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CONSUMPTION AND INCOME SMOOTHING

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Francesco Busato[*] and Bruno Chiarini[**]

Abstract

In this paper we describe a new proposal to reconcile Permanent Income Hypothesis (PIH) implications with selected stylized facts about income and consumption, and with empirical performances of equilibrium growth models. We cast our analysis into a two-sector equilibrium growth model, where one sector represents market economy, and the other stands for non-market activities. In addition we explicitly incorporate an *income smoothing contract*, designed to insure workers against idiosyncratic risk.

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1 Introduction.

In this paper we propose to reconcile Permanent Income Hypothesis (PIH) implications with selected stylized facts about income and consumption. We also propose to show that these stylized facts are consistent with the empirical performance of a particular two sector equilibrium growth model, where one sector represents the market economy, and the other stands for non-market activities (that is an underground economy)[1].

The model joins together three phenomena to understand dynamic consumption and production decision making: consumption smoothing, income smoothing, and risk sharing using a contract based upon a countercyclical non-market sector[2]. The contract provides the insurance opportunity for smoothing income and consumption. Intra-sector production smoothing, as well as the non-market activities, are generated by existence of distortionary taxation.

The principal results of the paper are as follows:

First, looking at disaggregated (i.e. market and non-market in our model) consumption and income series, we show that market and non-market consumption are much more sensitive to innovations in productivity and tax rates than market and non-market income. Furthermore, measures of volatility for disaggregated consumption series are greater than or equal to those of the corresponding income series. These two facts turn out to be consistent with PIH's theoretical predictions, and are robust to sensitivity analysis.

Second, this picture is reversed when aggregate series are considered. The impulse response of aggregate consumption to innovations in productivity and tax rates is smaller than that of aggregate income. In addition, aggregate consumption is less volatile than aggregate income, which is one of the most robust empirical stylized facts matched by equilibrium growth models. The former results are not consistent, however, with PIH implications, and Section 6 explains why this should not be puzzling.

Third, we show that in our model agents are able to disentangle consumption and income by relying on the countercyclical bahvior of the two sector.

We could conclude, roughly speaking, that PIH seems to hold, but consumers are smart enough to reallocate resources and labor supply over time and across sector as to smooth income, consumption, and confound economists and statisticians. These results allow us to reconcile volatility implications of the PIH with equilibrium growth models' empirical performance. This issue is important since it differs from the established perspective which attributes to these two classes of models (Permanent Income Models and Equilibrium Growth Models)

[1] There is no universal agreement on what defines the underground economy. Most recent studies use one of more of the following definitions: (a) unrecorded economy (failing to fully or properly record economic activity, such as hiring workers off-the-book); (b) unreported economy (legal activity meant to evade the tax code); (c) illegal economy (trading in illegal goods and services). We are interested about the size of the underground economy as encompassing those activities which are otherwise legal but go unreported or unrecorded, i.e. bits (a) and (b).

[2] Underground activities are especially significant in many European countries where the underground sector represents from 15 to 35 percent of the GDP. In the U.S. the underground sector is about 8 or 9 percent of the GDP. Even though it cannot be considered a small fraction, it is much lower than the European counterparts (Busato and Chiarini, 2001 or Schneider and Enste, 2000).

very different implications in terms of volatility of consumption and income (e.g. Christiano, 1987)[3]. The simulation outcomes, calibrated for the Italian economy, are likely to be robust for countries presenting a countercyclical non-market sector, as New Zealand, the United Kingdom, and the United States among the many (see Busato and Chiarini, 2001)[4].

The paper is organized as follows. In Section 2 we summarize the empirical evidence about non-market activities, consumption smoothing and income smoothing. In Section 3 we motivate the structure of the model, which we describe in Section 4. Section 5 discusses our choice of functional forms and parameters values. Section 6 outlines simulation results, while Section 7 presents our conclusions.

2 The Deaton Paradox and Selected Stylized Facts.

Here we reproduce for convenience the puzzling behavior of aggregate consumption and income. Then we outline how the two pillars of our solution, namely the existence of substantial non-market activities, and the countercyclicality of non-market income, upon which we build the consumption and income smoothing contract, are sizeable, robust and widespread phenomena.

First, aggregate consumption is smoother than aggregate income, and this finding is robust across different countries[5]. A classical explanation for consumption smoothing is a version of Friedman's (1953) Permanent Income Hypothesis (PIH). Unfortunately, when output growth is positively serially correlated, as large number of researchers agree (i.e. see Hall (1978), Davidson and Henry (1981), Flavin (1981), Mankiw (1982) and Muellbauer (1983)), the PIH has the strongly counterfactual implication that consumption is more variable than income, i.e. that an unexpected increase in output causes an even greater increase in consumption (Deaton, 1992). This theoretical implication is not reflected by the data, giving rise to the so called "Deaton Paradox"[6].

