state values of the wedges imply that frictions increase significantly with the steady state share of insiders' industries. Finally, in Part C.III, we compute and plot, for both the detailed and prototype economies, the impulse response functions (IRFs) of the aggregate state variables, wedges, taxes and industry variables, with respect to temporary shocks in the exogenous parts of TFP, government spending, the share of insiders' industries and the capital income tax rate. And, in the case of the detailed economy, we do so for steady states corresponding to three different values the share of insiders' industries.

The main quantitative theory results can be summarized as follows: (i) The steady state output per capita of the detailed economy is lower compared to that of the prototype economy. (ii) The consumption share of GDP is similar in the detailed and the prototype economies, while comparing the remaining great ratios (capital–output ratio, employment, investment share of GDP) between the detailed and the prototype economies, these are close but always smaller in the detailed economy, with employment characterized by the sharpest difference. (iii) The government spending share of GDP and the labor income tax rate are higher than the corresponding figures of the prototype economy. (iv) Differences (i)-(iii) mirror corresponding differences in the capital, labor, efficiency and government wedges. (v) Differences (i)-(iii) are sharper the larger is the share of insiders' industries. (vi) Differences (i)-(iii) are sensitive to the degree of monopoly power in insiders' industries (i.e., how close substitutes are the products of different insiders' industries and how close substitutes are the aggregate products of the insiders' and outsiders' sectors) and the combination of union relative bargaining power and the degree of union preferences for the wage premium over union employment. (vii) The impulse response functions of the endogenous variables to temporary changes in the exogenous variables in the prototype and detailed economies are qualitatively similar. (viii) The graphs of the IRFs of output, consumption, investment and employment with respect to an exogenous negative productivity shock lie lower than the corresponding graphs of the prototype economy, but the underlying quantitative differences are small. (ix) The IRFs of output, consumption, investment and employment with respect to an (exogenous) temporary increase in the share of insiders' industries are negative and quantitatively significant. (x) To a great extent the properties of the IRFs described in (vii) – (ix) emanate from properties of the

IRFs of the four wedges. (xi) In addition to (viii), there is a second amplification effect, since distortionary taxation has a stronger effect on the detailed rather than the prototype economy.

2. Model

The economy consists of a large number of identical households whose members supply labor and capital services to firms and consume and invest in a final good. This final good that can either be consumed or invested, is produced by means of physical capital and labor services, as well as the services of a number of intermediate goods produced in two sectors: the insiders' sector and the outsiders' sector.

2.1. Economic agents and their behavior

2.1.1. Final good producers

Production technology:

Production in the final good sector takes place in a large number of identical firms. The production technology of the representative firm in this sector is characterized by a CES production function of the form:

$$y_t = A_t\left[\chi_t\left(\mathrm{Y}_t^i\right)^{\phi} + (1-\chi_t)\left(\mathrm{Y}_t^o\right)^{\phi}\right]^{(1/\phi)}, \quad t \in \mathbb{N}_+ \tag{I.1}$$

where:

y_t : output of representative final good producer in period t

Y_t^i : composite input of intermediate goods produced in the insiders' sector

Y_t^o : composite input of intermediate goods produced in the outsiders' sector

A_t : (static) total factor productivity

χ_t : share of insiders' industries in the economy

$\frac{1}{1-\phi}$: input elasticity of substitution across sectors

Composite inputs are defined by the Dixit-Stiglitz aggregator functions:

$$\mathrm{Y}_t^i = \left[\int_0^{\chi_t} y_t^i(\varsigma)^\theta d\varsigma \right]^{(1/\theta)} \quad ;\theta \in (0,1) \tag{I.2}$$

$$\mathrm{Y}_t^o = \left[\int_{\chi_t}^{1} y_t^o(\varsigma)^\theta d\varsigma \right]^{(1/\theta)} \tag{I.3}$$

where:

$y_t^i(\varsigma)$: input of the intermediate good of the ς industry in insiders' sector

$y_t^o(\varsigma)$: input of the intermediate good of the ς industry in outsiders' sector

$\frac{1}{1-\theta}$: aggregation elasticity of substitution across industries

Following Cole and Ohanian (2004), we assume that there is continuum of intermediate good products indexed by ς; and that ς takes values in the unit interval. Accordingly, we assume that each intermediate good product is produced in a single industry, so that industries are also indexed by ς.[12]

***Profits*:**

The representative final good producer's (real) profits are given by:

$$\pi_t^y = y_t - \int_0^{\chi_t} p_t^i(\varsigma) y_t^i(\varsigma) d\varsigma - \int_{\chi_t}^{1} p_t^o(\varsigma) y_t^o(\varsigma) d\varsigma \tag{I.4}$$

where:

$p_t^i(\varsigma)$: real price of the intermediate good of the ς industry in the insiders' sector

$y_t^o(\varsigma)$: real price of the intermediate good of the ς industry in the outsiders' sector

[12] In Cole and Ohanian (2004), the variable that corresponds to χ_t (i.e., the relative size of the "cartel" sector in their model) is a constant. In this model, χ_t is an endogenous random variable. In Kollintzas et al. (2018), the variable that corresponds to χ_t (i.e., the number of insiders' industries in their model), is a non-stochastic variable.

***Behavior*:**

Final good producers behave competitively in all markets. The representative final good producer chooses output and inputs so as to maximize profits, (I.4), subject to the technology constraints (I.1) - (I.3). The necessary and sufficient conditions for profit maximization are:

$$p_t^i(\varsigma) = \Gamma_t^i y_t^i(\varsigma)^{(\theta-1)} \tag{I.5}$$

$$p_t^o(\varsigma) = \Gamma_t^o y_t^o(\varsigma)^{(\theta-1)} \tag{I.6}$$

where:

$$\Gamma_t^i \equiv \chi_t A_t^\phi y_t^{(1-\phi)} Y_t^{i(\phi-\theta)} \tag{I.7}$$

$$\Gamma_t^o \equiv (1-\chi_t) A_t^\phi y_t^{(1-\phi)} Y_t^{o(\phi-\theta)} \tag{I.8}$$

2.1.2. Intermediate good producers in the outsiders' sector

***Production technology*:**

Production in any given industry of the outsiders' sector takes place in a large number of identical firms. These firms are producing output using capital and labor services, that they rent from households. The production technology of the representative firm in the $\varsigma \in (\chi_t, 1]$ industry is characterized by a Cobb-Douglas production function of the form:

$$y_t^o(\varsigma) = B_t^o k_t^o(\varsigma)^\alpha l_t^o(\varsigma)^{(1-\alpha)}; \alpha \in (0,1) \tag{I.9}$$

where:

$k_t^o(\varsigma)$: capital input

$l_t^o(\varsigma)$: labor input

B_t^o : total factor productivity in outsiders' industries

α : capital input elasticity

Profits:

The (real) profits of the representative firm in the $\varsigma \in (\chi_t, 1]$ industry of the outsiders' sector are given by:

$$\pi_t^o(\varsigma) = p_t^o(\varsigma) y_t^o(\varsigma) - r_t k_t^o(\varsigma) - w_t^o l_t^o(\varsigma) \qquad \text{(I.10)}$$

where:

r_t : real rental cost of capital

w_t^o : real wage rate of outsiders

Technical progress:

We assume labor augmenting technical progress at a constant growth rate $(1+\eta)$. Thus, output, capital input and the wage rate are expressed in efficient household units and labor input is expressed in household units.

Behavior:

Intermediate good producers in all industries of the outsiders' sector behave competitively in all markets. The representative intermediate good producer in the ς industry of the outsiders' sector chooses output and inputs so as to maximize profits, given by (I.10), subject to the technology constraint (I.9). The necessary and sufficient condition for profit maximization are:

$$r_t = \alpha \frac{p_t^o(\varsigma) y_t^o(\varsigma)}{k_t^o(\varsigma)} \qquad \text{(I.11)}$$

$$w_t^o = (1-\alpha) \frac{p_t^o(\varsigma) y_t^o(\varsigma)}{l_t^o(\varsigma)} \qquad \text{(I.12)}$$

<u>Remark 1</u>: *It follows that* $\left(p_t^o(\varsigma), y_t^0(\varsigma), k_t^o(\varsigma), w_t^o(\varsigma), l_t^o(\varsigma), \pi_t^o(\varsigma)\right)$ *is the same for all* $\varsigma \in (\chi_t, 1]$. *Henceforth, we denote the common value of this vector by* $\left(p_t^o, y_t^o, k_t^o, w_t^o, l_t^o, \pi_t^o\right)$. *And, clearly,* π_t^o *=0.*

2.1.3 Intermediate good producers in the insiders' sector

***Production technology*:**

We assume the same type of production technology as in the industries of the outsiders' sector. That is:

$$y_t^i(\varsigma) = B_t^i k_t^i(\varsigma)^{\alpha} l_t^i(\varsigma)^{(1-\alpha)} \tag{I.13}$$

where:

B_t^i : total factor productivity in insiders' industries

***Profits*:**

In each industry of the insiders' sector, there is one producer and one labor union. The profits of the $\varsigma \in (0, \chi_t]$ producer in the insiders' sector is given by:

$$\pi_t^i(\varsigma) = p_t^i(\varsigma) y_t^i(\varsigma) - r_t k_t^i(\varsigma) - w_t^i(\varsigma) l_t^i(\varsigma) \tag{I.14}$$

where:

$w_t^i(\varsigma)$: real wage rate in the ς industry of the insiders' sector

***Behavior*:**

Union preferences are characterized by a utility function of the form:

$$u_t^i(\varsigma) = \left[w_t^i(\varsigma) - w_t^o \right]^{\lambda} \left[l_t^i(\varsigma) \right]^{(1-\lambda)} ; \lambda \in (0,1) \tag{I.15}$$

where:

λ : preference intensity of wage premium over union membership / employment

Behavior in each industry of the insiders' sector is defined as follows:

The producer behaves like a monopolist, setting the output price subject to the (inverse) demand function (I.5) and output and inputs are constrained by the production technology (I.13).

Both the producer and the union in each industry of the insiders' sector take as given: the economy and insiders' sector aggregates y_t and Y_t^i, respectively; the real rental cost of capital and the real wage rate in the outsiders' sector, r_t and w_t^o, respectively; and the fraction of insiders' industries in the economy, χ_t.

Further, behavior in any given industry ς of the insiders' sector, is characterized by a two-stage game, whereby:

(i) In the first stage, the producer and the union agree upon a wage–employment Nash bargaining contract:

$$\left(w_t^i(\varsigma)^*, l_t^i(\varsigma)^*\right) = \underbrace{argmax}_{\left(w_t^i(\varsigma), l_t^i(\varsigma)\right)} \left\{\left[u_t^i(\varsigma) - \bar{u}_t^i(\varsigma)\right]^{\mu} \left[\pi_t^i(\varsigma) - \bar{\pi}_t^i(\varsigma)\right]^{1-\mu}\right\}; \mu \in (0,1) \qquad \text{(I.16)}$$

$\bar{u}_t^i(\varsigma)$: union's reservation option

$\bar{\pi}_t^i(\varsigma)$: producer's reservation option

μ : union's relative bargaining power

(ii) in the second stage, the producer chooses capital input, so as to maximize profits associated with the wage rate and employment determined in the first stage:

$$k_t^i(\varsigma)^* = \underbrace{\arg\max}_{k_t^i(\varsigma)} \left(\Gamma_t^i \left\{ B_t^i k_t^i(\varsigma)^{\alpha} \left[l_t^i(\varsigma)^* \right]^{(1-\alpha)} \right\}^{\theta} - r_t k_t^i(\varsigma) - \left[w_t^i(\varsigma)^* \right]\left[l_t^i(\varsigma)^* \right] \right) \qquad \text{(I.17)}$$

Finally, we assume that if there is no contract:

(i) union members can work in the industries of the outsiders' sector for w_t^o, so that $\bar{u}_t^i(\varsigma) = 0$

(ii) the producer can operate in the industries of the outsiders' sector, earning π_t^o, so that $\bar{\pi}_t^i(\varsigma) = 0$.

The following proposition characterizes the industry variables in any given industry in the insiders' sector:

Proposition 1: *Provided that:*

[R1] $\lambda < \frac{(1-\alpha\theta)}{(1-\alpha\theta)+(1-\theta)} + \frac{(1-a)\theta}{(1-\alpha\theta)+(1-\theta)}\left(\frac{1-\mu}{\mu}\right)$,

behavior in any given insiders' industry $\varsigma \in (0, \chi_t]$ *is such that:*

$$r_t = \alpha\theta \frac{p_t^i(\varsigma) y_t^i(\varsigma)}{k_t^i(\varsigma)} \tag{I.18}$$

$$w_t^i(\varsigma) = (1-\alpha)\nu\xi \frac{p_t^i(\varsigma) y_t^i(\varsigma)}{l_t^i(\varsigma)} \tag{I.19}$$

$$\frac{w_t^i(\varsigma)}{w_t^o} = \nu \tag{I.20}$$

$$\pi_t^i(\varsigma) = \kappa p_t^i(\varsigma) y_t^i(\varsigma) \tag{I.21}$$

where:

$$\kappa \equiv 1-\alpha\theta-(1-\alpha)\nu\xi > 0 \tag{I.22}$$

$$\nu \equiv \frac{1}{1-\frac{(1-\theta)\lambda}{(1-\alpha\theta)(1-\lambda)+(1-\alpha)\theta\left(\frac{1-\mu}{\mu}\right)}} > 1 \tag{I.23}$$

$$\xi \equiv \frac{(1-\alpha)\theta + \left\{1-\alpha\theta-[(1-\alpha\theta)+(1-\theta)]\lambda\right\}\left(\frac{\mu}{1-\mu}\right)}{(1-\alpha)\left[1+(1-\lambda)\left(\frac{\mu}{1-\mu}\right)\right]} > 0 \tag{I.24}$$

Proof: In the Mathematical Appendix.

<u>Remark 2</u>: *It follows that* $\left(p_t^i(\varsigma), y_t^i(\varsigma), k_t^i(\varsigma), w_t^i(\varsigma), l_t^i(\varsigma), \pi_t^i(\varsigma)\right)$ *is the same for all* $\varsigma \in (0, \chi_t]$. *Henceforth, we denote the common value of this vector by* $\left(p_t^i, y_t^i, k_t^i, w_t^i, l_t^i, \pi_t^i\right)$.

Remark 3: *Restriction **[R1]** is a joint restriction on the relative union preferences for the wage premium over union membership, union bargaining power, and production technology. It ensures that the maximand defining the Nash bargaining contract is strictly concave over the interior of the subset of the wage premium – employment space, defined by the union and firm participation constraints.*[13] *And, its economic implications are that the wage premium, employment, and profits in insiders' industries are strictly positive. Moreover, as (I.23) implies, the wage premium in insiders' industries is larger: the greater the relative bargaining power of the unions,* $\left(\frac{\mu}{1-\mu}\right)$*; and, the stronger the preference intensity of the unions for the wage premium over employment,* λ*. On the contrary, as (I.22) implies, the revenue share of insiders' industries profits is larger: the smaller the relative bargaining power of the unions,* $\left(\frac{\mu}{1-\mu}\right)$*; and, the weaker the preference intensity of the unions for the wage premium over employment,* λ*.*

2.1.4. Households

***Flow Budget Constraint*:**

Households' income sources consist of wages and rents from labor and capital services provided to the intermediate goods sectors and profits from insiders' industries. They use their income to buy the final good that they turn to consumption and investment. Now, given that behaviour in all insiders' and outsiders' industries is characterized by symmetry (i.e., the results highlighted in Remarks 1 and 2), the representative household's flow budget constraint is given by:

$$c_t + (1+\eta)k_{t+1} \leq [1+(1-\tau_t^K)(r_t - \delta)]k_t + (1-\tau_t^L)[\chi_t w_t^i h_t^i + (1-\chi_t)w_t^o h_t^o + \chi_t \pi_t^i]; \ \delta \in (0,1) \qquad \text{(I.25)}$$

where,

c_t: (final good) consumption

k_t: capital stock at the beginning of period t

$\chi_t h_t^i$: labor supply to the insiders' sector

[13] When the bargaining power of the union equals that of the firm, the economic meaning of ***[R1]*** is equivalent to the well known condition that in the efficient contract: the union indifference curve is tangent to the firm's (inverse) demand for labor. See, e.g., Oswald (1982).

$(1-\chi_t)h_t^o$: labor supply to the outsiders' sector

$\chi_t \pi_t^i$: dividends from outsiders' industries

τ_t^K : capital income tax rate

τ_t^L : labor income tax rate

δ : fixed (geometric) capital depreciation rate

***Time Constraint*:**

Again, given that behaviour in all insiders' and outsiders' industries is characterized by symmetry (i.e., the results highlighted in Remarks 1 and 2), the time constraint of the representative household is given by:

$$\chi_t h_t^i + (1-\chi_t)h_t^o = h_t \leq 1 \qquad \text{(I.26)}$$

where:

h_t : fraction of available household time devoted to work

$1-h_t$: fraction of available household time devoted to leisure

Rationing Constraint:

Since, given ***[R1]***, $w_t^i > w_t^o$, households prefer to supply labor in the insiders' sector. But, in such a case there would be no outsiders' sector. For that matter, we need to impose a rationing constraint in insiders' industries to the effect that the supply of labor in insiders' industries is restricted to be less than the corresponding demand for labor.[14] That is,

$$h_t^i \leq l_t^i \text{ (given)} \qquad \text{(I.27)}$$

[14] Since l_t^i is also union membership, (I.27) could be interpreted as a constraint imposed by unions. Alternatively, we could introduce unemployment as in Cole and Ohanian (2004), so that the expected value of the wage rate in the insiders' sector is equal to the wage rate in the outsiders' sector, while $\chi_t(l_t^i - h_t^i)$ represents unemployment.

***Physical Constraints*:**

$$c_t, 1-h_t, h_t^i, h_t^o, k_{t+1} \geq 0 \tag{I.28}$$

Preferences

Household preferences are characterized by a time separable lifetime expected utility function of the form:

$$U_0^h \equiv E_0 \sum_{t=0}^{\infty} \beta^t u_t^h \tag{I.29}$$

where:

$$u_t^h = \frac{[c_t^{\vartheta}(1-h_t)^{1-\vartheta}]^{1-\gamma}}{1-\gamma}; \gamma > 0 \tag{I.30}$$

$\beta \in (0,1)$ is the efficient household constant discount factor

$1/\gamma$ is the intertemporal elasticity of substitution

ϑ is the preference intensity for consumption

***<u>Note</u>:** Since consumption is measured in efficient household units, the discount factor β is given by $\tilde{\beta}(1+\eta)^{\vartheta(1-\gamma)}$, where $\tilde{\beta} \in (0,1)$ is the pure discount factor of the household.*

Environment and Timeline

The economic environment is characterized by the exogenous state of the economy, z_t. The latter, in turn, is characterized by the vector of the three total factor productivities (A_t, B_t^i, B_t^o). All economic agents know z_t at the beginning of period t. In any given period t, government moves first and chooses the government policy variables, based on the information available at the beginning of the period, $z^t = \{z_v\}_{v=0}^t$. That is, $(g_t, \tau_t^K, \tau_t^L, \chi_t) = (g_t(z^t), \tau_t^K(z^t), \tau_t^L(z^t), \chi_t(z^t))$, where g_t is government consumption. Private sector economic agents move second and make their decisions, given $(g_t, \tau_t^K, \tau_t^L, \chi_t)$, based on z^t. In particular, households choose a contingency plan $\left\{c_t(z^t), h_t(z^t), h_t^i(z^t), h_t^o(z^t), k_{t+1}(z^t)\right\}_{t=0}^{\infty}$. The probability of any particular history of the exogenous state z_t, prob(z_t), is given. $E_t(\bullet)$ stands for the expectations operator, based on the information available at the beginning of period *t*, z_t. As usual in DSGE analysis, prob(z_t) will be specified indirectly, via the laws of motion of the exogenous state, later in Section C.I.

Behavior:

The representative household seeks a contingency plan $\left\{c_t(z^t), h_t(z^t), h_t^i(z^t), h_t^o(z^t), k_{t+1}(z^t)\right\}_{t=0}^{\infty}$ so as to maximize U_0^h, subject to (I.37)-(I.40) and the initial condition $k_0 \in (0,\infty)$ given.

Then, any solution to the household problem is such that constraints (I.25) - (I.27) are satisfied with equality, the physical constraints (I.28) are satisfied with strict inequality, and together with these constraints and the initial condition, $k_0 \in (0,\infty)$ *given*, the following conditions form a set of necessary and sufficient conditions for a solution to the household's problem:

Intratemporal condition:

$$\frac{\vartheta(1-\tau_t^L)w_t^o}{c_t} = \frac{1-\vartheta}{1-h_t} \tag{I.31}$$

Euler condition:

$$\frac{u_t}{c_t} = \frac{\beta}{(1+\eta)} E_t \left\{ \frac{u_{t+1}}{c_{t+1}} [1+(1-\tau_{t+1}^K)(r_{t+1}-\delta)] \right\} \tag{I.32}$$

Transversality condition:

$$\beta^T E_0 \frac{u_T k_{T+1}}{c_T} \to 0 \; as \; T \to \infty \tag{I.33}$$

<u>Remark 4</u>: *The necessity of the transversality condition follows from the nature of preferences and the fact that consumption and initial capital stock are strictly positive.*

2.2. Private Sector Equilibrium (PSE)

2.2.1. Definition:

Given any sequence of the exogenous state $\{z_t\}_{t=0}^{\infty}$ and any sequence of government policy variables $\left\{g_t(z^t), \tau_t^K(z^t), \tau_t^L(z^t), \chi_t(z^t)\right\}_{t=0}^{\infty}$, a private sector equilibrium is a sequence of the form: $\left\{y_t(z^t), y_t^i(z^t), y_t^o(z^t), k_t(z^t), k_t^i(z^t), k_t^o(z^t), l_t^i(z^t), l_t^o(z^t), c_t(z^t), h_t(z^t), h_t^i(z^t), h_t^o(z^t),\right.$ $\left. p_t^i(z^t), p_t^o(z^t), r_t(z^t), w_t^i(z^t), w_t^o(z^t), \pi_t^i(z^t)\right\}_{t=0}^{\infty}$, such that: (I.1)-(I.3), (I.5)-(I.6), (I.9), (I.11)-(I.13), (I.18)-(I.21), (I.25)-(I.27), (I.31)-(I.33) are satisfied, along with the market clearing conditions:

$$k_t = \chi_t k_t^i + (1-\chi_t)k_t^o \tag{II.1}$$

$$h_t^i = l_t^i \tag{II.2}$$

$$h_t^o = l_t^o \tag{II.3}$$

$$y_t = c_t + [(1+\eta)k_{t+1} - (1-\delta)k_t] + g_t \tag{II.4}$$

Equation (II.1) is the market clearing condition for capital, Equations (II.2) and (II.3) are the market clearing conditions for the insiders' and outsiders' labor markets, respectively. Equation (II.4) is the economy's resource constraint.

2.2.2. Analytic characterization of Private Sector Equilibrium

Proposition 2*: Given* ***[R1]****, the private sector equilibrium defined above has the following analytic characterization:*

(a) <u>*Sector Variables*</u>*: Outputs and inputs in the insiders' and outsiders' industries can be expressed in terms of the exogenous variables,* z_t*, the government policy variable,* χ_t *, and the aggregate state of the private sector,* $\left(k_t, h_t\right)$*, as follows:*

$$\left[\frac{\chi_t k_t^i}{(1-\chi_t)k_t^o}\right] = \theta\Delta_t(\chi_t) \tag{II.5}$$

$$(1-\chi_t)k_t^o = \frac{1}{1+\theta\Delta_t(\chi_t)}k_t \tag{II.6}$$

$$\left[\frac{\chi_t h_t^i}{(1-\chi_t)h_t^o}\right] = \xi\Delta_t(\chi_t) \tag{II.7}$$

$$(1-\chi_t)h_t^o = \frac{1}{1+\xi\Delta_t(\chi_t)}h_t \tag{II.8}$$

$$\left[\frac{\chi_t y_t^i}{(1-\chi_t)y_t^o}\right] = \left[\theta^\alpha \xi^{(1-\alpha)}\left(\frac{B_t^i}{B_t^o}\right)\right]\Delta_t(\chi_t) \tag{II.9}$$

$$(1-\chi_t)y_t^o = B_t^o\left[\frac{1}{1+\theta\Delta_t(\chi_t)}\right]^\alpha \left[\frac{1}{1+\xi\Delta_t(\chi_t)}\right]^{(1-\alpha)} k_t^\alpha h_t^{(1-\alpha)} \tag{II.10}$$

$$\left(\frac{p_t^i}{p_t^o}\right) = \frac{1}{\theta^\alpha \xi^{(1-\alpha)}\left(\frac{B_t^i}{B_t^o}\right)} \tag{II.11}$$

$$\left(\frac{w_t^i}{w_t^o}\right) = \nu = \frac{1}{1-\frac{(1-\theta)\lambda}{(1-\alpha\theta)(1-\lambda)+(1-\alpha)\theta\left(\frac{1-\mu}{\mu}\right)}} \tag{II.12}$$

where:

$$\Delta_t(\chi_t) \equiv \left[\theta^\alpha \xi^{(1-a)}\left(\frac{B_t^i}{B_t^0}\right)\right]^{\phi/(1-\phi)} \left(\frac{\chi_t}{1-\chi_t}\right)^{1+\frac{\phi}{\theta(1-\phi)}} \tag{II.13}$$

(b) *<u>Factor Prices, Profits' Share, and the Aggregate Production Function</u>: Factor prices, insiders' profits, and aggregate output can be expressed in terms of the exogenous variables,* z_t *, the government policy variable,* χ_t *and the aggregate state of the private sector,* (k_t, h_t)*, as follows:*

$$r_t = \alpha\hat{\omega}_t(\chi_t)\frac{y_t}{k_t} \tag{II.14}$$

$$w_t^o = (1-\alpha)\breve{\omega}_t(\chi_t)\frac{y_t}{h_t} \tag{II.15}$$

$$\frac{\chi_t \pi_t^i}{y_t} = \frac{\kappa \Delta_t(\chi_t)}{1+\Delta_t(\chi_t)} \tag{II.16}$$

$$y_t = \bar{\omega}_t(\chi_t) k_t^{\alpha} h_t^{(1-\alpha)} \tag{II.17}$$

where:

$$\hat{\omega}_t(\chi_t) \equiv \frac{1+\theta\Delta_t(\chi_t)}{1+\Delta_t(\chi_t)} \tag{II.18}$$

$$\breve{\omega}_t(\chi_t) \equiv \frac{1+\xi\Delta_t(\chi_t)}{1+\Delta_t(\chi_t)} \tag{II.19}$$

$$\begin{aligned} \bar{\omega}_t(\chi_t) &\equiv A_t B_t^o \frac{(1-\chi_t)^{[\theta+(1-\theta)\phi]/\theta\phi}[1+\Delta_t(\chi_t)]^{1/\phi}}{[1+\theta\Delta_t(\chi_t)]^{\alpha}[1+\xi\Delta_t(\chi_t)]^{(1-\alpha)}} \\ &= A_t B_t^o \frac{(1-\chi_t)^{[\theta+(1-\theta)\phi]/\theta\phi}[1+\Delta_t(\chi_t)]^{(1-\phi)/\phi}}{\hat{\omega}_t(\chi_t)^{\alpha}\,\breve{\omega}_t(\chi_t)^{(1-\alpha)}} \end{aligned} \tag{II.20}$$

(c) <u>Government Spending and the Aggregate State Variables:</u> Suppose that the government always runs a balanced budget, in the sense that government spending must satisfy the constraint:

$$g_t = \tau_t^K\left(r_t - \delta\right)k_t + \tau_t^L\left[\chi_t w_t^i h_t^i + (1-\chi_t)w_t^o h_t^o + \chi_t \pi_t^i\right] \tag{II.21}$$

and that government spending is defined by:

$$g_t = \left[\bar{\psi}_t + \hat{\psi}\chi_t + \frac{1}{2}\tilde{\psi}(\chi_{t+1} - \chi_t)^2\right]y_t; \quad \hat{\psi},\tilde{\psi} \geq 0\,; \tag{II.22}$$

Then, given z_t *and government policy variables* $\left(\bar{\psi}_t, \tau_t^k, \tau_t^L, \chi_t\right)$*, the laws of motion of the aggregate state of the private sector equilibrium: (i) depend only on the aggregate state of the private sector* $\left(k_t, h_t\right)$*; and (ii) they are characterized, completely, in terms of: the transversality condition (I.33); the initial condition,* $k_0 \in (0,\infty)$ *given; the resource constraint (II.4); and, the following conditions:*

$$\frac{1-\vartheta}{\vartheta}\frac{c_t}{1-h_t} = \breve{\omega}_t(\chi_t)(1-\tau_t^L)(1-\alpha)\frac{y_t}{h_t} \tag{II.23}$$

$$\frac{u_t}{c_t} = \frac{\beta}{(1+\eta)}E_t\left\{\frac{u_{t+1}}{c_{t+1}}\left[1+(1-\tau_{t+1}^K)\left[\hat{\omega}_{t+1}(\chi_{t+1})\alpha\frac{y_{t+1}}{k_{t+1}} - \delta\right]\right]\right\} \tag{II.24}$$

$$\bar{\psi}_t + \hat{\psi}\chi_t + \frac{1}{2}\hat{\psi}(\chi_{t+1} - \chi_t)^2 = \tau_t^K \left[\alpha\hat{\omega}_t(\chi_t) - \delta\left(\frac{k_t}{y_t}\right)\right] + (1-\alpha)\tau_t^L \tilde{\omega}_t(\chi_t) \qquad \text{(II.25)}$$

where:

$$\tilde{\omega}_t(\chi_t) \equiv \frac{1 + \frac{1-\alpha\theta}{1-\alpha}\Delta_t(\chi_t)}{1+\Delta_t(\chi_t)} > 1$$

Proof: In the Mathematical Appendix.

Proposition 2 has several interesting implications and several useful applications. The latter, studied in the next section, have to do with computing the steady state and the shock propagation mechanism of the PSE. The former, analysed below, emanate from the analytic characterization of the PSE which allows us to establish certain qualitative properties of the PSE. These properties help us understand the model economy and how this economy compares to DSGE model economies that are not subject to the frictions incorporated herein.

First, note that the ratio of output in insiders' industries over output in outsiders' industries will depend, in general, on the share of insiders' industries in the economy, χ_t and the ratio of the intermediate goods industry productivities, $\left(\frac{B_t^i}{B_t^0}\right)$. Note, however, that (II.9) and (II.13) imply: $\left(\frac{y_t^i}{y_t^o}\right) = \left[\theta^\alpha \xi^{(1-a)}\left(\frac{B_t^i}{B_t^0}\right)\right]^{1+\frac{\phi}{(1-\phi)}} \left(\frac{\chi_t}{1-\chi_t}\right)^{\frac{\phi}{\theta(1-\phi)}}$.

Since, $\left(1+\frac{\phi}{1-\phi}\right) > 0$, $\theta \in (0,1)$, and, given [R1], $\xi > 0$, it follows from the above equation, that, for any given level of χ_t and $\left(\frac{B_t^i}{B_t^0}\right)$, the ratio of output in insiders' industries to output in outsiders' industries will be smaller the smaller is ϕ, θ and ξ. With respect to $\phi \in (-\infty, 1)$, this mirrors the monopoly power of producers in the product market in insiders' industries. For, a smaller ϕ implies a lower elasticity of substitution across intermediate good sectors and therefore a less elastic demand facing producers in insiders' industries, allowing for higher mark-ups, higher prices, and lower outputs. With respect to θ, this also mirrors the monopoly power of producers in the product market in insiders' industries. For, a smaller θ

implies a lower elasticity of substitution across insiders' industries and therefore a less elastic demand facing the producer in each insiders' industry, allowing for a higher mark-up, higher price, and lower output. With respect to ξ, this reflects the degree by which the firm-union bargaining distortion increases wages and decreaes labor input in insiders' industries, decreasing output in these industries. To see this, observe that the size of ξ crucially depends on the size of λ, i.e. the relative intensity of union preferences for the wage premium over employment, and the relative bargaining power of unions, $\left(\frac{\mu}{1-\mu}\right)$. In particular, it follows from Proposition 1 that ξ decreases with λ and, to the extent that unions care about the wage premium more than they care about employment (i.e., $\lambda > 1/2$), also decreases with $\left(\frac{\mu}{1-\mu}\right)$.

Second, it follows from the above equation, that in the case of equal sector shares and equal levels of total factor productivities across intermediate good sector industries (i.e., $\left(\frac{\chi_t}{1-\chi_t}\right) = \left(\frac{B_t^i}{B_t^0}\right) = 1$, output in insiders' industries is less than output in outsiders' industries if and only if $\xi < \theta^{\frac{-\alpha}{1-a}}$. However, $\xi \geq \theta^{\frac{-\alpha}{1-a}} > 1$ does not necessarily violate ***[R1]***. For example, if unions care only about employment (i.e., $\lambda = 0$), $\xi \geq \theta^{\frac{-\alpha}{1-a}}$, for all $\mu > \dfrac{1}{1+\dfrac{\alpha(1-\theta)}{(1-\alpha)(\theta^{\frac{-\alpha}{1-a}}-\theta)}}$.

Since we are interested in characterizing economies where insiders' industries are producing less output than outsiders' industries, even when technology is the same across industries, due to the frictions described in the preceding paragraph, we shall impose a sufficient condition for $\xi < \theta^{\frac{-\alpha}{1-a}}$.[15] Namely, $\xi < 1$.[16]

<u>Remark 5</u>: $\xi < 1$ *if and only if the following condition holds:*

[R2] $\lambda > \dfrac{\alpha}{1+\alpha} - \dfrac{1-a}{1+\alpha}\left(\dfrac{1-\mu}{\mu}\right)$,

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[15] This restriction would not have been an appropriate modelling restriction for countries where unions care more about employment than wage premia, such as in Scandinavian and Central European countries. See Visser (2013), and Kollintzas, et al (2018b).

[16] Also, as shown in the next section, $\xi < 1$ has an additional desirable implication for our purposes.

Figure I in the Mathematical Appendix illustrates restrictions ***[R1]*** and ***[R2].*** Clearly, ***[R2]*** imposes a lower bound and ***[R1]*** imposes an upper bound on λ, respectively, with both bounds becoming more restricting with μ.

Turning now to the government spending function in (II,22), it should be pointed out that there is a number of ways that this assumption can be justified. For example, to the extent that insiders' industries are basic networks, government may directly provide for setting up and maintain the infrastructure associated with these industries. In that sense, (II.22) may be thought as incorporating maintenance and adjustment costs in public capital.[17] Alternatively, (II.22) may be thought as incorporating the cost of bureaucracy that needs to be put in place to regulate the "protected" insiders' sector and "promote" competition in the outsiders' sector, also to the benefit of the insiders.[18] Also, the government budget constraint incorporates the assumption that profits are taxed at the same rate as labor income. This assumption is made for simplicity only and it would make no difference for modelling purposes if profits were taxed at the capital income tax rate or at a separate (flat) tax rate.

Further, the following are corollaries of Proposition 2 for government policy and a sufficient specification of the stochastic properties of the exogenous state variables for a complete characterization of the stochastic properties of the aggregate state of the PSE.

R*emark 6 (Government Policy Variables):* *Given (χ_t, χ_{t+1}), only two out of the remaining three government policy variables $\bar{\psi}_t$, τ_t^K, and τ_t^L can be chosen independently of each other.*

Remark 7 (Exogenous State): *Along the PSE, the exogenous state of the economy affects the aggregate state of the private sector only through the random variables:*

$$\tilde{A}_t = \left(A_t B_t^o\right) \quad \text{(II.26)}$$

$$B_t = \left(\frac{B_t^i}{B_t^o}\right) \quad \text{(II.27)}$$

[17] See Kollintzas et al. (2018a).

[18] A similar point is made by Acemoglu (2006), who considers the imposition of distorting taxation to "middle class" producers, by a government controlled by "elite" producers, for "political consolidation" purposes.

A_t can be interpreted as the (static) total factor productivity of the industries in the outsiders' sector when industry inputs are measured in terms of aggregate state variables and B_t can be interpreted as the total factor productivity differential between the insiders' and the outsiders' sectors. As already mentioned, an important implication off the above two remarks is that in order to characterize the stochastic properties of the aggregate state of the economy it suffices to characterize the stochastic properties of A_t and B_t along with those of the government policy variable χ_t and two out of the three government policy variables: $\bar{\psi}_t, \tau_t^k, \tau_t^L$.

2.2.3. Steady State:

We proceed now to characterize the steady state of the PSE, given policy. Variables without a time subscript denote the steady state of the corresponding PSE variable.

***Great Ratios*:**

From the Euler condition for capital (I.44):

$$\left(\frac{k}{y}\right) = \frac{\alpha(1-\tau^K)\widehat{\omega}(\chi)}{\beta^{-1}(1+\eta) - [1-(1-\tau^K)\delta]} \qquad \text{(II.28)}$$

From the resource constraint (II.4):

$$\left(\frac{c}{y}\right) = 1 - \left(\frac{i}{y}\right) - \left(\frac{g}{y}\right) \qquad \text{(II.29)}$$

where:

$$\left(\frac{i}{y}\right) = (\eta+\delta)\left(\frac{k}{y}\right) \qquad \text{(II.30)}$$

gives the investment share of output and the government spending share of output can be obtained from (II.22), to get:

$$\left(\frac{g}{y}\right) = \bar{\psi} + \hat{\psi}\chi \qquad \text{(II.31)}$$

Finally, from the household intratemporal condition (I.43):

$$\left(\frac{h}{1-h}\right) = \frac{(1-\alpha)\vartheta(1-\tau^L)\breve{\omega}(\chi)}{(1-\vartheta)\left(\frac{c}{y}\right)} \qquad \text{(II.32)}$$

where, the labor income tax rate can be obtained from the government budget constraint (II.24), to get:

$$\tau^L = \frac{\bar{\psi} + \hat{\psi}\chi - \tau^K \left[\alpha\hat{\omega}(\chi) - \delta\left(\frac{k}{y}\right) \right]}{(1-\alpha)\tilde{\omega}(\chi)} \qquad \text{(II.33)}$$

It follows that, given *B* and χ, the great ratios can be computed in the following order: (i) Compute the capital – output ratio from (II.28). (ii) Compute the investment share of output from (II.30). (iii) Given $\bar{\psi}$, compute the government share of output from (II.31). (iv) Compute the consumption share of output from (II.29). (v) Given τ^K, compute τ^L from (II.33). (vi) Compute h from (II.32). Of course, the roles of τ^K and τ^L in (v) can be reversed.

***Aggregate state of the private sector*:**

Further, given *A*, the aggregate production function (II.17) can be used to compute k, as follows:

$$k = \left[\frac{\bar{\omega}(\chi)}{\left(\frac{k}{y}\right)} \right]^{1/(1-\alpha)} h \qquad \text{(II.34)}$$

Having computed the steady state values of the great ratios and the aggregate state of the PSE, Proposition 2 implies that the steady state of all endogenous variables used in the definition of the PSE, given policy, can be computed accordingly. We use this result in the quantitative theory exercises, in Section C.

2.3. Understanding the model

2.3.1. Detailed versus prototype economy

In order to understand the model, we follow the methodology of Chari, Kehoe, Mc Grattan (2007) and we compare it to its no-frictions counterpart. We shall refer to this model as the “prototype” economy. Recall that in addition to proportional capital and labor income taxes, the model introduced in Sections I and II involves three more frictions: (a) monopolistic producers in insiders' industries, (b) Nash bargaining between the union and the corresponding producer in each one of the insiders' industries, and (c) resources to maintain and adjust the fraction of insiders' industries in the economy.[19] Although a misnomer, it might be helpful to also think of the prototype economy as a detailed economy with an insiders' and an outsiders' sector. The outsiders' sector of the prototype economy is exactly the same with the outsiders' sector of the detailed economy. The insiders' sector of the prototype economy is not however the same with the insiders' sector of the detailed economy, since it is now characterized by the following three assumptions: (i) producers in insiders' industries behave perfectly competitive in all markets; (ii) workers supplying labor in insiders' industries behave perfectly competitive; and (iii) there are no resources to maintain and adjust the fraction of insiders' industries in the economy. In other words, under these assumptions the prototype economy is a two-sector neoclassical growth model (or a two sector RBC model, in the business cycle literature) with proportional capital and labor taxes and government spending. Also note that, if we make in the case of the prototype economy the additional assumption that there is only one sector in the economy (i.e, $\chi_t = 0$, for all t), the prototype economy becomes a one sector neoclassical growth model or a Canonical RBC model, with proportional capital and labor taxes and government spending. To avoid confusion, we shall refer to the two sector prototype economy as the prototype economy and we shall refer to the one sector prototype economy as the Canonical RBC economy. In what follows we shall focus on the comparison between the detailed economy and the prototype economy. This is because we are mainly interested in comparing the two economies exclusively with respect to the three additional frictions mentioned above, over and above the distortionary traxation friction shared by both the detailed and prototype economies. On the other hand, comparisons of the detailed economy to the Canonical RBC economy are also tainted with the difference in the production technology.

It is straightforward to show, by tracing the derivation of the results of Proposition 2 and imposing assumptions (i)-(iii), above, that the following is true.

[19] Typically, in the literature, the prototype economy involves no frictions. Here, we incorporate distortionary proportional capital and labor income taxes in the prototype economy, as well. For, we are interested in comparing the two economies solely with respect to the abovementioned frictions.

***Remark 8* (PSE of the Prototype Economy):** *Let the "*" superscript denote the variables of the PSE of the prototype economy. Then, this equilibrium has the following analytic characterization:*

(a) Sectoral Variables: Outputs and inputs in the insiders' and outsiders' industries can be expressed in terms of the exogenous variables, z_t *, the government policy variable,* χ_t *, and the aggregate state of the private sector,* $\left(k_t^*, h_t^*\right)$*, as follows:*

$$\left[\frac{\chi_t k_t^{i*}}{(1-\chi_t)k_t^{o*}}\right] = \Delta_t^*(\chi_t) \tag{III.1}$$

$$(1-\chi_t)k_t^{o*} = \frac{1}{1+\Delta_t^*(\chi_t)} k_t^* \tag{III.2}$$

$$\left[\frac{\chi_t h_t^{i*}}{(1-\chi_t)h_t^{o*}}\right] = \Delta_t^*(\chi_t) \tag{III.3}$$

$$(1-\chi_t)h_t^{o*} = \frac{1}{1+\Delta_t^*(\chi_t)} h_t^* \tag{III.4}$$

$$\left[\frac{\chi_t y_t^{i*}}{(1-\chi_t)y_t^{o*}}\right] = \left(\frac{B_t^i}{B_t^o}\right)\Delta_t^*(\chi_t) \tag{III.5}$$

$$(1-\chi_t)y_t^{o*} = B_t^o\left[\frac{1}{1+\Delta_t(\chi_t)}\right]k_t^{*\alpha} h_t^{*1-\alpha} \tag{III.6}$$

$$\left(\frac{p_t^{i*}}{p_t^{o*}}\right) = \frac{1}{\left(\frac{B_t^i}{B_t^o}\right)} \tag{III.7}$$

$$\left(\frac{w_t^{i*}}{w_t^{o*}}\right) = 1 \tag{III.8}$$

where:

$$\Delta_t^*(\chi_t) \equiv \left(\frac{B_t^i}{B_t^0}\right)^{\phi/(1-\phi)}\left(\frac{\chi_t}{1-\chi_t}\right)^{1+\frac{\phi}{\theta(1-\phi)}} \tag{III.9}$$

(b) Factor Prices, Profits' Share, and the Aggregate Production Function: Factor prices, insiders' profits, and aggregate output can be expressed in terms of the exogenous variables,

z_t *, the government policy variable,* χ_t *, and the aggregate state of the private sector,* $\left(k_t^*, h_t^*\right)$ *as follows:*

$$r_t^* = \alpha\hat{\omega}_t^*(\chi_t)\frac{y_t^*}{k_t^*} \tag{III.10}$$

$$w_t^{o*} = (1-\alpha)\breve{\omega}_t^*(\chi_t)\frac{y_t^*}{h_t^*} \tag{III.11}$$

$$\frac{\chi_t \pi_t^{i*}}{y_t^*} = 0 \tag{III.12}$$

$$y_t^* = \bar{\omega}_t^*(\chi_t)k_t^{*\alpha}h_t^{*1-\alpha} \tag{III.13}$$

where:

$$\hat{\omega}_t^*(\chi_t) \equiv 1 \tag{III.14}$$

$$\breve{\omega}_t^*(\chi_t) \equiv 1 \tag{III.15}$$

$$\bar{\omega}_t^*(\chi_t) \equiv A_t B_t^o \left(1-\chi_t\right)^{[\theta+(1-\theta)\phi]/\theta\phi}\left[1+\Delta_t^*(\chi_t)\right]^{(1-\phi)/\phi} \tag{III.16}$$

<u>(c) Government Spending and the Aggregate State Variables:</u> Suppose that the government always runs a balanced budget, in the sense that government spending must satisfy the constraint:

$$g_t^* = \tau_t^K(r_t^* - \delta)k_t^* + \tau_t^{L*}[\chi_t w_t^{i*}h_t^{i*} + (1-\chi_t)w_t^{o*}h_t^{o*} + \chi_t\pi_t^{i*}] \tag{III.17}$$

and that government spending is defined by:

$$g_t^* = \bar{\psi}_t y_t^* \tag{III.18}$$

Then, given z_t *and government policy variables* $(\bar{\psi}_t, \tau_t^k, \chi_t)$*, the laws of motion of the aggregate state of the private sector equilibrium: (i) depend only on the aggregate state of the private sector* $\left(k_t, h_t\right)$*; and (ii) they are characterized, completely, in terms of: the transversality condition (I.32); the initial condition,* $k_0^* \in (0,\infty)$ *is given; the resource constraint (II.4); and, the following conditions:*

$$\frac{1-\vartheta}{\vartheta}\frac{c_t^*}{1-h_t^*} = (1-\tau_t^{L*})(1-\alpha)\frac{y_t^*}{h_t^*} \tag{III.19}$$

$$\frac{u_t^*}{c_t^*} = \frac{\beta}{(1+\eta)} E_t \left\{ \frac{u_{t+1}^*}{c_{t+1}^*} \left[1 + (1-\tau_{t+1}^K)[\widehat{\omega}_{t+1}^*(\chi_{t+1})\alpha \frac{y_{t+1}^*}{k_{t+1}^*} - \delta] \right] \right\} \quad \text{(III.20)}$$

$$\overline{\psi}_t = \tau_t^K \left[\alpha \widehat{\omega}_t^*(\chi_t) - \delta \left(\frac{k_t^*}{y_t^*} \right) \right] + (1-\alpha)\tau^{L*} \quad \text{(III.21)}$$

Then, the following is an immediate consequence of Remark 8, for χ_t =0, for all *t*.