In all industrialized countries the non-market sector is large both in terms of the labor input used and in terms of output produced. Schneider and Enste (2000) show that the non-market economic activity represents on average 16.9% of the GNP of the main OECD countries. It is also important to note that different measurement techniques provide similar approximate magnitudes of the size and development of the non-market economy[7]. In addition, what is most

[3]Note, however, that permanent income and equilibrium growth models have very similar implications for other dynamic characteristics of consumption, i.e. the martingale property for consumption).

[4]Our model is calibrated to match selected moments for the Italian economy within the sample 1970-1996. We choose Italy because of the availability of a complete data set on the non-market sector. Note however, that Italy presents a share of underground economy equally to approximately 20 or 30 percent of the GDP, which according to Schneider and Enste (2000), corresponds to several European countries like Norway, Belgium, Portugal, Spain, Greece and Denmark.

[5]See Hayashi (1989) and (1991) for US. and Japan, and Jappelli and Pagano (1989) for Italy.

[6]As a results, a number of researchers have attempted to explain PIH failures by bringing into the model liquidity constraints, agents myopia, agents heterogeneity, bounded rationality, labor rationing, seasonal fluctuations or costly decision making (e.g. Flavin (1985), Hall (1985), Campbell and Mankiw (1987) and (1989), or Deaton (1992), Allen and Carroll (2001), Lettau and Uhlig (1999)).

[7]There exist several methods of estimating the size of the underground economy. A detailed survey of the

interesting from the short run perspective, is the countercyclical behavior of the non-market component. Busato and Chiarini (2001) present evidence of this phenomenon for Italy, New Zealand, the United States and the United Kingdom.

Income smoothing is also a relevant phenomenon. Indeed, as presented in Mordoch (1995) a great deal of risk is averted by households in inputs allocation [8]. This means that the members of a family can pool together their resources, and in particular their labor supplies, and allocate them more efficiently over time, and across sectors (i.e. Gallie and Paugam, 2000)[9].

3 Motivation for the Model: Two Critical Discrepancies

Between consumption data and the majority of theoretical models, there exist two critical discrepancies, which are frequently neglected. First, consumption data usually refers to households, while majority of theoretical models is cast into the representative agent framework. Second, since a countercyclical non-market sector may offer hedging opportunities to workers, the conclusions of models that do not explicitly incorporate this sector, may be seriously compromised. Indeed, it seems that there exist a substantial difference between individual consumption and household consumption profiles, and that this issue can be reasonably tied to the presence of a countercyclical non market sector. Evidence and details are presented in next sections.

In other words, we argue that what is usually acknowledged as a failure of PIH may follow from the way in which analysis is structured; specifically, from the mismatch between the theoretical scheme and the empirical data. Hence a sensible analysis should look simultaneously at household consumption, as well as at individuals' consumption patters.

The model we present in Section 4 specifically addresses these issues. We tell a simple story of a two person household, then we compare the individual consumption and income profiles, with those of the family. The results are quite interesting: PIH holds, and also the stylized facts on aggregate consumption and income are satisfied.

4 Structure of the Model

The model is based on the one presented in Busato and Chiarini (2001), while differing in two important aspects. First, we generalize the household structure by introducing a simple

three most widely methods used to measure the hidden activity (the direct approaches, the indicator approaches and the model approach) are discussed in Schneider and Enste 2000. See also Feige (1989) and Thomas (1992; 1999) among others.

[8]Note, however, that altruism within extended family is still controversial, at least for the United States. Altonji, Hayashi and Kotlikoff (1992) for instance reject the hypothesis of altruism within the extended family. But, in the conclusions, the authors underline how they do believe that significant altruistically motivated transfers occur in United States, especially between wealthy, who are underrepresented in the Panel Study on Income Dynamics (PSID).

[9]For example we may think to the fact that in a large percentage of married and/or cohabiting persons between 25 and 54 years old, only one of both spouses has a job (i.e. Gallie and Paugam, 2000).

form of heterogeneity[10]. Second, we model income smoothing and within-family consumption reallocation via a specific contract.

There are three agents in the model: the firm, the extended family, and the government. In addition there are the market and the non-market sectors.

The members of extended family choose consumption, investment, and hours worked at each date and in each sector to maximize the expected discounted value of the family's utility subject to an income smoothing contract, a budget constraint, a proportional tax rate on the market wage, and the law of motion for the capital stock.