<u>Remark 9 (PSE of the Canonical RBC Economy)</u>: *Let the superscript "+" denote the variables of the PSE of the prototype economy, when* $\chi_t = 0$, for all *t. Then, this equilibrium has exactly the same representation as the PSE of the prototype economy, where the "*" superscripted variables are replaced by the corresponding "+" superscripted variables, and where, in addition:*

$$\Delta_t^+(\chi_t) = \Delta_t^*(1) = 0 \quad \text{(III.22)}$$

$$\overline{\omega}_t^+(\chi_t) \equiv \overline{\omega}_t^*(1) = A_t \quad \text{(III.23)}$$

Understanding the properties of the detailed economy reduces to defining and understanding the "time- varying wedges in the prototype economy that distort the equilibrium decisions of agents operating in otherwise competitive markets," as suggested by Chari, Kehoe, McGrattan (2007). Here we have four such wedges, namely, the capital, labor, efficiency and government wedges defined as, $\frac{\widehat{\omega}_t(\chi_t)}{\widehat{\omega}_t^*(\chi_t)}$, $\frac{\breve{\omega}_t(\chi_t)}{\breve{\omega}_t^*(\chi_t)}$, $\frac{\overline{\omega}_t(\chi_t)}{\overline{\omega}_t^*(\chi_t)}$ and $\frac{g_t(\chi_t)}{g_t^*(\chi_t)}$, respectively.[20] Hence, understanding the differences between the prototype and detailed economies is equivalent to understanding the properties of these four wedges. The following proposition gives a qualitative description of the properties of the capital, labor, and efficiency wedges.

[20] Strictly speaking, the way we define the capital, labor and efficiency wedges in this paper, these are actually inverse wedges in the terminology of Chari, Kehoe and McGrattan. In other words, in our case, the greater the corresponding distortion of the detailed vis-a-vis the prototype economy, the smaller the value of the respective wedge. The opposite holds for the government wedge.

Proposition 3: *Given [R1] and [R2], suppressing time subscripts, the following are true:*

(a) Capital Wedge:

$$\frac{\widehat{\omega}(\bullet)}{\widehat{\omega}^*(\bullet)}:(0,1)\to(\theta,1); \qquad \lim_{\chi\to 0}\frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)}=\begin{cases}1, & when \quad \phi\in\left(-\frac{\theta}{1-\theta},1\right)\\ \theta, & when \quad \phi\in\left(-\infty,-\frac{\theta}{1-\theta}\right)\end{cases};$$

$$\lim_{\chi\to 1}\frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)}=\begin{cases}\theta, & when \quad \phi\in\left(-\frac{\theta}{1-\theta},1\right)\\ 1, & when \quad \phi\in\left(-\infty,-\frac{\theta}{1-\theta}\right)\end{cases};$$

and when $\phi=-\frac{\theta}{1-\theta}$, $\quad \frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)}=\frac{1+\xi\left[\theta^{\alpha}\xi^{(1-a)}\left(\frac{B^i}{B^0}\right)\right]^{-\theta}}{1+\left[\theta^{\alpha}\xi^{(1-a)}\left(\frac{B^i}{B^0}\right)\right]^{-\theta}}, \quad \forall\chi\in(0,1).$ *Moreover,*

$$\frac{d\left[\frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)}\right]}{d\chi}\begin{cases}<0, & when \quad \phi\in(-\frac{\theta}{1-\theta},1)\\ >0, & when \quad \phi\in(-\infty,-\frac{\theta}{1-\theta})\end{cases}, \quad \forall\chi\in(0,1).$$

(b) Labor Wedge:

$$\frac{\breve{\omega}(\bullet)}{\breve{\omega}^*(\bullet)}:(0,1)\to(\xi,1); \qquad \lim_{\chi\to 0}\frac{\breve{\omega}(\chi)}{\breve{\omega}^*(\chi)}=\begin{cases}1, & when \quad \phi\in\left(-\frac{\theta}{1-\theta},1\right)\\ \xi, & when \quad \phi\in\left(-\infty,-\frac{\theta}{1-\theta}\right)\end{cases};$$

$$\lim_{\chi\to 1}\frac{\breve{\omega}(\chi)}{\breve{\omega}^*(\chi)}=\begin{cases}\xi, & when \quad \phi\in\left(-\frac{\theta}{1-\theta},1\right)\\ 1, & when \quad \phi\in\left(-\infty,-\frac{\theta}{1-\theta}\right)\end{cases};$$

and when $\phi=-\frac{\theta}{1-\theta}$, $\quad \frac{\breve{\omega}(\chi)}{\breve{\omega}^*(\chi)}=\frac{1+\xi\left[\theta^{\alpha}\xi^{(1-a)}\left(\frac{B^i}{B^0}\right)\right]^{-\theta}}{1+\left[\theta^{\alpha}\xi^{(1-a)}\left(\frac{B^i}{B^0}\right)\right]^{-\theta}}<1, \quad \forall\chi\in(0,1).$

Moreover,

$$\frac{d\left[\frac{\breve{\omega}(\chi)}{\breve{\omega}^*(\chi)}\right]}{d\chi}\begin{cases}<0, & when \quad \phi\in(-\frac{\theta}{1-\theta},1)\\ >0, & when \quad \phi\in(-\infty,-\frac{\theta}{1-\theta})\end{cases}, \quad \forall\chi\in(0,1).$$

(c) Efficiency Wedge:

Let: $\upsilon\equiv\left(\theta^{\alpha}\xi^{(1-a)}\right)^{-\phi/(1-\phi)}$*. Then, for* $\phi=0$ *and for all* $\phi\in(-\infty,1)\setminus\{0\}$ *such that*

[R3] $$\frac{1-\upsilon}{1-\frac{\alpha\xi+(1-a)\theta}{\theta\xi}\upsilon}<\phi<\frac{1-\upsilon}{[\alpha\theta+(1-a)\xi]-\upsilon}$$

holds, the following are true:

$\frac{\bar{\omega}(\bullet)}{\bar{\omega}^*(\bullet)}:(0,1)\to(0,1);\ \lim_{\chi\to 0}\frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)}=\lim_{\chi\to 1}\frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)}1;$ *and, for all* $\phi\in(-\infty,1)\setminus\left\{-\frac{\theta}{1-\theta},0\right\}$

there exists an $\chi_+\in(0,1)\ni\frac{d\left[\frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)}\right]}{d\chi}\begin{cases}<0, & when \quad \chi<\chi_+\\ =0, & when \quad \chi=\chi_+\\ >0, & when \quad \chi>\chi_+\end{cases}.$

Proof: In the Mathematical Appendix.

We shall refer to the case where $-\frac{\theta}{1-\theta}<\phi<1$ $\left(\phi<-\frac{\theta}{1-\theta}\right)$ as a situation where the output of the insiders' sector and the output of outsiders' sector in the final good production are not (are) strong complements. We follow Cole and Ohanian (2004) in considering the empirically relevant case to be the case where the output of the insiders' sector and the output of outsiders' sector in the final good production are not strong complements.

Capital Wedge: Following Proposition 3, the capital wedge, $\frac{\hat{\omega}(\chi)}{\hat{\omega}^*(\chi)}$, is less than one, in general, and decreasing (increasing) with χ, if insiders' and outsiders' sector inputs in final good production are not (are) strong complements. The reason this is happening is that the demand for capital is lower in the detailed economy than in the prototype economy for two reasons: (i) the monopolistic producer restricts output needing less from both inputs, and (ii) the firm-union bargaining results in a higher wage rate and further reduces labor input in such a way that the output effect dominates the substitution effect. The main implication of this distortion is to lower the marginal product of capital in the economy. This has a static and a dynamic effect. The static effect is immediate from the steady state relationship (II.29) and implies a lower steady state capital-output ratio for the economy. The dynamic consequence follows from the Euler condition for capital (II.24). That is, in the detailed economy investment, in any given period t, must equate the marginal value of sacrificing current consumption to a lower discounted expected marginal value of next period consumption due to the after tax gross return of this investment. Because of the capital wedge, the latter is lower in the detailed economy than in the prototype economy.

Labor Wedge: Qualitatively, the labor wedge, $\frac{\breve{\omega}(\chi)}{\breve{\omega}^*(\chi)}$, behaves much the same and for similar reasons like the capital wedge. The main implication of the labor wedge is the distortion of the equality of the marginal rate of substitution (MRS) between consumption and leisure and the corresponding marginal rate of transformation (MRT) in the economy. This is manifested in the intratemporal condition (II.23). Specifically, because of the labor wedge, the detailed economy has a lower MRT than the prototype economy. This again has a static and a dynamic consequence. The static consequence is immediate from the steady state version of (II.23) (i.e., (II.33)) and implies lower employment in the steady state of the detailed economy than in the prototype economy. And, again, in view of (II.23), the dynamic consequences are apparent from (II.24).

Efficiency Wedge**:** As explained above, the capital wedge results in less capital both in the long run and in any given period. Likewise, the labor wedge results in less employment both in the long run and in any given period. The efficiency wedge, $\frac{\bar{\omega}_t(\chi_t)}{\bar{\omega}_t^*(\chi_t)}$, characterizes the static total factor productivity (TFP) for any input levels and, again, is defined as the ratio of TFP in the detailed over the prototype economy. The exogenous parts of these TFPs are the same and cancel out. Thus, Proposition 3 implies that, due to all frictions in the economy, output will be lower in the detailed economy over that of the prototype economy. There are three sources of these frictions: (i) the way capital and labor are combined in insiders' industries, (ii) the way capital and labor are combined in outsiders' industries, and (iii) the way output from insiders' and outsiders' industries are combined in the production of the final good. The first two effects are incorporated in the term $\frac{1+\Delta_t^*(\chi_t)}{[1+\theta\Delta_t(\chi_t)]^{\alpha}[1+\xi\Delta_t(\chi_t)]^{1-\alpha}}$, in the denominator of the efficiency wedge. The third effect is incorporated directly in the term $\left[\frac{1+\Delta_t(\chi_t)}{1+\Delta_t^*(\chi_t)}\right]^{1/\phi}$, in the numerator of the efficiency wedge. (See (A.20) in the Mathematical Appendix.) Further, Proposition 3 implies that the efficiency wedge falls continuously and then rises continuously with the share of insiders' industries for all ϕ that satisfy condition **[R3].** In particular, the graph of the efficiency wedge with respect to the share of insiders' industries in the economy is "U" shaped, as the efficiency wedge is equal to one in the two cases where there is only one sector in the economy (i.e., $\chi = 0$ and $\chi = 1$). Thus, there is no efficiency loss due to the frictions mentioned above when there is only one sector producing intermediate goods, while the efficiency loss is maximized in an intermediate value for the share of sectors producing intermediate goods in the economy near 1/2. The key to understand this somewhat counterintuitive result - in the sense that it might had been expected that the efficiency wedge monotonically declines with χ throughout $\chi \in (0,1)$ - is the combination of two effects: (i) input complementarity in the final good sector ("complementarity effect"), and (ii) a kind of multiplicity in what concerns the adverse effect (i.e., output reduction) when the insiders' sector of the detailed economy is characterized by either a few but "strong" monopolistic industries, i.e., χ close to zero, or many but "weak" monopolistic industries, i.e., χ close to one ("multiplicity effect".) The multiplicity effect is brought about by the fact that the output of the insiders' sector in the detailed economy is less than the output of the insiders' sector in the prototype economy due to the monopolistic product markets, the wage-employment bargaining arrangements, and the extra fiscal policy distortions.[21] But, any given reduction in the output of the insiders' sector in the detailed economy can be achieved in two different ways. One way is with a relatively small share of insiders' industries in the economy, whereby there are relatively few non-competitive industries (but due to the structure of the model) resulting in big output reductions. And the second way is with a relatively large share of insiders' industries in the economy, whereby there are relatively many non-competitive industries resulting in big output reductions. Accordingly, in the extreme cases $\chi = 0$ and $\chi = 1$ this output reduction in the insiders' sector of the detailed economy is non-existent while, on the other hand is maximized for some intermediate value of χ near 1/2. The case $\chi = 1$ is exactly the same as the case where $\chi = 0$, as the product

[21]Remember that the prototype economy is a two sector model where both sectors are perfectly competitive. We continue, however, to use the "insiders" – "outsiders" terminology in order to distinguish between these two perfectly competitive sectors of the prototype economy.

demand in each industry in the economy is perfectly elastic and the same is true for the industry demand for both factors of production. Turning now to the complementarity effect, to the degree that intermediate good inputs are complements in the production of the final good, balanced input combinations produce more output than one-sided input combinations. Note, however, that this effect relates to the quantities of the inputs from the two intermediate good sectors and not the shares of these sectors in the economy. Combining, now the two effects, it is straightforward that efficiency losses between the two economies are non-existent in the extreme cases when $\chi = 0$ and $\chi = 1$ and are maximized for some intermediate value of χ. Around this point, TFP both in the prototype and the detailed economy is the highest, due to the complementarity effect, but so is their difference due to the output loss of the insiders' sector, described by the multiplicity effect. Loosely speaking, the maximum efficiency loss occurs when the lower output of the insiders' sector in the detailed economy hinders the complementarity effect when the latter is strongest. That is, in a balanced input combination of the insiders' and outsiders' sectors in the production of the final good.

Finally, it should be mentioned that **[R3]** is a regularity condition that limits extreme values of the input elasticity of substitution in the production of the final good. It works so as to exclude large absolute values of ϕ in both cases. That is, when ϕ is negative and when ϕ is positive.

3. Steady state and IRFs of the private sector equilibrium

First, in this section we conduct a sensitivity analysis of the private sector equilibrium (PSE) steady state. Second, we compute the impulse response functions (IRFs) of the endogenous variables in response to temporary shocks in the exogenous variables. These tasks necessitate that we assign values to the model's parameters and specify the stochastic laws of motion of the exogenous variables.

3.1. Assignment of parameter values

The assigned parameter values and the values for the policy instruments correspond to standard values used in the DSGE and RBC literature. We think of USA as a benchmark for the parameterization of the prototype model while Southern European countries serve as our reference point for the parameterization of the detailed economy. More specifically, the parameterization is based on the hypothesis that the model that describes the US economy is that of the prototype economy (i.e., is a two sector RBC model with distortionary factor taxation) and the model that describes the economies of South Europe is that of the detailed economy, analysed in the previous section. Essentially, this amounts to relating the wedges of the detailed economy using data from the South European economies. Alternatively, the differences between the detailed and the prototype economy could be interpreted as indicative of the differences between two scenarios -the case where Southern European economies run as detailed economies and the case where these economies run as the US economy. The lack of actual data on the share of insiders' industries and the various wedges is an obstacle for the calibration of the detailed economy. Thus we investigate the sensitivity of the behaviour of our model to alternative values of the parameters related to frictions, namely, $\chi, \phi, \theta, \lambda$, and μ.

The benchmark parameterization along with some notes on the assignment of the parameter values we use in our computations are given in Table C.1. This table has four columns: The first column presents the parameter symbols used in the previous section (i.e, the theoretical model). The second column gives the economic meaning of each parameter. The third column gives the value, values, or range of the parameter used in the computations. The range refers to the sensitivity analysis we carry out. The fourth column gives the source of the parameter value. Here, SVL stands for "standard value in the DSGE literature," equation numbers refer to the previous section, CO refers to values used in Cole and Ohanian (2004). The sources and details on the data used are described in Kollintzas, et al (2018b).

The values of ϕ we use lie between 0 and $-\frac{\theta}{1-\theta}$. As shown in the previous section, with values of ϕ in this region, the detailed economy has the desired properties, in the sense that all wedges imply that frictions increase with the share of insiders' industries χ. And, we consider five alternative values of χ = [0.25, 0.35, 0.50, 0.65, 075]. We consider, 0.50 and 0.75 to correspond to a lower and an upper bound for χ in the Southern European countries. Cole and Ohanian (2004) considered 0.25 and 0.50 to represent the US economy before and after the New Deal policies, respectively. As already mentioned, we take τ^K along with the GDP-share of the part of government spending that does not relate to the maintenance and adjustment of the insiders-outsiders politico-economic structure, $\bar{\psi}$, to be set exogenously. Since we hypothesize that the US economy is described by the prototype economy and that the South European economies are described by the detailed economy, we set $\bar{\psi}$ equal to the average GDP share of government spending of the US economy. That is, 22.5%. And, we set $\bar{\psi} + \hat{\psi}\chi$ =0.25. This corresponds to the average GDP-share of government spending in the Southern European economies, assuming χ =0.50. Also, in the characterization of the PSE, we treat the share of insiders' industries as an exogenous variable that follows a stochastic law of motion.

Table C.1: Parameterization

α	capital input elasticity in industry production	0.33	SVL*
$\tilde{\beta}$	constant discount factor of households	0.98	SVL*
$1/\gamma$	household intertemporal elasticity of substitution	0.50	SVL*
δ	capital depreciation rate	0.07	SVL*
η	growth rate of labor of augmenting technology	0.02	SVL*
ϑ	intensity of consumption in household preferences	0.33	SVL*
$\frac{1}{1-\theta}$	aggregation elasticity of substitution across industries in the same sector	10 (i.e., $\theta = 0.9$) or 20 ($\theta = 0.8$)	jointly calibrated from equations (I.17) and (I.21) so that given α, θ, λ and μ the wage premium $v = \frac{w^i}{w^o}$ equals 1.25 (for $\theta = 0.9$) or 1.75 (for $\theta = 0.8$)
λ	intensity of wage premium in union preferences	0.75	
μ	relative bargaining power of insiders' unions	0.75	
τ^K	capital income tax rate	0.20	indicative of South European data
$\frac{1}{1-\phi}$	elasticity of substitution across sectors in final good production function	0.50 (i.e., $\phi = -1$)	CO**
χ	share of insiders' industries	0.25, 0.35, 0.5, 0.65, 0.75	
$\bar{\psi}$	GDP share of government consumption in the prototype economy	0.225	indicative of US data
$\hat{\psi}$	such that the difference between the GDP share of government consumption in South Europe and the US is $\hat{\psi}\chi$	0.025	calibrated on South European data, such that $\bar{\psi} + \hat{\psi}\chi$ =0.25
$\tilde{\psi}$	GDP share of government spending devoted to the expansion of the insiders' sector	0	

Notes: *SVL: stands for "standard value in the DSGE literature;**CO: stands for values used in Cole and Ohanian (2004).

The laws of motion of the logarithms of the exogenous stochastic variables $Z = \left\{A, B^i, B^o, x/(1-x), \tau^K, \bar{\psi}\right\}$**,** are taken to be AR(1) processes with drift (whose values are defined in Table C.1.): $Z_{t+1} = \left(1-\rho^Z\right)\bar{Z} + \rho^Z Z_t + \varepsilon_t^Z$. In all cases the persistence parameter is set to 0.9 and the variance of the shocks is set to 0.1. The reason why we consider $\frac{\chi}{1-\chi}$ to be the exogenous stochastic variable and not χ is that we impose normality on the shocks of all exogenous variables.

3.2. Steady State

The steady state computation for the benchmark parameterization described in Table C.1. for $\theta = 0.8$ and five alternative values of the share of insiders' industries, χ = [0.25, 0.35, 0.50, 0.65, 075], is given in Table C.2. The star superscripted variables refer to the prototype economy as in Section B.[22], [23]

It follows from Part A of Table C.2 that the steady state output per capita of the detailed economy is less than the steady state output per capita of the prototype economy while this gap deepens with χ (from about 23% when χ = 0.25 to about 33% for χ = 0.75.) The capital-output ratio share of GDP in the detailed economy is smaller than that of the prototype economy and declines with the share of insiders' industries in the economy χ. The employment to total hours ratio behaves much like the capital-output ratio but the percentage divergence between the detailed economy and the prototype economy is twice as large in comparison the corresponding divergence in the capital-output ratio. The consumption share of GDP is similar in the detailed and the prototype economies. But, the gap between the investment share of GDP in the detailed versus the prototype economy mirrors the behaviour of the capital-output ratio. Consequently, the government spending share of GDP in the detailed economy, increases with the share of insiders' industries in the economy χ, reflecting a strong crowding out effect.

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[22] The respective comparison of the detailed economy relative to the canonical RBC model ("+" superscripted variables) for the benchmark parameterization described in Table C.1. for $\theta = 0.9$ and three alternative values of the share of insiders' industries χ = [0.20, 0.35, 0.50] is given in Tables II.A and II.B in Appendix II. Note that the figures in the Tables C and Tables II are non-comparable as total factor productivities are not comparable between the one sector and the two sector RBC models.

[23] To further assess the properties of the steady state, we have also conducted a sensitivity analysis of the steady state computations for alternative values for the parameters ϕ, θ, λ and μ, than the benchmark values reported in Table C.1. We also experimented with a grid for χ from 0.05 to 0.95 with a 0.05 step. The results for alternative parameter values examined are available on request.

Table C.2. Private Sector Equilibrium: Steady State Sensitivity with respect to χ.
Part A: Great Ratios

	χ = 0.25	**χ = 0.35**	**χ= 0.50**	**χ = 0.65**	**χ= 0.75**
y	0.1121	0.1020	0.0951	0.0948	0.0985
y^*	0.1461	0.1368	0.1324	0.1368	0.1461
y / y^*	0.7671	0.7456	0.7184	0.6925	0.6738
k / y	2.3361	2.3130	2.2833	2.2545	2.2331
k^* / y^*	2.5713	2.5713	2.5713	2.5713	2.5713
$(k / y) / (k^* / y^*)$	0.9085	0.8996	0.8880	0.8768	0.8685
h	0.2503	0.2447	0.2374	0.2303	0.2250
h^*	0.3029	0.3029	0.3029	0.3029	0.3029
h / h^*	0.8264	0.8080	0.7839	0.7603	0.7428
c / y	0.5523	0.5493	0.5445	0.5396	0.5365
c^* / y^*	0.5436	0.5436	0.5436	0.5436	0.5436
$(c / y) / (c^* / y^*)$	1.0159	1.0106	1.0017	0.9927	0.9870
i / y	0.2102	0.2082	0.2055	0.2029	0.2010
i^* / y^*	0.2314	0.2314	0.2314	0.2314	0.2314
$(i / y) / (i^* / y^*)$	0.9085	0.8996	0.8880	0.8768	0.8685
g / y	0.2375	0.2425	0.2500	0.2575	0.2625
g^* / y^*	0.2250	0.2250	0.2250	0.2250	0.2250
$(g / y) / (g^* / y^*)$	1.0556	1.0778	1.1111	1.1444	1.1667

Part B of Table C.2 presents the steady state of the wedges or what sometimes is referred to as “static wedges.” Confirming the theoretical results of the previous section, the capital, labor, and efficiency wedges are all less than one. Moreover, the capital and labor wedges are decreasing (implying that the respective frictions increase) with the share of insiders’ industries, while the efficiency wedge remains roughly constant.[24] The fact that the capital and labor wedges decline with χ, reflect the greater frictions in input and output markets. Note also that, clearly, from the three wedges the labour wedge is the most distortive. These wedges, along with the government spending wedge $(g / y)/(g^* / y^*)$ and the consequent labour tax distortion, justify the observed differences in output between the detailed and the prototype economies.

[24] Recall that, as mentioned in footnote 15, unlike the government wedge, the way the capital, labor, and efficiency wedges are defined here, the greater the corresponding distortion of the detailed vis-a-vis the prototype economy, the smaller the value of the respective wedge.

Table C.2: Private Sector Equilibrium: Steady State Sensitivity with respect to χ. Part B: Wedges

	χ **= 0.25**	χ **= 0.35**	χ**= 0.50**	χ **= 0.65**	χ **= 0.75**
$\widehat{\omega}$	0.9085	0.8996	0.8880	0.8768	0.8685
$\widehat{\omega}^*$	1.0000	1.0000	1.0000	1.0000	1.0000
$\widehat{\omega}/\widehat{\omega}^*$	0.9085	0.8996	0.8880	0.8768	0.8685
$\breve{\omega}$	0.7909	0.7704	0.7440	0.7184	0.6994
$\breve{\omega}^*$	1.0000	1.0000	1.0000	1.0000	1.0000
$\breve{\omega}/\breve{\omega}^*$	0.7909	0.7704	0.7440	0.7184	0.6994
$\bar{\omega}$	0.4412	0.4220	0.4127	0.4219	0.4410
$\bar{\omega}^*$	0.4490	0.4298	0.4204	0.4298	0.4490
$\bar{\omega}/\bar{\omega}^*$	0.9825	0.9819	0.9816	0.9817	0.9822
g/y	0.2375	0.2425	0.2500	0.2575	0.2625
g^*/y^*	0.2250	0.2250	0.2250	0.2250	0.2250
$(g/y)/(g^*/y^*)$	1.0556	1.0778	1.1111	1.1444	1.1667

We conclude this subsection with the observation that the great ratio findings are sensitive, as expected, to the degree of monopoly power in insiders' industries (i.e., how close substitutes are the products of different insiders' industries (θ) and how close substitutes are the aggregate products of the insiders' and outsiders' sectors (ϕ) and the combination of union relative bargaining power (μ) and the intensity of union preferences for the wage premium over union employment (λ).

3.3. Impulse response functions

In Figures C3.1-C3.21 in Appendix III, we plot, for the benchmark parameterization described in Table C.1. and for $\theta = 0.8$ and χ = 0.50, the impulse response functions (IRFs) of the endogenous variables to temporary (one period shocks) changes in the exogenous variables of the PSE in the prototype and detailed economies. Responses for both exogenous and endogenous variables are expressed in percentage deviations from the steady state of the PSE.[25]

In what follows, we discuss the response of the endogenous variables: $y, k, h, c, i, g, r, w^o, \tau^L, \widehat{\omega}, \breve{\omega}, \bar{\omega}, \tilde{\omega}, \chi y^i, (1-\chi)y^o, \chi k^i, (1-\chi)k^o, \chi h^i, (1-\chi)h^o$, to changes in

[25] To further assess the properties of the IRFs, we have also carried out these experiments for χ =0.35 and χ =0.65, as well as for different values of the parameters associated with frictions, $\phi, \theta, \lambda, \mu$. The results are available upon request.

the exogenous variables: A, B^o, B^i $\dfrac{\chi}{1-\chi}$, τ^K, $\bar{\psi}$, in the order of the figures and we summarize results at the end of the subsection.

The response of detailed economy variables y, k, h, c, i, g, r, w^o to a negative change in the TFP parameter of the final good sector, *A*, is plotted in Figure C.3.1. This response is qualitatively similar to the response of the prototype economy variables $y^*, k^*, h^*, c^*, i^*, g^*, r^*, w^{o*}$, respectively. The latter are, of course, indicative of the well-known response of output, capital, employment, consumption, investment, government spending, real rental cost of capital and real wage rate to a negative productivity shock of the canonical RBC model.[26] The negative response of output, capital, employment, consumption, and investment is more pronounced in the detailed economy case, but the differences between the corresponding responses in the two economies are small.

The no response of the capital and labor inverse wedges, $\hat{\omega}/\hat{\omega}^*$ and $\breve{\omega}/\breve{\omega}^*$, to the change in *A*, as well the identical response of the inverse efficiency wedge, $\bar{\omega}/\bar{\omega}^*$, to the change in *A*, in Figure C3.2 are clear from the definition of these wedges in Section B. The same is true for the symmetric responses of the industry variables in response to the change in *A* under consideration, observed in Figure C3.3.

In Figures C3.4 and C3.7, the responses of the aggregate variables to the negative TFP in insiders' industries, B^i, and an equal change in the TFP in outsiders' industries, B^o ,respectively, are similar. Clearly, the effects are quantitatively smaller than the change in the TFP of the final good sector, considered above, as they involve only one of the two intermediate good sectors. There is an asymmetry in the response of the aggregate variables to these shocks. For example, the drop of output in Figure C3.4 is smaller than the drop in output in Figure C3.7, as the drop in B^o affects a larger sector than the drop in B^i. Moreover, from Figures, C3.6 and C3.9, we observe that when there is a negative TFP shock in any intermediate goods sector, output in both of these two sectors drops. However, the drop in the outsiders' sector in response to a negative TFP shock in the outsider' sector, is larger than the drop in the output of the insiders' sector in response to an identical negative TFP shock in the same sector.

Figures C3.10 to C3.12 plot the response of the endogenous variables to an increase in the share of insiders' industries in the economy. First, we should clarify that the small positive

[26] See, e.g., Sims (2016).

response of output and inputs on impact reflects the fact that χ is a state variable and the change in its driving shock in the current period can only change χ in the next period. Now, in response to the increase in χ, output, capital and labor inputs, consumption, investment, government spending, outsiders' wages and real rental costs all drop. Most importantly for our purposes these drops are relatively large. Confirming theory, these effects work through the wedges. In Figure C3.11, all inverse wedges drop and the labor income tax rate increases. Interestingly, the most significant drop is in the inverse efficiency wedge. This result has important implications for the politico-economic equilibrium and the possibility that a government influenced by insiders may amplify the effects of a negative shock by increasing the share of insiders' industries in the economy.

To see this, in Figures C3.19- C3.21 we present the IRFs with respect to, simultaneously, a negative shock in A and a positive shock in $\chi/(1-\chi)$. Clearly the response of the detailed economy to such an adverse productivity shock is considerably worse compared to that of the prototype economy. Such an experiment simulates a situation where a negative productivity shock is accompanied by an increase in the share of insiders' industries. This is motivated by our conjecture that in case when the policy makers decisions is influenced by powerful insiders, the resulting reaction of such a government to a negative TFP shock would be to increase $\chi/(1-\chi)$ in order to protect the insiders' unions welfare. This remains to be investigated in a natural extension of this paper where the policy is chosen optimally and x becomes a policy instrument.

Figures C3.13 – C3.18 plot the response of the endogenous variables to changes in the exogenous part of the GDP share of government spending and the capital income tax rate. The main finding from these experiments is that the behaviour of the endogenous variables of the detailed economy is qualitatively similar to the prototype economy. The difference is that the reaction of the endogenous variables is stronger. This amplification effect is similar but not due to the wedge increases.

Summarizing, the graphs of the IRFs of output, consumption, investment and employment with respect to an exogenous negative productivity shock in final good production, lie lower than the corresponding graphs of the prototype economy, but the underlying quantitative differences are small. The graphs of the IRFs for output, consumption, investment and employment with respect to an exogenous negative productivity shock in the insiders' sector, lie lower than the corresponding graphs of the prototype economy and the underlying quantitative differences are significant. The graphs of the IRFs for output, consumption, investment and employment with respect to an exogenous negative productivity shock in the outsiders' sector, lie lower than the corresponding graphs of the prototype economy and the underlying quantitative differences between the two cases are discussed above. The differences in the quantitative responses of the three productivity shocks are brought about by differences in the response of the labor wedge that reduces the MRT between consumption and leisure. (Compare the IRFS of $\breve{\omega}$ in the upper part of Figures C.3.2, C3.5, and C.3.8.) The IRFs of output, consumption, investment and employment with respect to an (exogenous) temporary increase in the share of insiders' industries are negative and quantitatively significant. To a great extent the properties of the IRFs described above emanate from properties of the IRFs of the four wedges. Finally, as with negative productivity shocks, increasing taxes (i.e., capital taxes directly or labor taxes indirectly) has a greater effect in the detailed economy compared to that in the prototype economy.

4. Concluding remarks

Simple stylized facts indicate that the economic growth of a group of Southern European countries, over the last fifty years, was relatively slow and that the Great Recession was deeper and lasted longer than in other major economies with similar liberal democracy institutions. We propose that one of the main causes of these disparities is the particular kind of interrelations between market and political power that characterizes the politico-economic system of these countries. Trying to explain how such a politico-economic system may lead to relatively low economic growth and deeper and longer recessions than in other countries, we developed a two sector DSGE model, based on Cole and Ohanian (2004), that incorporates major features of these interrelations. Accordingly, the "insiders'" sector consists of industries with monopolistic producers that bargain over wages and employment with "selfish" labor unions. And, the "outsiders'" sector consists of industries with competitive firms and workers.

Such a framework will allow as a natural extension at a further stage, for the investigation of optimal policy setting, when, the share of insiders' industries in the economy become a policy instrument decided by a government that is influenced by the coalition of all insiders' unions. That way, a Ramsey government opts for politico-economic equilibria with a nonzero share of insiders' industries in the economy.

In this paper we carried out the tasks necessary to set the stage for a well-defined, suitable Ramsey government problem. Moreover, this paper, being a part of a research agenda that seeks to examine if the aforementioned stylized facts can be explained by such a politico-economic equilibrium, sets also the stage for assessing the model's ability to match the data. In so doing we characterized qualitatively and investigated quantitatively the properties of the private sector equilibrium, given policy. We showed that, given restrictions, this private sector equilibrium can be expressed only in terms of aggregate variables like a typical macro model. Following the insight of Chari, Kehoe, Mc Grattan (2007), we showed that this equilibrium (the equilibrium of the "detailed" economy) can be represented as the equilibrium of a fully competitive economy or an economy without insiders' industries (the equilibrium of the "prototype" economy) that is being distorted by four wedges. These wedges summarize all the frictions of the detailed economy. And, this is very important to understand the workings of the detailed economy. It is shown that, given restrictions, the behaviour of the wedges reveal that frictions increase with the size of the insiders' sector and that the steady state of the detailed economy, because of these wedges, is consistent with output per capita that is significantly less than the output per capita of the steady state of the prototype economy. This alone can explain the dismal growth performance of South European economies In fact, following Prescott (2002), the growth implication can also account for deep and long recessions, like the ones these countries experienced during the Great Recession. Furthermore, from the IRF analysis, from a model calibrated on pertinent stylized facts (i.e., price mark ups, wage premia, factor taxes, output share of government spending), we found two shock amplification results: First, in the detailed economy the effects of negative TFP and positive tax shocks are moderately amplified, compared to the corresponding shocks in the prototype economy. Second, the effects of positive shocks on the share of insiders' industries has significant negative and prolonged effects on economy.

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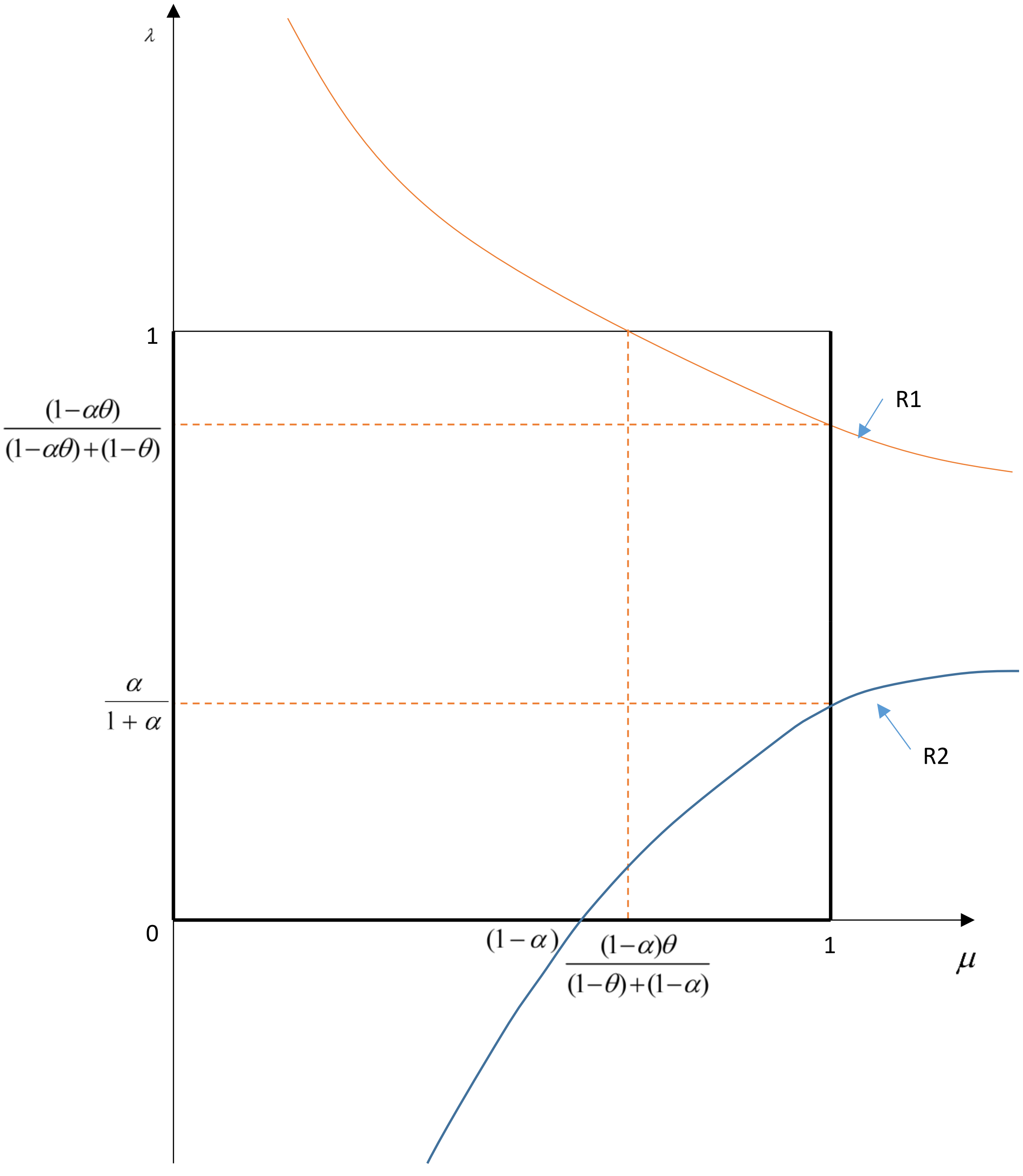
APPENDIX I. Mathematical Appendix

Figure I



Proof of Proposition 1: Given the strict concavity of the objective function in the second stage of the game, given by (I.17), the necessary and sufficient condition is (I.18). This condition gives the unique level of capital input:

$$k_t^i(\varsigma) = \left(\frac{\alpha\theta B_t^{i\theta} \Gamma_t^i}{r_t} \right)^{1/(1-\alpha\theta)} l_t^i(\varsigma)^{(1-\alpha)\theta/(1-a\theta)} \tag{A.1}$$

Using (A.1) to substitute out capital input in the producer's profit function (I.14), we can re-express the producer's profit function in the first stage of the game as:

$$\pi_t^i(\varsigma) = (1-\alpha\theta)\left[\frac{(\alpha\theta)^{\alpha\theta} B_t^{i\theta} \Gamma_t^i}{r_t^{\alpha\theta}} \right]^{1/(1-\alpha\theta)} l_t^i(\varsigma)^{(1-\alpha)\theta/(1-a\theta)} - w_t^i(\varsigma) l_t^i(\varsigma) \tag{A.2}$$

Therefore, the problem associated with the solution to the first stage of the game can be expressed as follows:

$$\max_{\left(w_t^i(\varsigma), l_t^i(\varsigma)\right)} \left(\left[w_t^i(\varsigma) - w_t^o \right]^{\lambda\left(\frac{\mu}{1-\mu}\right)} \left\{ (1-\alpha\theta)\left[\frac{(\alpha\theta)^{\alpha\theta} B_t^{i\theta} \Gamma_t^i}{r_t^{\alpha\theta}} \right]^{\left(\frac{1}{1-\alpha\theta}\right)} l_t^i(\varsigma)^{\left[\frac{(1-\alpha)\theta}{1-\alpha\theta} + (1-\lambda)\left(\frac{\mu}{1-\mu}\right)\right]} - w_t^i(\varsigma) l_t^i(\varsigma)^{1+(1-\lambda)\left(\frac{\mu}{1-\mu}\right)} \right\} \right) \tag{A.3}$$

subject to the union and producer participation constraints:

$$w_t^i(\varsigma) > w_t^o \tag{A.4}$$

$$(1-\alpha\theta)\left[\frac{(\alpha\theta)^{\alpha\theta} B_t^{i\theta} \Gamma_t^i}{r_t^{\alpha\theta}} \right]^{1/(1-\alpha)} l_t^i(\varsigma)^{(1-\alpha)\theta/(1-a\theta)} > w_t^i(\varsigma) l_t^i(\varsigma) \tag{A.5}$$

To conserve notation, this problem can be re-stated as follows:

$$\max_{(x_1, x_2) > \left(A_1, \left(\frac{A_2}{x_1}\right)^{1/(\alpha_3-\alpha_2)} \right)} f(x_1, x_2) \tag{A.6}$$

where: $f:(A_1,\infty)x(0,\infty) \to \mathbb{R}$, $f(x_1,x_2) = (x_1 - A_1)^{\alpha_1}(A_2 x_2^{\alpha_2} - x_1 x_2^{\alpha_3})$, $x_1 = w_t^i(\varsigma)$, $x_2 = l_t^i(\varsigma)$,

$A_1 = w_t^o$, $A_2 = (1-\alpha\theta)\left[\frac{(\alpha\theta)^{\alpha\theta} B_t^{i\theta} \Gamma_t^i}{r_t^{\alpha\theta}} \right]^{1/(1-\alpha\theta)}$, $\alpha_1 = \lambda\left(\frac{\mu}{1-\mu}\right)$, $\alpha_2 = \frac{(1-\alpha)\theta}{1-\alpha\theta} + (1-\lambda)\left(\frac{\mu}{1-\mu}\right)$,

$\alpha_3 = 1 + (1-\lambda)\left(\frac{\mu}{1-\mu}\right)$.

Clearly, $A_1, A_2, \alpha_1, \alpha_2, \alpha_3$>0 and $\alpha_3 > \alpha_2$. Now, ignoring temporarily the constraints in (x_1, x_2), since f is differentiable and its domain is an open set, any extreme points of f satisfy the conditions : $f_{x_1} = f_{x_2} = 0$. That is,

$$\alpha_1(A_2 x_2^{\alpha_2} - x_1 x_2^{\alpha_3}) = (x_1 - A_1) x_2^{\alpha_3} \tag{A.7}$$

$$\alpha_2 A_2 x_2^{\alpha_2 - 1} = \alpha_3 x_1 x_2^{\alpha_3 - 1} \tag{A.8}$$

But, the above two-equation system in x_1 and x_2 has the unique solution:

$$x_1^* = \frac{1}{1 - \alpha_1\left(\frac{\alpha_3}{\alpha_2} - 1\right)} A_1 \tag{A.9}$$

$$x_2^* = \left(\frac{\alpha_2 A_2}{\alpha_3 x_1^*}\right)^{1/(\alpha_3 - \alpha_2)} \tag{A.10}$$

Hence, (x_1^*, x_2^*) is the solution to the problem defined by (A.6), provided that: (i) satisfies the participation constraints $(x_1, x_2) > \left(A_1, \left(\frac{A_2}{x_1}\right)^{1/(\alpha_3 - \alpha_2)}\right)$ and (ii) is a local maximum. Next, we show that given ***[R1]***, both of these conditions are satisfied.

To show (i) note that $x_1^* > A_1$ if and only if $\alpha_1\left(\frac{\alpha_3}{\alpha_2} - 1\right)$<1 and $\alpha_1\left(\frac{\alpha_3}{\alpha_2} - 1\right)$<1 if and only if $\alpha_1 < \left(\frac{\alpha_2}{\alpha_3 - \alpha_2}\right)$ or $\lambda\left(\frac{\mu}{1-\mu}\right) < \left[\frac{\frac{(1-\alpha)\theta}{(1-a\theta)} + (1-\lambda)\left(\frac{\mu}{1-\mu}\right)}{\frac{(1-\theta)}{(1-a\theta)}}\right]$ or if and only if ***[R1]*** holds. Also, since $\alpha_3 > \alpha_2$ it is immediate from (A.10), that $x_2^* > \left(\frac{A_2}{x_1^*}\right)^{1/(\alpha_3 - \alpha_2)}$.

To show (ii) it suffices to show that f is strictly concave around (x_1^*, x_2^*), or since f is twice differentiable that $f^*_{x_1 x_1}, f^*_{x_2 x_2} < 0$ and $f^*_{x_1 x_1} f^*_{x_2 x_2} - \left(f^*_{x_1 x_2}\right)^2 > 0$. Using conditions (A.7) and (A.8), that are by construction satisfied by (x_1^*, x_2^*), it is straightforward that:

$$f^*_{x_1x_1} = -(1+\alpha_1)\left(x_1^* - A_1\right)^{(a_1-1)}(x_2^*)^{\alpha_3} < 0$$

$$f^*_{x_2x_2} = -\alpha_2(\frac{\alpha_3}{\alpha_2} - 1)\left(x_1^* - A_1\right)^{a_1}(x_2^*)^{(\alpha_3-2)} < 0, \text{ as } \alpha_3 > \alpha_2,$$

and

$$f^*_{x_1x_1} f^*_{x_2x_2} - \left(f^*_{x_1x_2}\right)^2 =$$
$$= \left(x_1^* - A_1\right)^{(2a_1-1)}(x_2^*)^{(\alpha_3-2)}\{[(1+\alpha_1)[\alpha_3^2 x_1^*(x_2^*)^{\alpha_3} - \alpha_2^2 A_2(x_2^*)^{\alpha_2}] - \alpha_3^2(x_1^* - A_1)(x_2^*)^{\alpha_3}\}.$$

Therefore, $f^*_{x_1x_1} f^*_{x_2x_2} - \left(f^*_{x_1x_2}\right)^2 > 0$ if and only if:

$$[(1+\alpha_1)[\alpha_3^2 x_1^*(x_2^*)^{\alpha_3} - \alpha_2^2 A_2(x_2^*)^{\alpha_2}] - \alpha_3^2(x_1^* - A_1)(x_2^*)^{\alpha_3} > 0.$$

Using (A.9) to substitute for $(x_1^* - A_1)$ in the LHS of the above inequality, it follows that this inequality holds if and only if: $\frac{x_1^*(x_2^*)^{\alpha_3}}{A_2(x_2^*)^{\alpha_2}} > \frac{(1+\alpha_1)\alpha_2^2 + \alpha_1\alpha_3^2}{(1+\alpha_1)\alpha_3^2 + \alpha_1\alpha_3^2}$. But, (A.10) implies that $\frac{x_1^*(x_2^*)^{\alpha_3}}{A_2(x_2^*)^{\alpha_2}} = \frac{\alpha_2}{\alpha_3}$. Therefore, the above inequality holds if and only if:

$\frac{\alpha_2}{\alpha_3} > \frac{(1+\alpha_1)\alpha_2^2 + \alpha_1\alpha_3^2}{(1+\alpha_1)\alpha_3^2 + \alpha_1\alpha_3^2}$. But, then the last inequality holds if and only if:

$$\left(\frac{\alpha_2}{\alpha_3}\right)^2 - \left(1 + \frac{\alpha_1}{1+\alpha_1}\right)\left(\frac{\alpha_2}{\alpha_3}\right) + \left(\frac{\alpha_1}{1+\alpha_1}\right) < 0, \text{ or } \left[\left(\frac{\alpha_2}{\alpha_3}\right) - 1\right]\left[\left(\frac{\alpha_2}{\alpha_3}\right) - \left(\frac{\alpha_1}{1+\alpha_1}\right)\right] < 0.$$

Then, since $\alpha_3 > \alpha_2$ the last inequality holds if and only if $\left(\frac{\alpha_2}{\alpha_3}\right) > \left(\frac{\alpha_1}{1+\alpha_1}\right)$, or $\alpha_1\left(\frac{\alpha_3}{\alpha_2} - 1\right) < 1$, which, as already shown, is equivalent to restriction ***[R1]***. Hence, given ***[R1]***, $f^*_{x_1x_1} f^*_{x_2x_2} - \left(f^*_{x_1x_2}\right)^2 > 0$. And, therefore (x_1^*, x_2^*) is a local maximum of $f(x_1, x_2)$ It follows that given ***[R1]***, (x_1^*, x_2^*) is the unique global maximum of $f(x_1, x_2)$ and satisfies the participation constraints, $(x_1, x_2) > \left(A_1, \left(\frac{A_2}{x_1}\right)^{1/(\alpha_3-\alpha_2)}\right)$. Hence, (x_1^*, x_2^*) is a unique solution to (A.6).

Now, returning to the original notation, observe that, in view of the definition of ν in (I.23), (A.9) implies (I.20). Further, (A.10) implies:

$$(1-\alpha\theta)\left[\frac{\frac{(1-\alpha)\theta}{1-\alpha\theta}+(1-\lambda)\left(\frac{\mu}{1-\mu}\right)}{1+(1-\lambda)\left(\frac{\mu}{1-\mu}\right)}\right]\left[\frac{(\alpha\theta)^{\alpha\theta}B_t^{i\theta}\Gamma_t^i}{r_t^{\alpha\theta}}\right]^{1/(1-\alpha\theta)} l_t^i(\varsigma)^{(1-\alpha)\theta/(1-\alpha\theta)} = w_t^i(\varsigma)l_t^i(\varsigma)$$

The latter, in view of (A.2) and (I.18), implies that:

$$(1-\alpha\theta)\left[\frac{\frac{(1-\alpha)\theta}{1-\alpha\theta}+(1-\lambda)\left(\frac{\mu}{1-\mu}\right)}{1+(1-\lambda)\left(\frac{\mu}{1-\mu}\right)}\right]p_t^i(\varsigma)y_t^i(\varsigma) = w_t^i(\varsigma)l_t^i(\varsigma) \tag{A.11}$$

But, in view of the definition in view of the definitions of ν in (I.23) and ξ in (I.24),

$$(1-\alpha\theta)\left[\frac{\frac{(1-\alpha)\theta}{1-\alpha\theta}+(1-\lambda)\left(\frac{\mu}{1-\mu}\right)}{1+(1-\lambda)\left(\frac{\mu}{1-\mu}\right)}\right] = (1-\alpha)\nu\xi \tag{A.12}$$

Therefore, (A.11) and (A.12) imply (I.19). Finally, in view of the definition of κ in (I.22), (I.21) follows from the definition of profits in (I.14) and (I.18) and (I.19). Finally, to show that κ >0, note that in view of the definition of κ in (I.22) and (A.12),

$$\kappa = (1-\alpha\theta)\left(1-\frac{1-\alpha}{1-\alpha\theta}\nu\xi\right) = (1-\alpha\theta)\left[1-\frac{\frac{(1-\alpha)\theta}{1-\alpha\theta}+(1-\lambda)\left(\frac{\mu}{1-\mu}\right)}{1+(1-\lambda)\left(\frac{\mu}{1-\mu}\right)}\right]$$

And, since $\alpha,\theta \in (0,1)$, it is straightforward from the above equation that κ >0.

This completes the proof of Proposition 1.

Proof of Proposition 2:

Part a:

In view of symmetry characterizing the private sector equilibrium, industry demand functions (I.5) and (I.6) imply:

$$\left(\frac{p_t^i}{p_t^o}\right)=\left(\frac{\Gamma_t^i}{\Gamma_t^o}\right)\left(\frac{y_t^i}{y_t^o}\right)^{(\theta-1)} = \left(\frac{\chi_t}{1-\chi_t}\right)\left(\frac{Y_t^i}{Y_t^o}\right)^{(\phi-\theta)}\left(\frac{y_t^i}{y_t^o}\right)^{(\theta-1)}$$

From the sectoral aggregation functions (I.2) and (I.3), $Y_t^i=\chi_t^{1/\theta}y_t^i$ and $Y_t^o=(1-\chi_t)^{1/\theta}y_t^o$, respectively. Thus, we can re-express the above equation as:

$$\left(\frac{p_t^i}{p_t^o}\right)=\left(\frac{\chi_t}{1-\chi_t}\right)^{\phi/\theta}\left(\frac{y_t^i}{y_t^o}\right)^{(\phi-1)} \tag{A.13}$$

From the industry capital input demand equations (I.11) and (I.18):

$\left(\frac{k_t^i}{k_t^o}\right)=\theta\left(\frac{p_t^i}{p_t^o}\right)\left(\frac{y_t^i}{y_t^o}\right)$ or, in view of (II.20), $\left(\frac{k_t^i}{k_t^o}\right)=\theta\left(\frac{\chi_t}{1-\chi_t}\right)^{\phi/\theta}\left(\frac{y_t^i}{y_t^o}\right)^{\phi}$

Now, multiplying both hand sides of the above equation by $\frac{\chi_t}{1-\chi_t}$, we have:

$$\left[\frac{\chi_t k_t^i}{(1-\chi_t)k_t^o}\right]=\theta\left(\frac{\chi_t}{1-\chi_t}\right)^{1+\frac{\phi(1-\theta)}{\theta}}\left[\frac{\chi_t y_t^i}{(1-\chi_t)y_t^o}\right]^{\phi} \tag{A.14}$$

Likewise, from the industry labor input demand equations (I.12) and (I.18), in view of the insiders' wage premium equation (I.20) and the labor market equilibrium conditions (II.2) and (II.3), we have

$$\left[\frac{\chi_t h_t^i}{(1-\chi_t)h_t^o}\right]=\xi\left(\frac{\chi_t}{1-\chi_t}\right)^{1+\frac{\phi(1-\theta)}{\theta}}\left[\frac{\chi_t y_t^i}{(1-\chi_t)y_t^o}\right]^{\phi} \tag{A.15}$$

But, from the industry output supply functions (I.9) and (I.13) and in view of the fact that these functions are homogeneous of degree one, we have:

$$\left[\frac{\chi_t y_t^i}{(1-\chi_t)y_t^o}\right]=\left(\frac{B_t^i}{B_t^o}\right)\left[\frac{\chi_t k_t^i}{(1-\chi_t)k_t^o}\right]^{\alpha}\left[\frac{\chi_t h_t^i}{(1-\chi_t)h_t^o}\right]^{(1-a)}$$

The last equation, in view of (A.14) and (A.15), gives the important result:

$$\left[\frac{\chi_t y_t^i}{(1-\chi_t) y_t^o}\right] = \left[\theta^\alpha \xi^{(1-\alpha)} \left(\frac{B_t^i}{B_t^o}\right)\right]^{1/(1-\phi)} \left(\frac{\chi_t}{1-\chi_t}\right)^{1+\frac{\phi}{\theta(1-\phi)}} \qquad \text{(A.16)}$$

And, in view of the definition of $\Delta_t(\chi_t)$ in (II.13), (A.16) yields (II.9). Now, in view of (II.9), (A.14) and (A.15) give (II.5) and (II.7), respectively. Moreover, (II.5) and the market equilibrium for capital (II.1) imply (II.6); and, (II.7) and the household time constraint (I.26) imply (II.8). Furthermore, the supply of output in the outsiders' industries (I.9), in view of (II.6) and (II.8) yields (II.10). Finally, the price ratio in (II.11) follows from (A.13) and (A.16).

Part b

Combining the industry output demand and the demand for capital input in the outsiders' sector, (I.6) and (I.11), respectively, we have:

$$r_t = \frac{\alpha\left(1-\chi_t\right) \tilde{A}_t^\phi y_t^{(1-\phi)} Y_t^{o(\phi-\theta)} y_t^{o\theta}}{k_t^o} = \alpha\left(1-\chi_t\right) A_t^\phi \left(\frac{Y_t^o}{y_t}\right)^\phi \left(\frac{y_t^o}{Y_t^o}\right)^\phi \left(\frac{y_t}{k_t^o}\right) \qquad \text{(A.17)}$$

Consider the expression $A_t^\phi \left(\frac{Y_t^o}{y_t}\right)^\phi \left(\frac{y_t^o}{Y_t^o}\right)^\phi$. Using the aggregate output supply (I.1) and the industry aggregation function for the outsiders' sector (I.3), we have:

$$\begin{aligned} A_t^\phi \left(\frac{Y_t^o}{y_t}\right)^\phi \left(\frac{y_t^o}{Y_t^o}\right)^\theta &= \frac{1}{\left[1+\left(\frac{\chi_t}{1-\chi_t}\right)^{1+\frac{\phi}{\theta}} \left(\frac{y_t^i}{y_t^o}\right)^\phi\right](1-\chi_t)} \\ &= \frac{1}{\left[1+\left(\frac{\chi_t}{1-\chi_t}\right)^{1-\phi+\frac{\phi}{\theta}} \left(\frac{\chi_t y_t^i}{(1-\chi_t) y_t^o}\right)^\phi\right](1-\chi_t)} \\ &= \frac{1}{\left[1+\Delta_t\left(\chi_t\right)\right](1-\chi_t)} \end{aligned} \qquad \text{(A.18)}$$

Where, the last equation follows from results established in the proof of Part a. Therefore, (A.17) and (A.18) imply:

$$r_t = \alpha \frac{1}{\left[1+\Delta_t(\chi_t)\right]} \frac{y_t}{(1-\chi_t) k_t^o} \qquad \text{(A.19)}$$

Now, in view of (II.6) and the definition of $\widehat{\omega}(x)$ in (II.18), (A.19) yields (II.14). Following a similar procedure, we can establish (II.15). To establish (II.16), we use the profits in the representative insiders' industry derived in Proposition 1 (i.e., (I.21)) to get: $\chi_t \pi_t^i = \kappa p_t^i \chi_t y_t^i$, which, in view of (I.19), (II.7), (II.8), and (II.15) leads to (II.16). Finally, the final good supply, (II.17), follows from the final good production function, (I.1), by a similar procedure as in the proof of (II.14).

Part c:

Condition (II.23) follows from the household intratemporal condition (I.31) and the wage equation (II.15). Condition (II.24) follows from the household Euler condition (I.32) and the real rental cost of capital equation (II.14). And, the government budget constraint equation (II.25) follows from (II.22) and (II.23), using results established in Parts a and b, above.

Finally, it remains to show that , given z_t and government policy variables $\left(\bar{\psi}_t, \tau_t^k, \chi_t\right)$, the laws of motion of the aggregate state of the private sector equilibrium depend only on the aggregate state of the private sector (k_t, h_t) and (ii) they are characterized, completely, in terms of: the transversality condition (I.33); the initial condition, $k_0 \in (0, \infty)$ given; the resource constraint (II.4) and conditions (II.23)-(II.24). This simply follows from the fact that (II.4) can be used to express household consumption, c_t, and the labor income tax rate, τ_t^L, in terms of the aggregate state (k_t, h_t). Hence, it follows that all variables used to define the private sector equilibrium can be expressed exclusively in terms of the aggregate state, the exogenous variables z_t and the policy variables $\left(\bar{\psi}_t, \tau_t^k, \chi_t\right)$.

This completes the proof of Proposition 2.

Proof of Proposition 3

The proof is in two parts. First, for $\phi \in (-\infty,1)\setminus\{0\}$ and then for $\phi = 0$.

I. The Case where $\phi \in (-\infty,1)\setminus\{0\}$:

Properties of $\Delta(\chi)$: Recall that: $\Delta(\chi) \equiv (\theta^{\alpha}\xi^{(1-a)}B)^{\phi/(1-\phi)}\left(\frac{\chi}{1-\chi}\right)^{1+\frac{\phi}{\theta(1-\phi)}} > 0; \quad \forall \chi \in (0,1)$. Let $x = \frac{\chi}{1-\chi}$ and note that:

$$\Delta'(x) = \left[1+\frac{\phi}{\theta(1-\phi)}\right]\frac{\Delta(x)}{x}\begin{cases} >0, & when \quad \phi \in \left(-\frac{\theta}{1-\theta},1\right) \\ =0, & when \quad \phi = -\frac{\theta}{1-\theta} \\ <0, & when \quad \phi \in \left(-\infty,-\frac{\theta}{1-\theta}\right) \end{cases}$$

$$\Delta''(x) = \frac{\phi}{\theta(1-\phi)}\left[1+\frac{\phi}{\theta(1-\phi)}\right]\frac{\Delta(x)}{x^2}\begin{cases} <0, & when \quad \phi \in \left(-\frac{\theta}{1-\theta},1\right) \\ =0, & when \quad \phi = -\frac{\theta}{1-\theta} \\ >0, & when \quad \phi \in \left(-\infty,-\frac{\theta}{1-\theta}\right) \end{cases}$$

$$\lim_{\chi \to 0}\Delta(\chi) = \begin{cases} 0, & when\ \phi \in \left(-\frac{\theta}{1-\theta},1\right) \\ +\infty, & when\ \phi \in \left(-\infty,-\frac{\theta}{1-\theta}\right) \end{cases} \quad \text{and} \quad \lim_{\chi \to 1}\Delta(\chi) = \begin{cases} +\infty, & when\ \phi \in \left(-\frac{\theta}{1-\theta},1\right) \\ 0, & when\ \phi \in \left(-\infty,-\frac{\theta}{1-\theta}\right) \end{cases}$$

And, when $\phi = -\frac{\theta}{1-\theta}$, $\Delta(\chi) \equiv \left(\theta^{\alpha}\xi^{(1-a)}B\right)^{-\theta}; \quad \forall \chi \in (0,1)$.

Now, the stage has been set to establish the properties of the capital, labor, and efficiency wedges, $\frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)}$, $\frac{\breve{\omega}(\chi)}{\breve{\omega}^*(\chi)}$ and $\frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)}$, respectively.

(a) Capital Wedge, $\frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)}$:

From (II.18) and (III.14), the capital wedge is defined by: $\frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)} = \widehat{\omega}(\chi) = \frac{1+\theta\Delta(\chi)}{1+\Delta(\chi)}$.

Clearly, since $\theta \in (0,1)$ and $\Delta(\chi) > 0, \forall \chi \in (0,1)$, $\frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)} : (0,1) \to (0,1)$. Further, given the properties of $\Delta(x)$, established above, it is straightforward that:

$$\frac{d\left[\frac{\widehat{\omega}(x)}{\widehat{\omega}^*(x)}\right]}{dx} = -(1-\theta)\frac{\Delta'(x)}{[1+\Delta(x)]^2}\begin{cases} < 0, & if \quad \phi \in (-\frac{\theta}{1-\theta}, 1) \\ = 0, & if \quad \phi = -\frac{\theta}{1-\theta} \\ > 0, & if \quad \phi \in (-\infty, -\frac{\theta}{1-\theta}) \end{cases}$$

Since $x = \frac{\chi}{1-\chi}$ is a strictly increasing function of χ, the sign of the above derivative is the same as that of $\widehat{\omega}'(\chi)$. Moreover, given the properties of $\Delta(\chi)$, it follows by L'Hospital's rule that:

$$\lim_{\chi \to 0} \frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)} = \begin{cases} 1, & if \quad \phi \in (-\frac{\theta}{1-\theta}, 1) \\ \theta, & if \quad \phi \in (-\infty, -\frac{\theta}{1-\theta}) \end{cases} \text{ and } \lim_{\chi \to 1} \frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)} = \begin{cases} \theta, & if \quad \phi \in (-\frac{\theta}{1-\theta}, 1) \\ 1, & if \quad \phi \in (-\infty, -\frac{\theta}{1-\theta}) \end{cases}.$$

Finally, when $\phi = -\frac{\theta}{1-\theta}$, $\frac{\widehat{\omega}(\chi)}{\widehat{\omega}^*(\chi)} = \frac{1+\theta\left[\theta^{\alpha}\xi^{(1-a)}\left(\frac{B^i}{B^0}\right)\right]^{-\theta}}{1+\left[\theta^{\alpha}\xi^{(1-a)}\left(\frac{B^i}{B^0}\right)\right]^{-\theta}}, \forall \chi \in (0,1).$

(b) Labor Wedge, $\frac{\breve{\omega}(\chi)}{\breve{\omega}^*(\chi)}$: Given **[R2],** $\xi \in (0,1)$. It follows that the proof of the properties of the labor wedge is identical to the proof of the properties of the capital wedge.

(c) Efficiency Wedge, $\frac{\bar{\omega}_t(\chi_t)}{\bar{\omega}_t^*(\chi_t)}$: From (II.20) and (III.16), suppressing time subscripts:

$$\frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)} = \frac{\left[1+\Delta(\chi)\right]^{1/\phi}}{[1+\theta\Delta(\chi)]^{\alpha}[1+\xi\Delta(\chi)]^{(1-\alpha)}\left[1+\Delta^*(\chi)\right]^{1-\phi/\phi}} \tag{A.20}$$

And, in view of (II.13) and (III.9), (A.20) implies that:

$$\frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)} = \frac{\left[1+\Delta(\chi)\right]^{1/\phi}}{[1+\theta\Delta(\chi)]^{\alpha}[1+\xi\Delta(\chi)]^{(1-\alpha)}\left[1+(\theta^{\alpha}\xi^{(1-a)})^{-\phi/(1-\phi)}\Delta(\chi)\right]^{1-\phi/\phi}} \tag{A.21}$$

where:

$$\upsilon \equiv \left(\theta^{\alpha}\xi^{(1-a)}\right)^{-\phi/(1-\phi)} \tag{A.22}$$

Since $\Delta(\cdot):(0,1)\to(0,+\infty)$ and θ,ξ >0, $\frac{\bar{\omega}(\cdot)}{\bar{\omega}^*(\cdot)}:(0,1)\to(0,+\infty)$. Moreover, it follows from the facts:

$$\lim_{\chi\to 0}\Delta(\chi)=\begin{cases}0, & when\ \phi\in(-\frac{\theta}{1-\theta},1)\\ +\infty, & when\ \phi\in(-\infty,-\frac{\theta}{1-\theta})\end{cases} \quad \text{and} \quad \lim_{\chi\to 1}\Delta(\chi)=\begin{cases}+\infty, & when\ \phi\in(-\frac{\theta}{1-\theta},1)\\ 0, & when\ \phi\in(-\infty,-\frac{\theta}{1-\theta})\end{cases}$$

that: $\lim_{\chi\to 0}\frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)} = \lim_{\chi\to 1}\frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)} = 1$. In particular, in the cases where $\Delta(\chi)\to+\infty$, the preceding results follow by application of L'Hospital's Rule. For example, when $\phi\in\left(-\frac{\theta}{1-\theta},1\right)$ and with an obvious abuse of notation,

$$\lim_{\Delta\to+\infty}\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}=\frac{\lim\limits_{\Delta\to+\infty}\left\{ d\left[\frac{1+\Delta}{1+\upsilon\Delta}\right]^{\left(\frac{1}{\phi}\right)} \Big/ d\Delta \right\}}{\lim\limits_{\Delta\to+\infty}\left\{ d\left[\frac{1+\upsilon\Delta}{(1+\theta\Delta)^{\alpha}(1+\xi\Delta)^{1-\alpha}}\right] \Big/ d\Delta \right\}}=\frac{\left[\frac{1}{\upsilon}\right]^{\left(\frac{1}{\phi}\right)}}{\frac{\upsilon}{\theta^{\alpha}\xi^{(1-a)}}}=\theta^0\xi^0=1$$

Finally, to characterize the sign of the derivative of $\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}$ with respect to χ, it follows from (A.21) that:

$$\frac{d\left[\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}\right] \Big/ d\chi}{\left[\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}\right]}=\left(\frac{1}{\phi}\right)\Delta'(\chi)\left[\frac{1}{1+\Delta(\chi)}-\frac{\alpha\phi\theta}{1+\theta\Delta(\chi)}-\frac{(1-\alpha)\phi\xi}{1+\xi\Delta(\chi)}-\frac{\upsilon(1-\phi)}{1+\Delta(\chi)}\right]$$

Then, it follows from the above equation, after some straightforward algebra, that:

$$sign\left\{\frac{d\left[\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}\right]}{d\chi}\right\}=sign(\phi)\ \ sign\left[\Delta'(\chi)\right]\ \ sign(T_2)\ \ sign\left\{\left[\Delta(\chi)\right]^2+\left(\frac{T_1}{T_2}\right)\left[\Delta(\chi)\right]+\left(\frac{T_0}{T_2}\right)\right\} \quad \text{(A.23)}$$

where:

$$\begin{aligned}
T_2 &\equiv \theta\xi(1-\upsilon)+\{[\alpha\xi+(1-\alpha)\theta]\upsilon-\theta\xi\}\phi \\
T_1 &\equiv \theta[1-\alpha(1+\xi+\upsilon)\phi]+\xi[1-(1-\alpha)(1+\theta+\upsilon)\phi]+\upsilon[1-(1+\theta+\xi)(1-\phi)] \qquad \text{(A.24)} \\
T_0 &\equiv 1-\upsilon+\{\upsilon-[a\theta+(1-\alpha)\xi]\}\phi
\end{aligned}$$

Next, we show that for all $\phi\in(-\infty,1)\setminus\{0\}$ such that

[R3] $$\frac{1-\upsilon}{1-\frac{\alpha\xi+(1-a)\theta}{\theta\xi}\upsilon}<\phi<\frac{1-\upsilon}{[\alpha\theta+(1-a)\xi]-\upsilon}$$

is satisfied, the following are true:

(i) When $\phi\in(0,1)$, $T_2>0$ and $T_0<0$.

(ii) When $\phi\in(-\infty,0)$, $T_2<0$ and $T_0>0$.

To show (i), first note that given **[R2],** $\theta, \xi, [\alpha\theta+(1-a)\xi]\in(0,1)$ and

$\upsilon \equiv \left(\theta^{\alpha}\xi^{(1-a)}\right)^{-\phi/(1-\phi)} \in \begin{cases} (\theta\xi,1), & \phi \in (-\infty,0) \\ (1,\frac{1}{\theta\xi}), & \phi \in (0,1) \end{cases}$. Hence, when $\phi \in (0,1)$, the second inequality in **[R3],** implies $0 < \phi < \frac{\upsilon - 1}{\upsilon - [\alpha\theta + (1-a)\xi]} < 1$ and therefore,

$T_0 = 1 - \upsilon + \{\upsilon - [\alpha\theta + (1-a)\xi]\} < 0$.

Further, it follows by the facts used to establish T_0 <0, that $\frac{\alpha\xi + (1-a)\theta}{\theta\xi}\upsilon$ >1, so that the first inequality in **[R3]** implies $0 < \frac{1-\upsilon}{1 - \frac{\alpha\xi + (1-a)\theta}{\theta\xi}\upsilon} < \phi < 1$ and therefore

$T_2 = \theta\xi(1-\upsilon) + \{[\alpha\xi + (1-\alpha)\theta]\upsilon - \theta\xi\}\phi$ >0.

To show (ii), first note that in this case $0 < \left(\frac{-\phi}{1-\phi}\right)$, $\upsilon < 1$. Then, it follows by the strict concavity of the logarithmic function that:

$$\ln\left[a\theta + (1-\alpha)\xi\right] > a\ln\theta + (1-\alpha)\ln\xi > \left(\frac{-\phi}{1-\phi}\right)\left[a\ln\theta + (1-\alpha)\ln\xi\right] = \ln\left(\theta^{\alpha}\xi^{(1-\alpha)}\right)^{\left(\frac{-\phi}{1-\phi}\right)} = \ln\upsilon$$

Hence, $[a\theta + (1-\alpha)\xi] > \upsilon$. It follows that, in this case, 0<$\phi < \frac{1-\upsilon}{[\alpha\theta + (1-a)\xi] - \upsilon}$<1 and therefore, $T_0 = 1 - \upsilon + \{\upsilon - [\alpha\theta + (1-a)\xi]\} > 0$. (That is, in this case the second inequality in **[R3]** is always satisfied.)

Next, using again the strict concavity of the logarithmic function, we have:

$$\ln\left[a\left(\frac{1}{\theta}\right) + (1-\alpha)\left(\frac{1}{\xi}\right)\right] > a\ln\left(\frac{1}{\theta}\right) + (1-\alpha)\ln\left(\frac{1}{\xi}\right) > \left(\frac{-\phi}{1-\phi}\right)\left[a\ln\theta + (1-\alpha)\ln\xi\right] = \ln\left(\theta^{\alpha}\xi^{(1-\alpha)}\right)^{\left(\frac{-\phi}{1-\phi}\right)} = \ln\upsilon$$

Hence, $\frac{a\xi + (1-\alpha)\theta}{\theta\xi} = a\left(\frac{1}{\theta}\right) + (1-\alpha)\left(\frac{1}{\xi}\right) > \upsilon$. Thus, it follows from, the first inequality in **[R3]** that $\frac{1-\upsilon}{1 - \frac{\alpha\xi + (1-a)\theta}{\theta\xi}\upsilon} < \phi < 0$ or $\frac{\upsilon - 1}{\frac{\alpha\xi + (1-a)\theta}{\theta\xi}\upsilon - 1} < \phi < 0$ and therefore

$T_2 = \theta\xi(1-\upsilon) + \{[\alpha\xi + (1-\alpha)\theta]\upsilon - \theta\xi\}\phi$<0.

Applying the preceding results to (A.23), we can conclude as follows: Next, we show that for all $\phi \in (-\infty,1) \setminus \{0\}$ such that **[R3]** holds:

$$sign\left\{\frac{d\left[\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}\right]}{d\chi}\right\}=\begin{cases} sign\left\{[\Delta(\chi)]^2+\left(\frac{T_1}{T_2}\right)[\Delta(\chi)]+\left(\frac{T_0}{T_2}\right)\right\}, when \quad \phi\in(-\frac{\theta}{1-\theta},1) \\ -sign\left\{[\Delta(\chi)]^2+\left(\frac{T_1}{T_2}\right)[\Delta(\chi)]+\left(\frac{T_0}{T_2}\right)\right\}, when \quad \phi\in(-\infty,-\frac{\theta}{1-\theta}) \end{cases} \quad (A.25)$$

where $\left(\frac{T_0}{T_2}\right)<0$. But, then the roots of the quadratic in the RHS of (A.25), are real numbers of opposite sign. Let these roots be denoted by $D_+>0$ and $D_-<0$. It follows that the quadratic can be factored as follows:

$$[\Delta(\chi)]^2+\left(\frac{T_1}{T_2}\right)[\Delta(\chi D)]+\left(\frac{T_0}{T_2}\right)=[\Delta(\chi)-D_+][\Delta(\chi)-D_-].$$

Therefore, (A.25) implies:

$$sign\left\{\frac{d\left[\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}\right]}{d\chi}\right\}=\begin{cases} sign[\Delta(\chi)-D_+], when \quad \phi\in\left(-\frac{\theta}{1-\theta},1\right) \\ sign[D_+-\Delta(\chi)], when \quad \phi\in\left(-\infty,-\frac{\theta}{1-\theta}\right) \end{cases}$$

Recall that $\Delta(\cdot):(0,1)\to(0,+\infty)$ is strictly increasing when $\phi\in\left(-\frac{\theta}{1-\theta},1\right)$, constant for $\phi=-\frac{\theta}{1-\theta}$ and strictly decreasing for $\phi\in\left(-\infty,-\frac{\theta}{1-\theta}\right)$. Moreover,

$$\lim_{\chi\to 0}\Delta(\chi)=\begin{cases} 0, \quad when\ \phi\in(-\frac{\theta}{1-\theta},1) \\ +\infty, when\ \phi\in(-\infty,-\frac{\theta}{1-\theta}) \end{cases} \quad \text{and} \quad \lim_{\chi\to 1}\Delta(\chi)=\begin{cases} +\infty, \quad when\ \phi\in\left(-\frac{\theta}{1-\theta},1\right) \\ 0, \quad when\ \phi\in\left(-\infty,-\frac{\theta}{1-\theta}\right) \end{cases}.$$

Hence, when $\phi\in\left(-\frac{\theta}{1-\theta},1\right)$,

$$\frac{d\left[\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}\right]}{d\chi}\begin{cases} <0, \Delta(\chi)<D_+ \\ =0, \Delta(\chi)=D_+ \\ >0, \Delta(\chi)>D_+ \end{cases} \text{and} \quad \frac{d\left[\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}\right]}{d\chi}\begin{cases} <0, \Delta(\chi)>D_+ \\ =0, \Delta(\chi)=D_+ \\ >0, \Delta(\chi)<D_+ \end{cases} \text{when } \phi\in\left(-\infty,-\frac{\theta}{1-\theta}\right).$$

Since there is a unique $\chi_+\in(0,1)\ni\Delta^{-1}(D_+)=\chi_+$. Abstracting from the case, $\phi=-\frac{\theta}{1-\theta}$, where $\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}$ is a positive constant smaller than one, defined by (A.20), it follows that for all

$\phi \in (-\infty,1) \setminus \left\{-\frac{\theta}{1-\theta}, 0\right\}$, such that **[R3]** holds, there exists an $\chi_+ \in (0,1) \ni$

$$\frac{d\left[\frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)}\right]}{d\chi} \begin{cases} <0, & when \quad \chi < \chi_+ \\ =0, & when \quad \chi = \chi_+ \\ >0, & when \quad \chi > \chi_+ \end{cases}.$$

Finally, combining this result with the previously established results that $\lim_{\chi \to 0} \frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)} = \lim_{\chi \to 1} \frac{\bar{\varpi}(\chi)}{\bar{\varpi}^*(\chi)} = 1$, it is clear that under the stated assumption $\frac{\bar{\varpi}(\cdot)}{\bar{\varpi}^*(\cdot)} : (0,1) \to (0,1)$, for all $\phi \in (-\infty,1) \setminus \{0\}$.

II. The Case where $\phi = 0$:

As first shown in the pioneering work of Arrow et al. (1961), in this case the CES production function in (I.1) takes the Cobb-Douglas form:

$$y_t = \tilde{A}_t \left(\mathrm{Y}_t^i\right)^{\chi_t} \left(\mathrm{Y}_t^o\right)^{1-\chi_t} \tag{A.26}$$

It follows as in the proof of Proposition 2 that PSE conditions (II.5)-(II.12) hold with $\Delta_t(\chi_t)$ given by:

$$\Delta_t(\chi_t) \equiv \left(\frac{\chi_t}{1-\chi_t}\right) \tag{A.27}$$

Likewise, it follows that PSE conditions (II.14) – (II.16) and (II.18) – (II.19) hold. However, the equation for the aggregate production function, (II.17), and the equation for the efficiency wedge related term $\bar{\varpi}_t(\chi_t)$, (II.20), are no longer valid. But, in view of (I.2), (I.3), (I.9) and (I.13), (A.26) and (A.27) imply that the aggregate production function continues to be characterized by (II.17), for:

$$\bar{\varpi}_t(\chi_t) = A_t \frac{\left[\theta^{\alpha} \xi^{(1-\alpha)} B_t\right]^{\chi_t} (1-\chi_t)^{\frac{1-\theta}{\theta}} \Delta_t(\chi_t)^{\frac{\chi_t}{\theta}}}{[1+\theta\Delta(\chi)]^{\alpha}[1+\xi\Delta(\chi)]^{(1-\alpha)}} \tag{A.28}$$

Next, it follows by a similar argument like the one used above, that in the prototype economy in the case $\phi = 0$, the PSE continues to be characterized by (III.1)-(III.21) with (III.9) and (III.16) replaced by:

$$\Delta_t^*(\chi_t) \equiv \left(\frac{\chi_t}{1-\chi_t} \right) \tag{A.29}$$

and

$$\bar{\omega}_t^*(\chi_t) = \frac{A_t B_t^{\chi_t} (1-\chi_t)^{\frac{1-\theta}{\theta}} \Delta^*(\chi_t)^{\frac{\chi_t}{\theta}}}{1+\Delta^*(\chi_t)} = \frac{A_t B_t^{\chi_t} (1-\chi_t)^{\frac{1-\theta}{\theta}} \Delta(\chi_t)^{\frac{\chi_t}{\theta}}}{1+\Delta(\chi_t)} \tag{A.30}$$

respectively. Combining results for the representation of the PSE, in the case $\phi = 0$, in the detailed and the prototype economy, we conclude that: (i) the capital and labor wedges continue to be characterized as in the case where $\phi \in (-\infty,1) \setminus \{0\}$ and (ii) the efficiency wedge is characterized by:

$$\frac{\bar{\omega}(\chi_t)}{\bar{\omega}^*(\chi_t)} = \frac{\left(\theta^{\alpha}\xi^{(1-\alpha)}\right)^{\chi_t}[1+\Delta(\chi_t)]}{[1+\theta\Delta(\chi_t)]^{\alpha}[1+\xi\Delta(\chi_t)]^{(1-\alpha)}} \tag{A.31}$$

Now, in view of (A.27), and the facts: $\Delta(\chi):(0,1) \to (0,+\infty)$, $\lim_{\chi \to 0} \Delta(\chi) = 0$, $\lim_{\chi \to 1} \Delta(\chi) = +\infty$ and $\Delta'(\chi) > 0$, it is straightforward that: $\frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)}:(0,1) \to (0,+\infty)$ and $\lim_{\chi \to 0} \frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)} = \lim_{\chi \to 1} \frac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)} = 1$. Further,

$$\frac{\dfrac{d\left[\dfrac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)}\right]}{d\chi}}{\left[\dfrac{\bar{\omega}(\chi)}{\bar{\omega}^*(\chi)}\right]} = \ln\left[\theta^{\alpha}\xi^{(1-\alpha)}\right] + \Delta'(\chi)\left[\frac{\Delta'(\chi)}{1+\Delta(\chi)} - \frac{\alpha\theta\Delta'(\chi)}{1+\theta\Delta(\chi)} - \frac{(1-\alpha)\xi\Delta'(\chi)}{1+\xi\Delta(\chi)}\right] \tag{A.32}$$

$$= \ln\left[\theta^{\alpha}\xi^{(1-\alpha)}\right] + \Sigma(\chi), \forall \chi \in (0,1)$$

where:

$$\Sigma(\chi) \equiv \frac{[1-\alpha\theta-(1-\alpha)\xi]+[(1-\alpha)\theta+\alpha\xi]\chi}{[1+\Delta(\chi)][1+\theta\Delta(\chi)][1+\xi\Delta(\chi)](1-\chi)^2} \tag{A.33}$$

Then, observe that given **[R2]**, $\theta, \xi \in (0,1)$, so that $\ln\left[\theta^{\alpha}\xi^{(1-\alpha)}\right]<0$ and $\Sigma(\bullet):[0,1) \to (0,+\infty)$ is a strictly increasing function of χ, such that $\Sigma(0) = [1-\alpha\theta-(1-\alpha)\xi]$.

Further, it follows by the definition of differentiable concave functions over a convex set, such as the logarithmic function, that $\ln\theta - \theta,\ \ln\xi - \xi < -1$ and therefore,

$\ln\left[\theta^{\alpha}\xi^{(1-\alpha)}\right]+\Sigma(0)=1-\alpha(\ln\theta-\theta)-(1-\alpha)(\ln\xi-\xi)<0$. Hence, since $\Sigma(\bullet)$ is a strictly increasing function of χ, it follows that there exists a unique $\chi_{+}\in(0,1)$ such that:

there exists an $\chi_{+}\in(0,1)\ni \dfrac{d\left[\dfrac{\bar{\varpi}(\chi)}{\bar{\varpi}^{*}(\chi)}\right]}{d\chi}\begin{cases}<0, & when \quad \chi<\chi_{+}\\ =0, & when \quad \chi=\chi_{+}\\ >0, & when \quad \chi>\chi_{+}\end{cases}$.

Finally, it follows as in the previous case that $\dfrac{\bar{\varpi}(\cdot)}{\bar{\varpi}^{*}(\cdot)}:(0,1)\rightarrow(0,1),$ for $\phi=0.$

This completes the proof of Proposition 3.

APPENDIX II

Table II.A. Private Sector Equilibrium: Steady State Sensitivity with respect to χ
***Detailed economy vs the canonical RBC model ("+")* - Part A: Great Ratios**

	$\chi = 0.20$	$\chi = 0.35$	$\chi = 0.50$
y	0.1626	0.1406	0.1332
y^+	0.4857	0.4857	0.4857
y / y^+	0.3348	0.2894	0.2742
c / y	0.5423	0.5367	0.5308
c^+ / y^+	0.5436	0.5436	0.5436
$(c / y) / (c^+ / y^+)$	0.9976	0.9873	0.9764
k / y	2.4749	2.4537	2.4360
k^+ / y^+	2.5713	2.5713	2.5713
$(k / y) / (k^+ / y^+)$	0.9625	0.9543	0.9474
i / y	0.2227	0.2208	0.2192
i^+ / y^+	0.2314	0.2314	0.2314
$(i / y) / (i^+ / y^+)$	0.9625	0.9543	0.9474
g / y	0.2350	0.2425	0.2500
g^+ / y^+	0.2250	0.2250	0.2250
$(g / y) / (g^+ / y^+)$	1.0444	1.0778	1.1111
h	0.2816	0.2766	0.2723
h^+	0.3029	0.3029	0.3029
h / h^+	0.9298	0.9131	0.8989

Table II.B. Private Sector Equilibrium: Steady State Sensitivity with respect to χ
***Detailed economy vs the canonical RBC model ("+")* - Part B: Wedges**

	$\chi = 0.20$	$\chi = 0.35$	$\chi = 0.50$
$\hat{\varpi}$	0.9625	0.9543	0.9474
$\hat{\varpi}^+$	1.0000	1.0000	1.0000
$\hat{\varpi} / \hat{\varpi}^+$	0.9625	0.9543	0.9474
$\breve{\varpi}$	0.9144	0.8955	0.8798
$\breve{\varpi}^+$	1.0000	1.0000	1.0000
$\breve{\varpi} / \breve{\varpi}^+$	0.9144	0.8955	0.8798
$\bar{\varpi}$	0.5126	0.4722	0.4614
$\bar{\varpi}^+$	1.0000	1.0000	1.0000
$\bar{\varpi} / \bar{\varpi}^+$	0.5126	0.4722	0.4614
$\tilde{\varpi}$	1.0187	1.0229	1.0263
$\tilde{\varpi}^+$	1.0000	1.0000	1.0000
$\tilde{\varpi} / \tilde{\varpi}^+$	1.0187	1.0229	1.0263

APPENDIX III

Figure C3.1: IRFs with respect to *A* – Aggregate State Variables

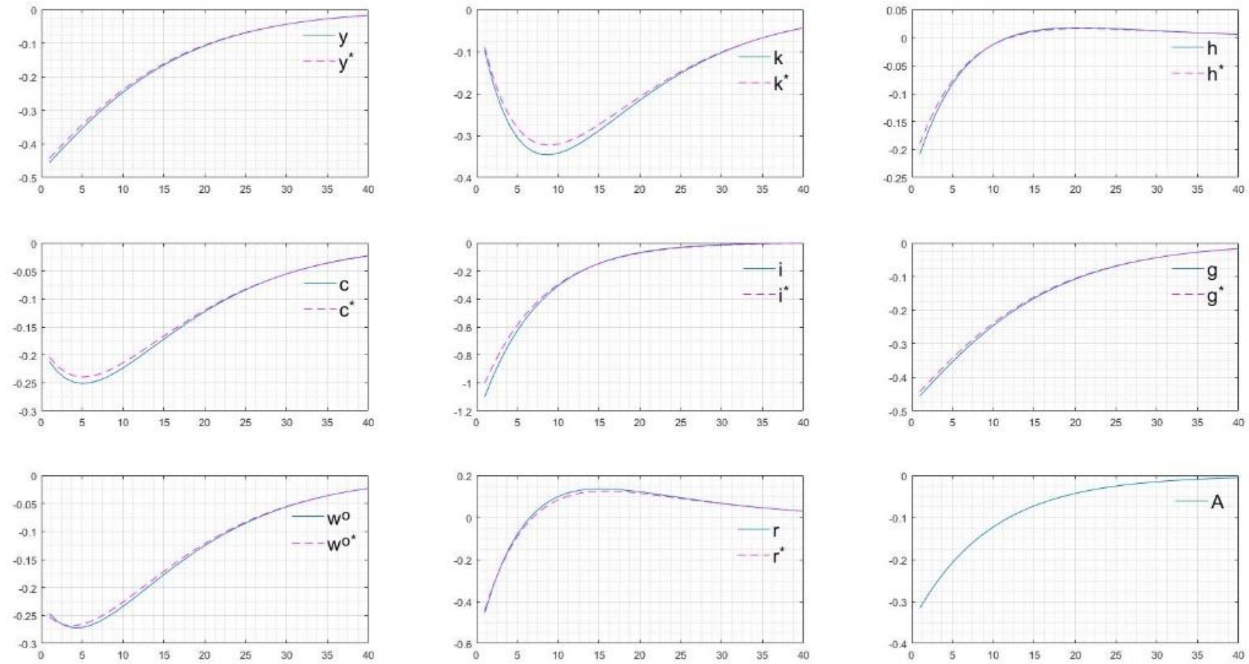


Figure C3.2: IRF with respect to *A* – Wedges and Taxes

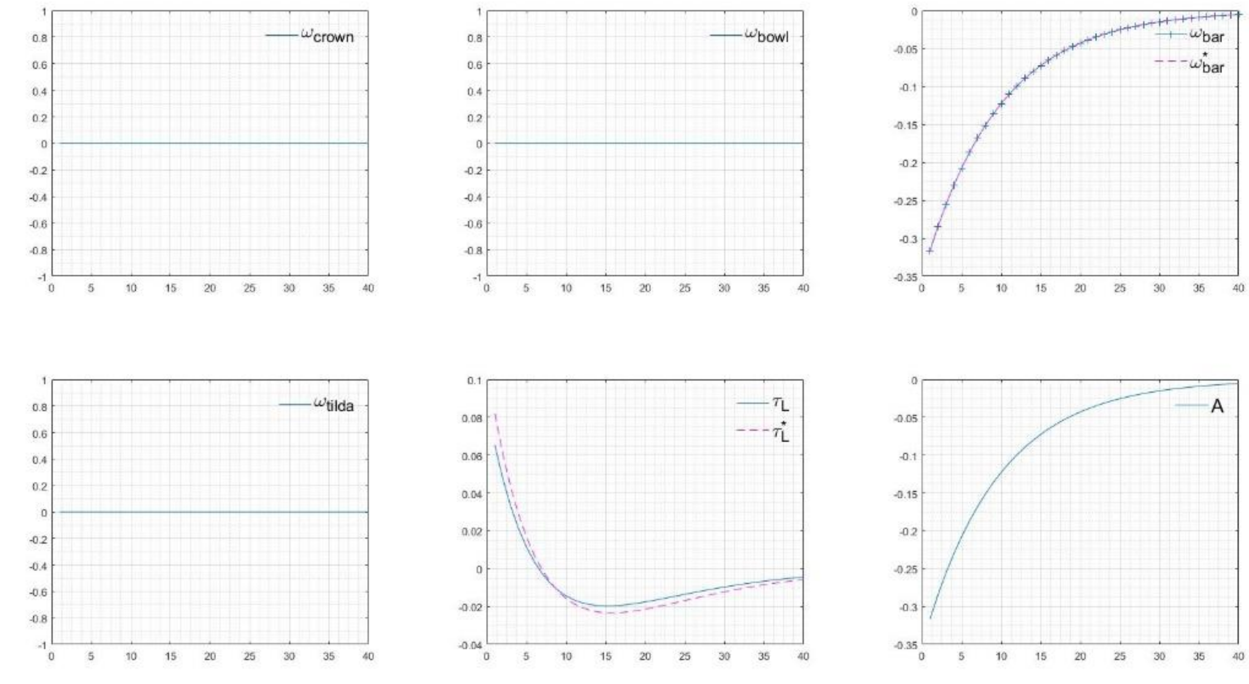


Figure C3.3: IRFs with respect to *A* – Industry Variables

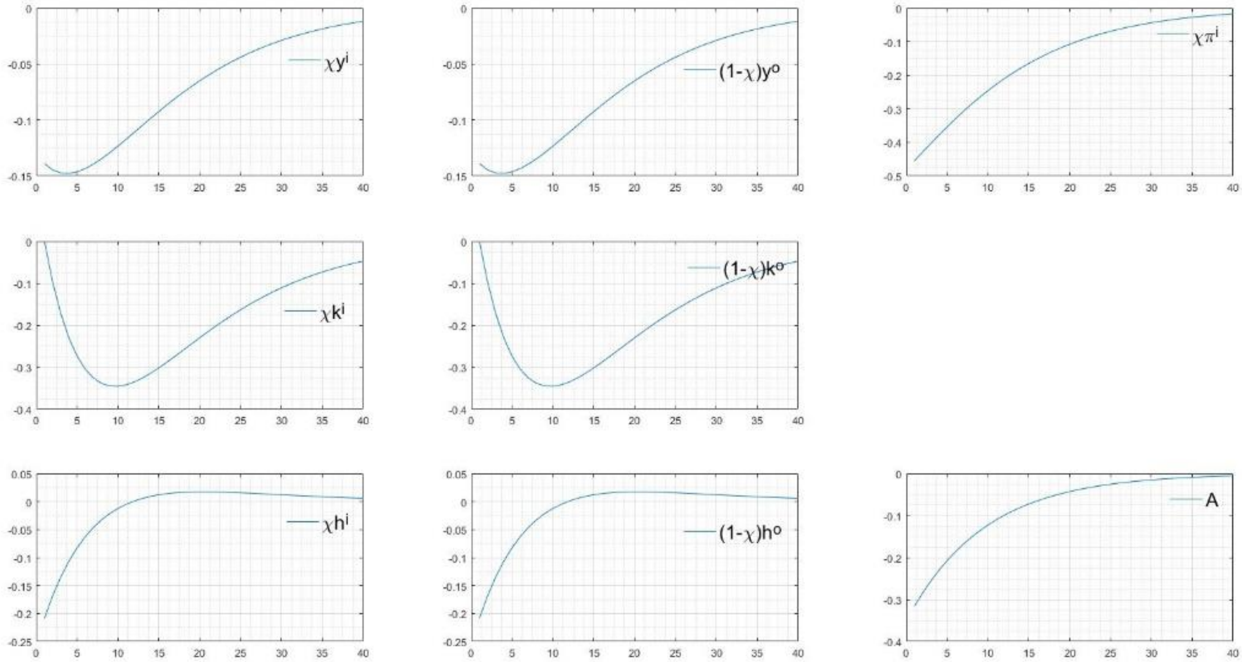


Figure C3.4: IRFs with respect to B^i – Aggregate State Variables

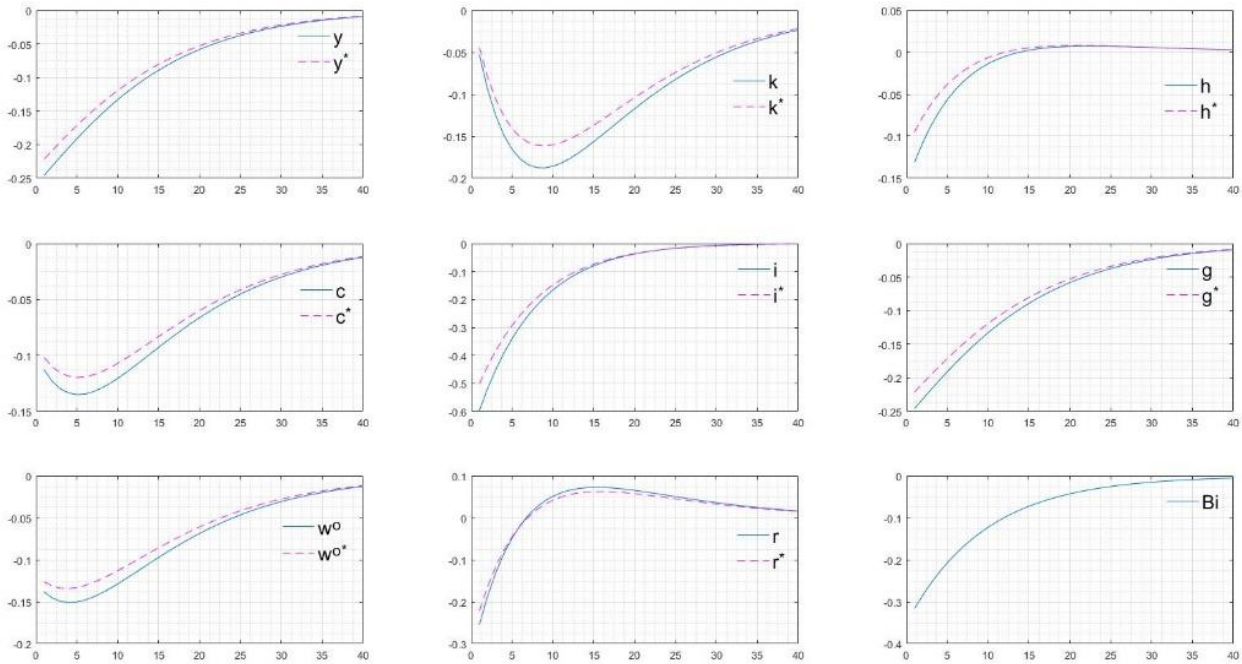


Figure C3.5: IRFs with respect to B^i – Wedges and Taxes

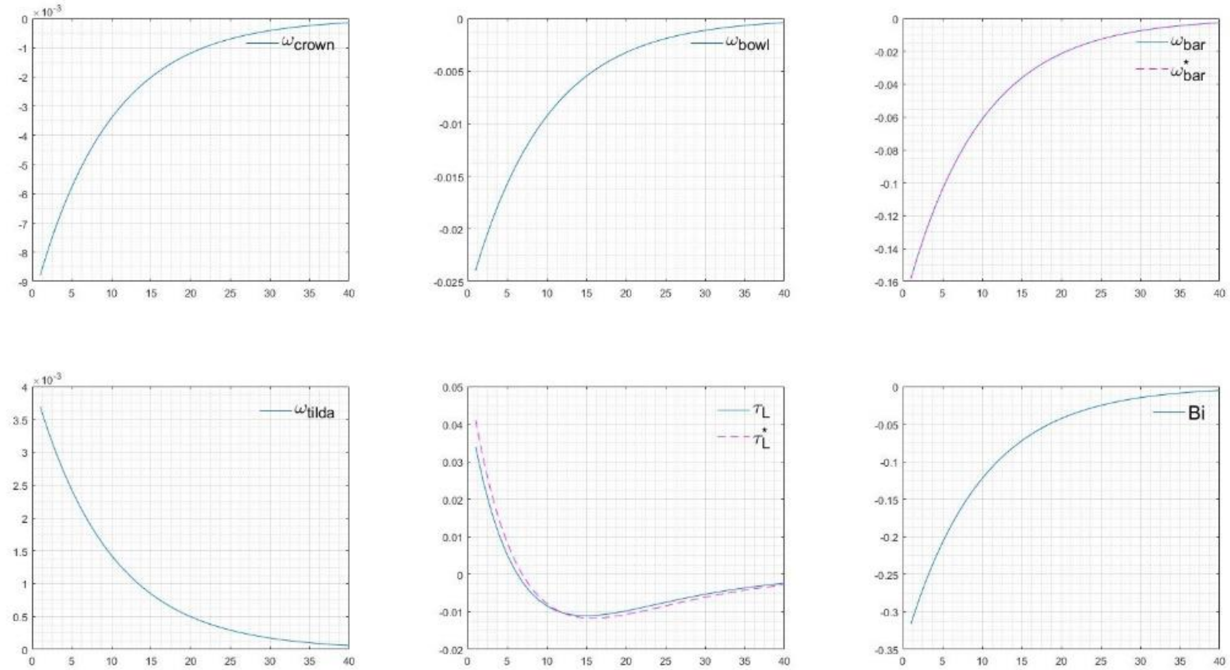


Figure C3.6: IRFs with respect to B^i – Industry Variables

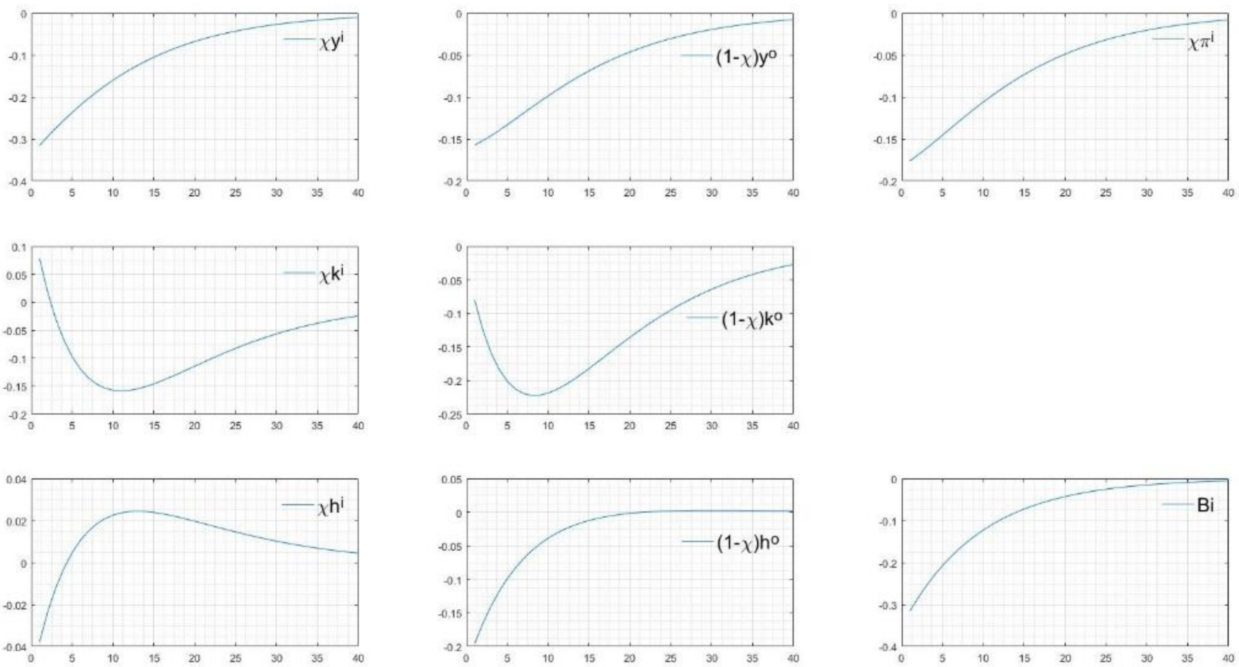


Figure C3.7: IRFs with respect to B^o – Aggregate State Variables

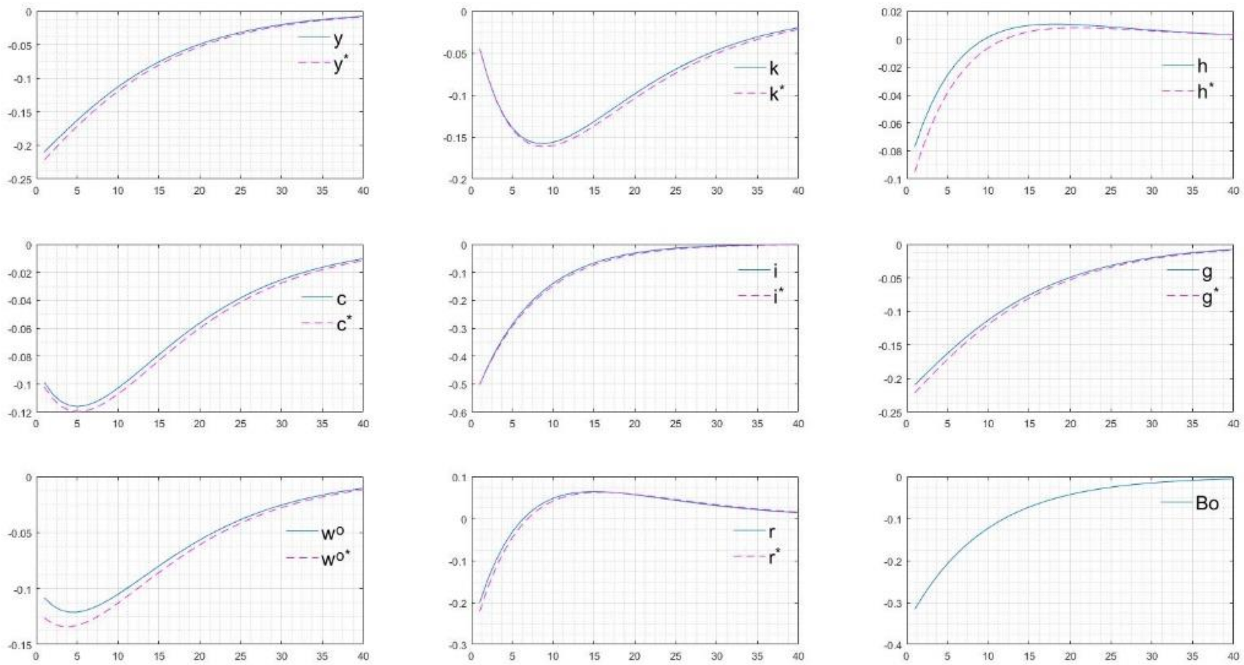


Figure C3.8: IRFs with respect to B^o – Wedges and Taxes

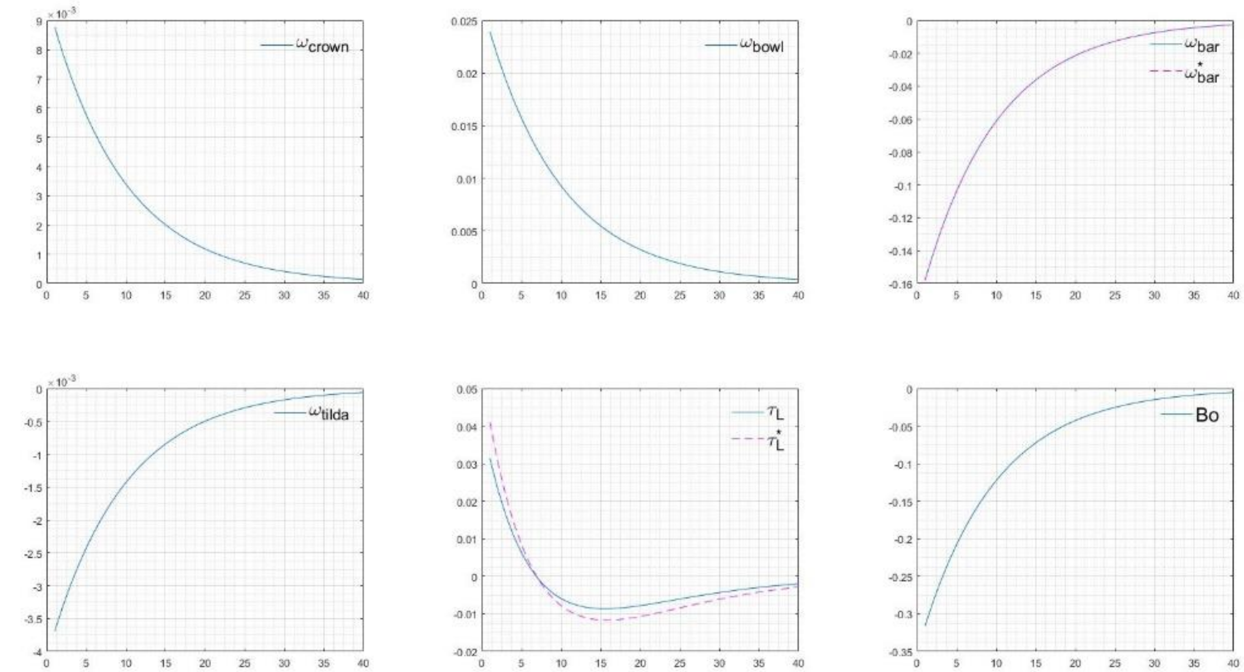


Figure C3.9: IRFs with respect to B^{o} – Industry Variables

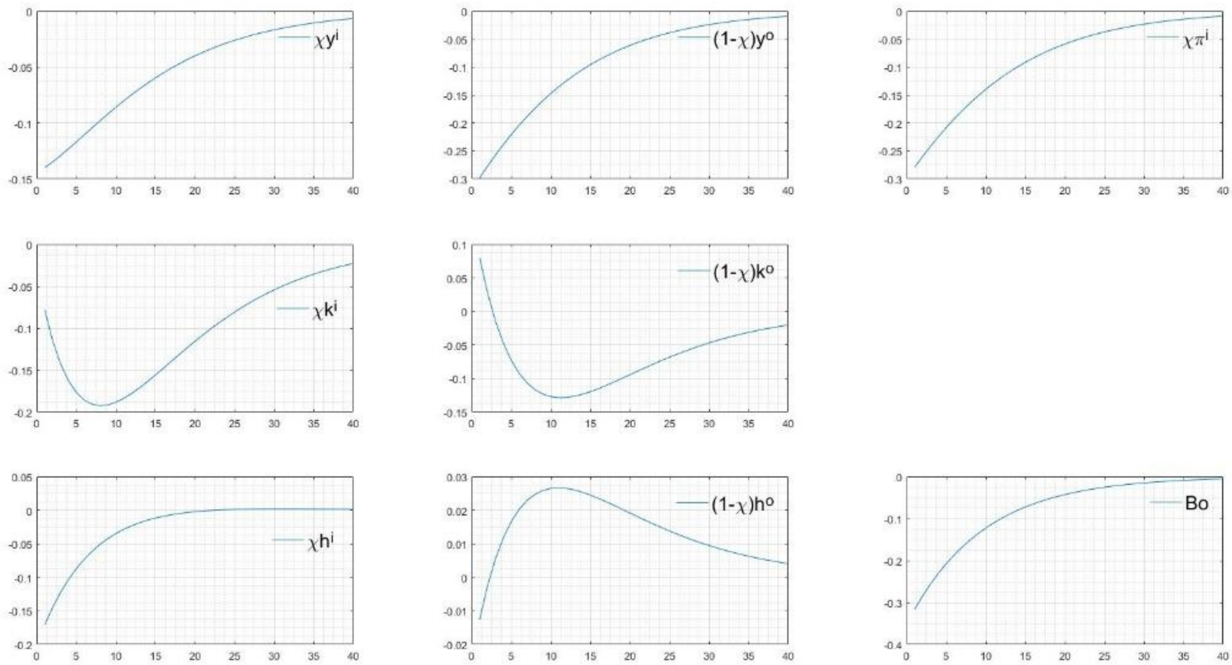


Figure C3.10: IRFs with respect to $x/(1-x)$ - Aggregate State Variables

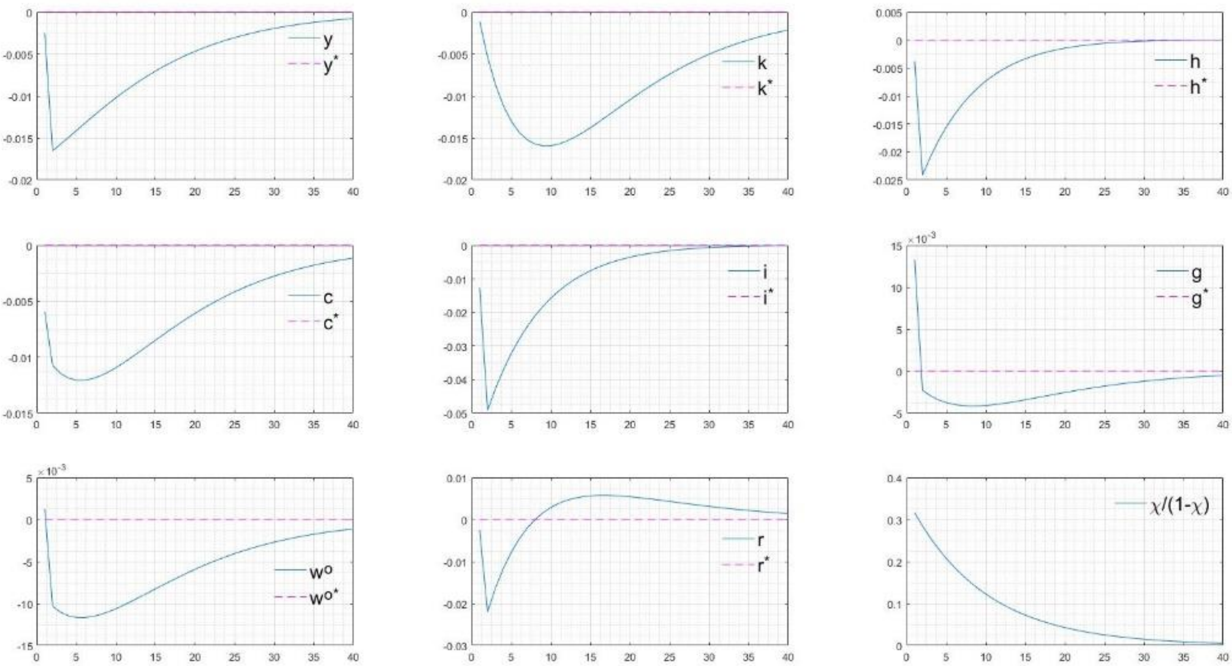


Figure C3.11: IRFs with respect to $x/(1-x)$ – Wedges and Taxes

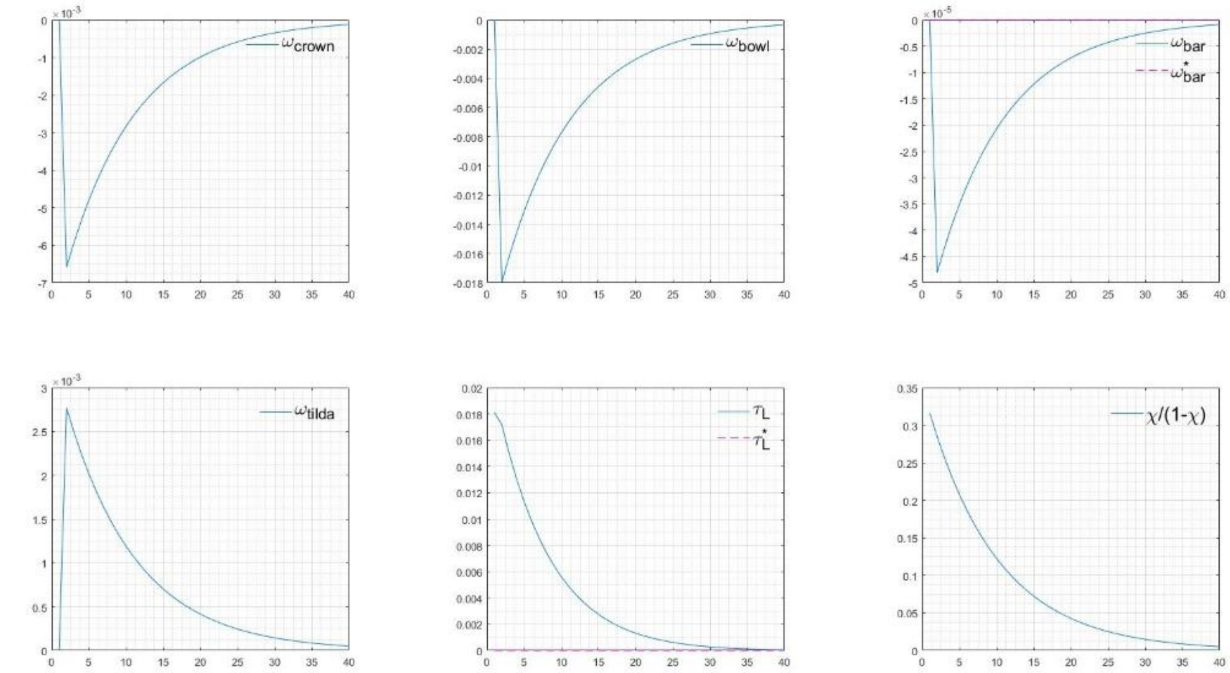


Figure C3.12: IRFs with respect to $x/(1-x)$ – Industry Variables

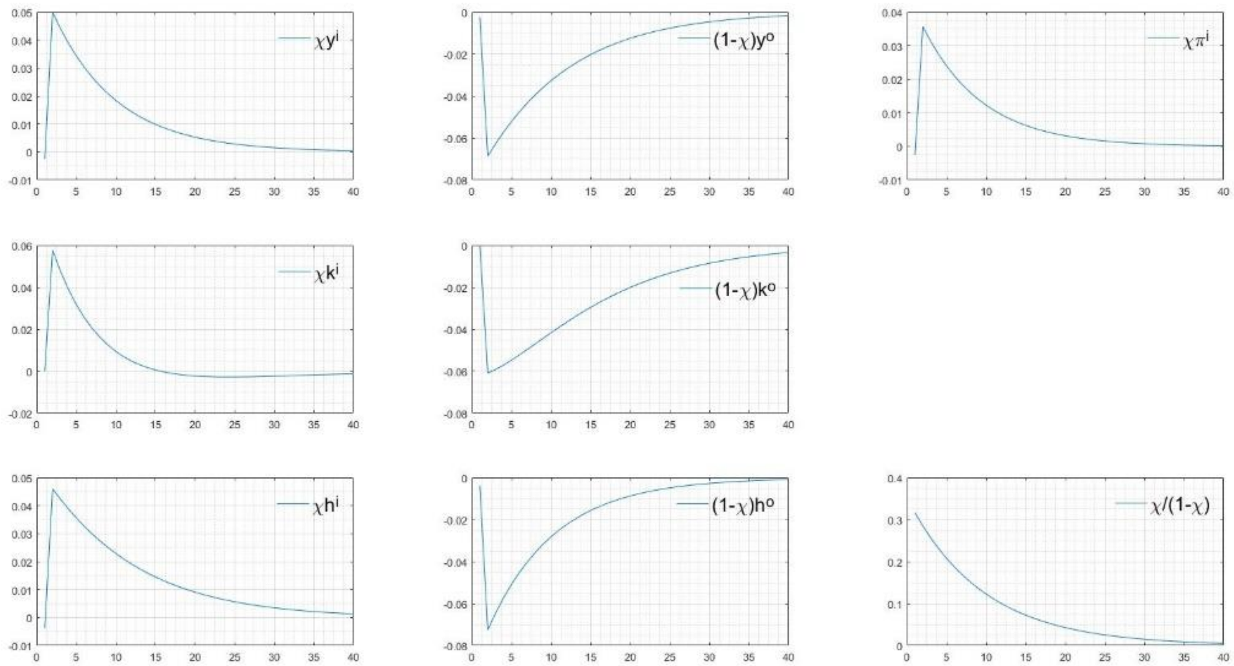


Figure C3.13. IRF with respect to τ^K - Aggregate State Variables

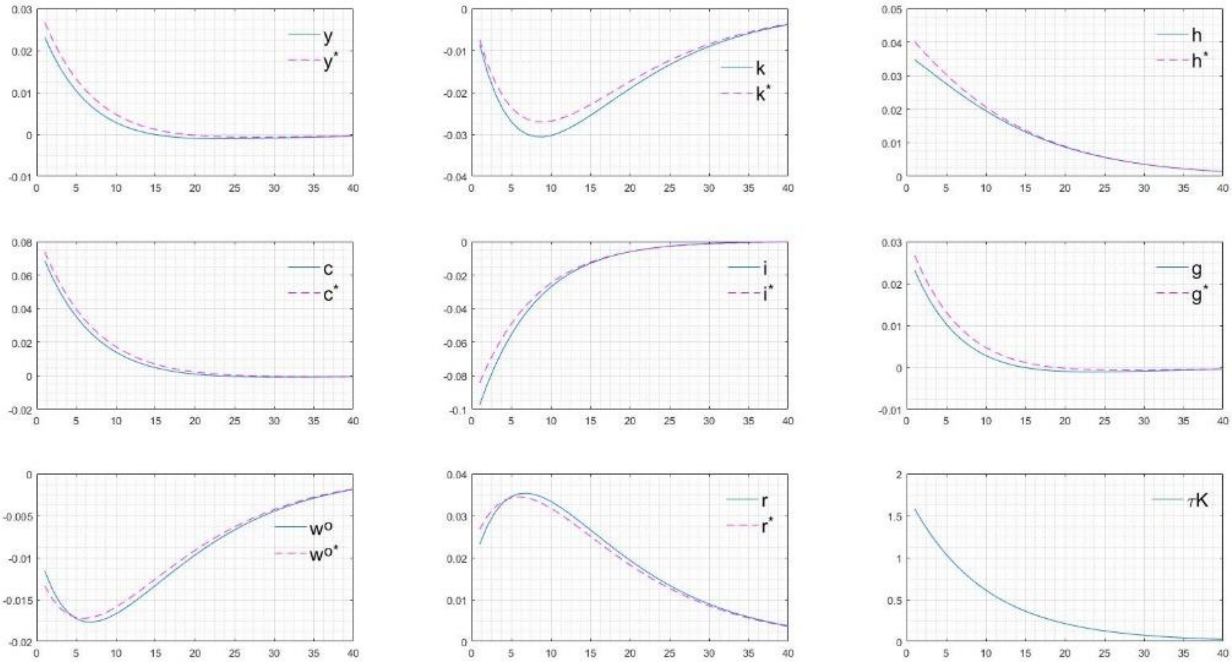


Figure C3.14: IRFs with respect to τ^K - Wedges and Taxes

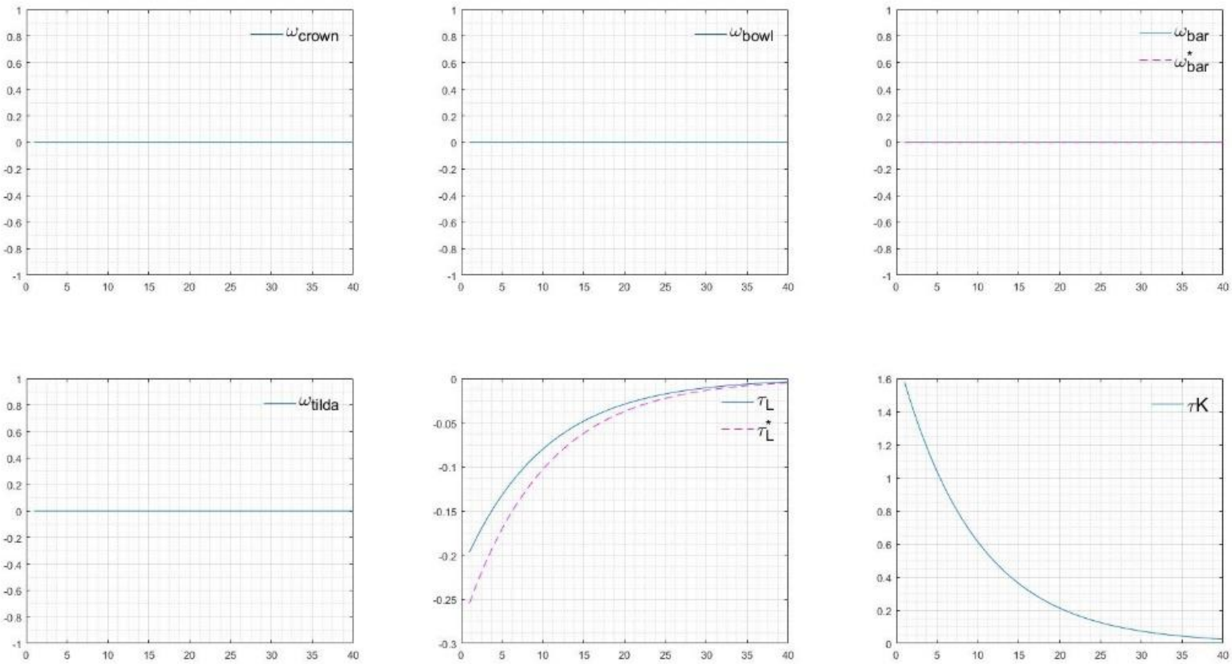


Figure C3.15: IRFs with respect to τ^K - Industry Variables

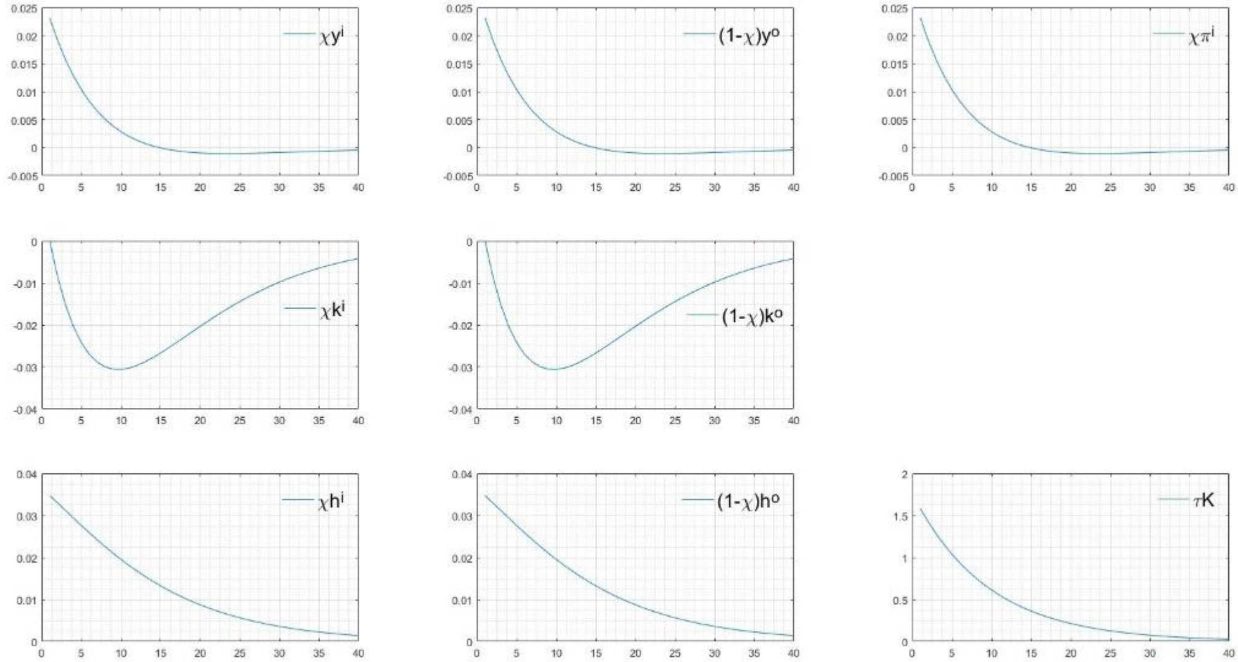


Figure C3.16: IRFs with respect to $\bar{\psi}$ - Aggregate State Variables

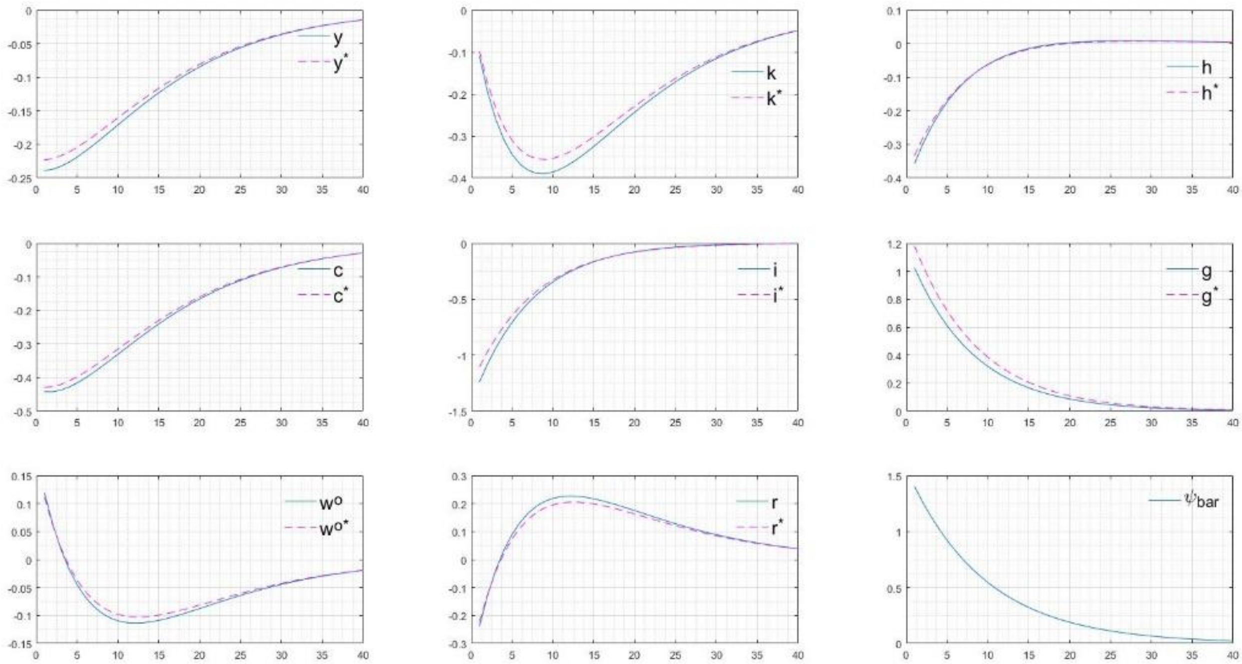


Figure C3.17: IRFs with respect to $\bar{\psi}$ - Wedges and Taxes

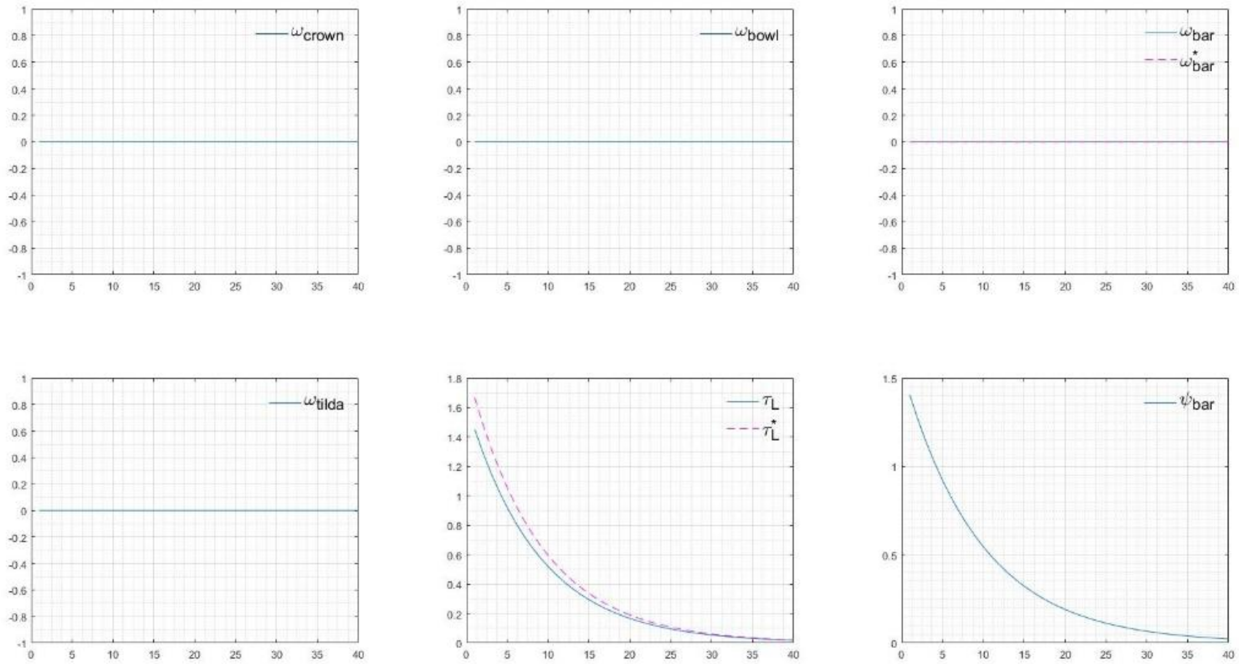


Figure C3.18: IRFs with respect to $\bar{\psi}$ - Industry Variables

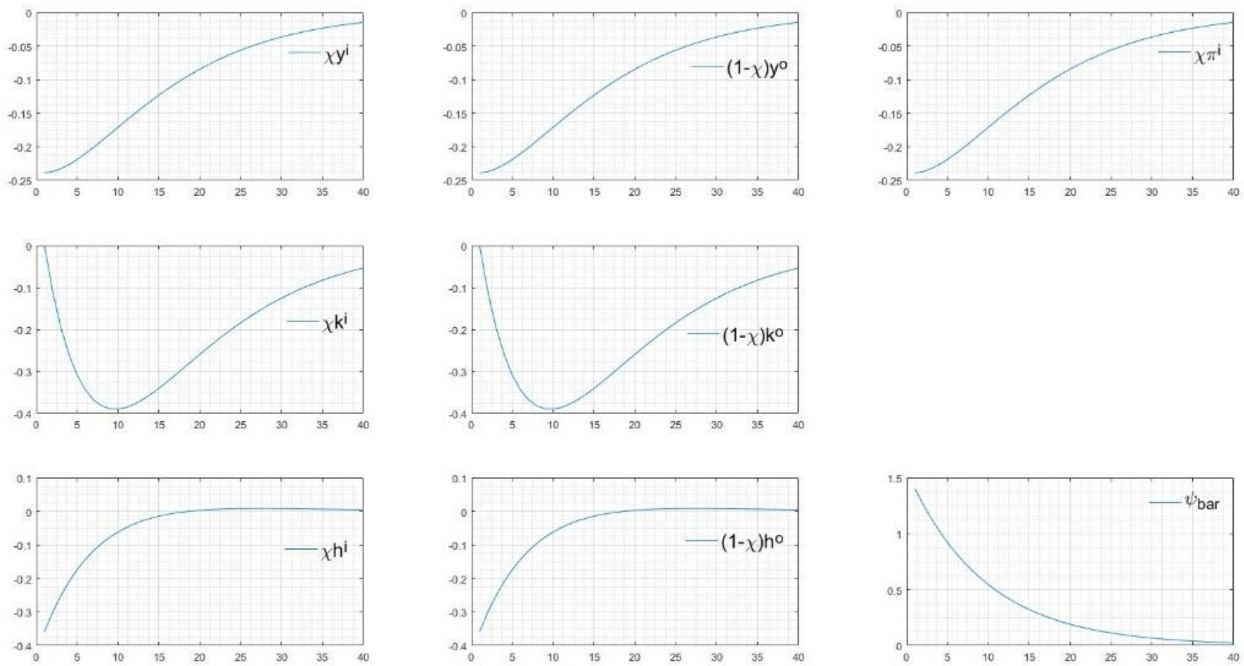


Figure C3.19 IRFs with respect to simultaneously a negative shock in *A* and a positive shock in $x/(1-x)$ - Aggregate State Variables

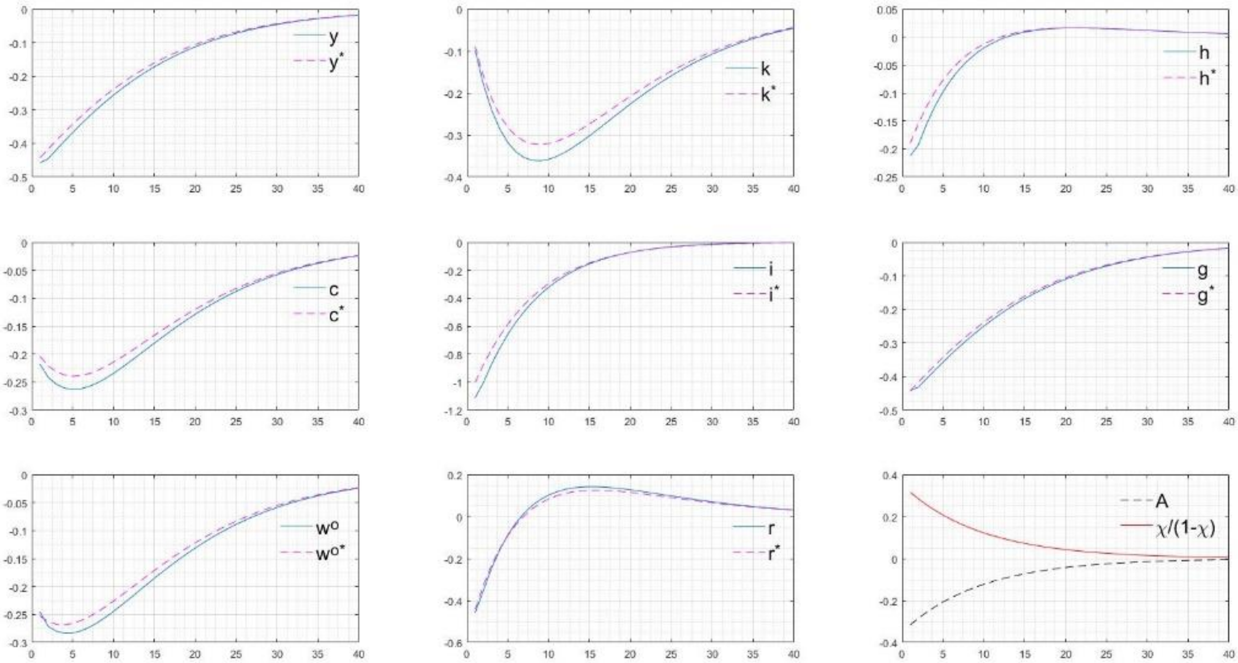


Figure C3.20: IRFs with respect to simultaneously a negative shock in *A* and a positive shock in $x/(1-x)$ - Wedges and taxes

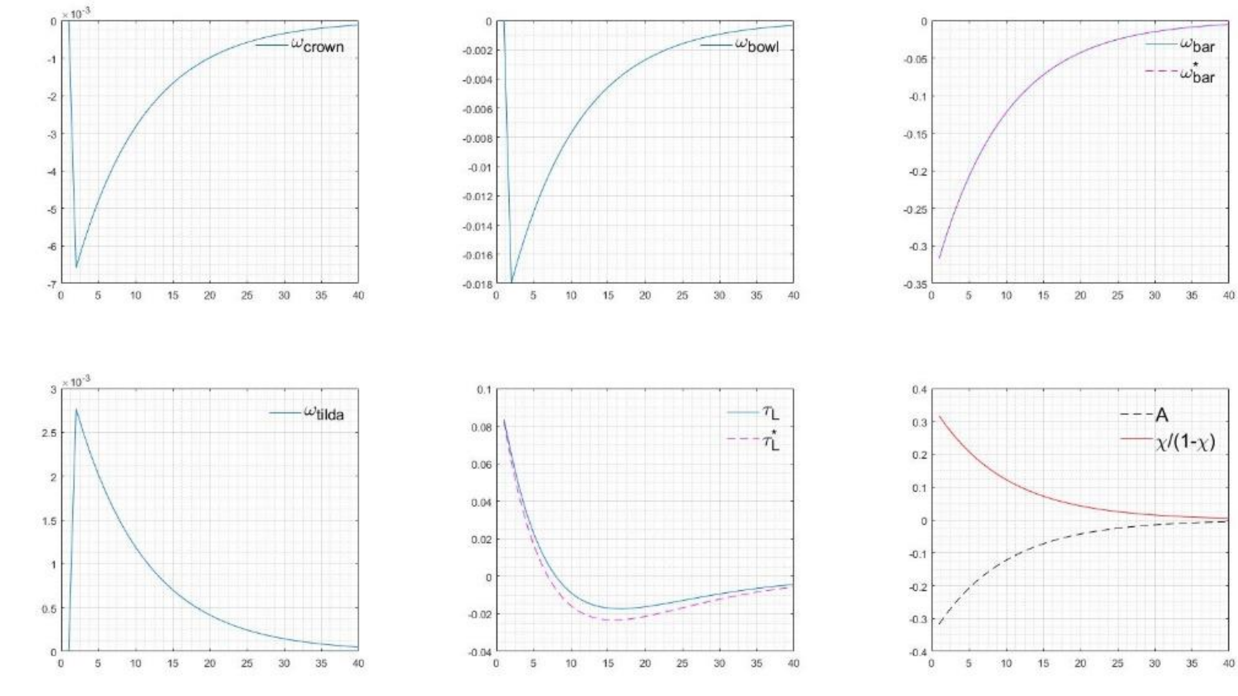
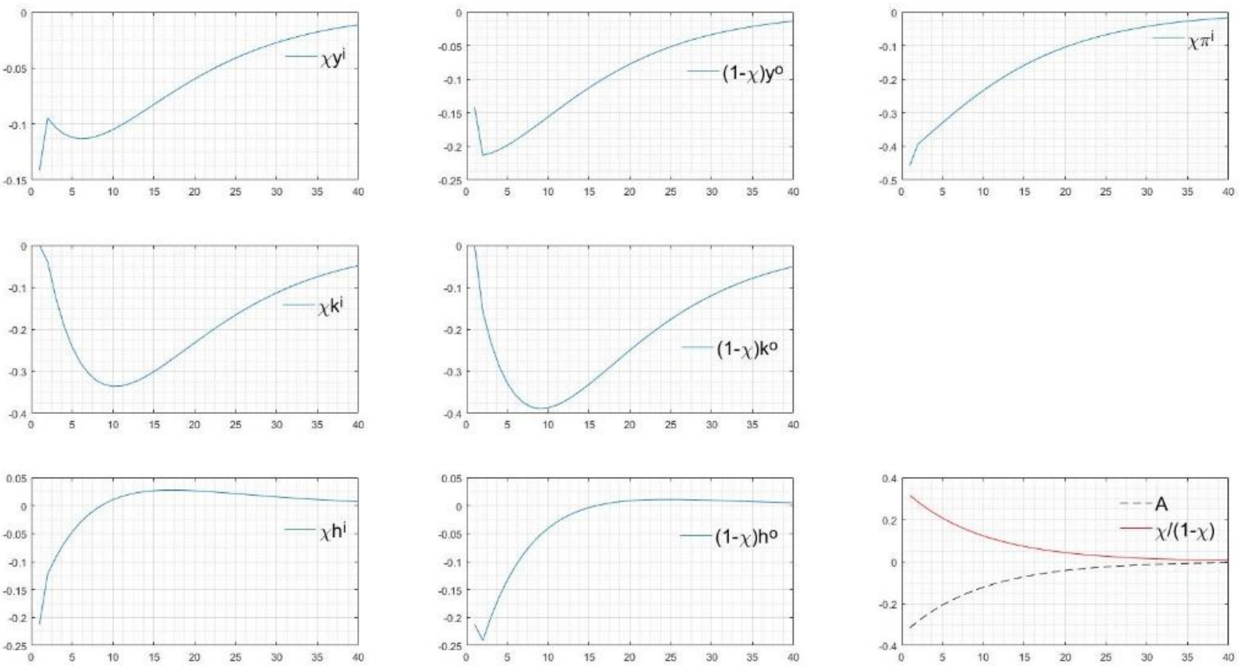


Figure C3.21: IRFs with respect to simultaneously a negative shock in *A* and a positive shock in $x/(1-x)$ - Industry Variables



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