In each period, the firm rents capital only in the market sector, but hires labor in both sectors[11]. It produces output in both the sectors by solving a period-by-period profit maximization problem. The firm solves this series of one-period problems subject to a probability that it may be discovered producing in the non-market economy, convicted of tax evasion and subject to a penalty surcharge.

Finally, a government levies proportional taxes on output and labor income, and balances its budget at each point in time. We assume that government spending on goods and services does not contribute to either production or to extended family utility.

4.1 The Extended Families.

Consider a production economy populated by many consumers. Each consumer works in only one of the two sectors. They receive incomes that are functions of idiosyncratic shocks. Within the economy there exist extended families, exogenously determined and of fixed size. Within each family, the members have perfect information concerning each other's idiosyncratic shocks to each sector[12]. For simplicity we assume that there exists one family, which is composed by two working individuals, Mr. κ and Miss. l[13]. Without loss of generality, we assume that Mr. κ works in market sector, while Miss. l works in the non-market sector.

Since Mr. κ and Miss. l are good friends since high school, we can follow Cho and Rogerson's (1988) extended family labor supply model[14]. Specifically, extended family composed of Mr. and Mrs. κ is characterized by the following instantaneous utility function:

$$U(c_t^\kappa, c_t^l, l_t^\kappa, l_t^l) = \phi_\kappa u(c_t^\kappa) + \phi_l u(c_t^l) - v\left(l_t^\kappa\right) l_t^l - \mu(l_t^l) \tag{1}$$

[10]We will see that, given the structure of our income smoothing contract, we may rewrite the heterogenous agent model as a representative agent model. This claim is proved in Proposition 1.

[11]This assumption reflects a basic stylized fact of many underground economies.

[12]This hypothesis will be important since it simplifies agents' interaction after the contract introduction. Indeed, as long there is perfect and complete information, and perfect competition, a general equilibrium model, where agents interact through the price system, holds (Salanie', 1997).

[13]We choose to restrict the analysis to one family to keep notation simple. The size and the number of the extended family can easily be enlarged.

[14]Since Mr. κ and Miss. l are good friends until many years, we may argue that their preferences are not too far. Hence, assuming that they have the same utility function for consumption should not be seen as a forcing. They have, however, a different preference structure for labor supply, which is consistent with the fact they work in different sectors.

where $u(c_t^\kappa)$ and $u(C_t^l)$ represent utility from Mr. κ and Miss l consumption, and $v(l_t^\kappa)l_t^l$ describes the disutility of working in both sectors. We interpret the last term, $\mu(l_t^l)$, as reflecting the idiosyncratic cost of working in the non-market sector. This cost may be associated in particular with the lack of any social and health insurance in the non-market sector[15]. Given their long standing friendship, Mr. κ shares part of Miss. l concerns of working in that sector. For the same reason, we assume $\phi_\kappa = \phi_l = 1/2$[16].

An aspect of primary interest in our labor market is workers' labor supply in the two sectors of the economy. Mr. κ, which works in the market sector, supplies l_t^κ, and receive a wage $w_t^\kappa = w_t(1-\tau_t)$, where τ_t is the stochastic tax rate on wage income. Miss l, who works in the other sector, offers l_t^l, and earns a wage $w_t^l = w_t$. The family budget constraint is

$$w_t(1-\tau_t)l_t^\kappa + w_t l_t^l + R_t K_t^{tot} = C_t^{tot} + X_t^{tot}. \tag{2}$$

where $C_t^{tot} = c_t^\kappa + c_t^l$ and X_t^{tot} represents total consumption and total investment by the family, respectively. Eventually they pool their savings together, and rent the grand total, X_t^{tot}, to the firms, which capital stock evolves according to the following state equation:

$$K_{t+1}^{tot} = (1-\delta)K_t^{tot} + X_t^{tot} \tag{3}$$

where δ denotes the exogenous and constant depreciation rate. We refer to equations (1) to (3) as to the Heterogenous Agent Model (HAM).

But one day, unexpectedly, a spark ignites between the two. Mr. κ and Miss. l fall in love, and are offered an "*consumption and income smoothing contract (CISC)*". Readers unfamiliar with Contract Theory would call it a "marriage" contract. The contract, defined below, says the consumers should pool together income (and thus labor supply) and consumption[17].

Definition 1 (Consumption and Income Smoothing Contract) *The contract has three features:*

1. *$l_t^\kappa = \theta_t L_t$ and $l_t^l = (1-\theta_t)L_t$. This means, that Mr. κ and Miss. l pool together their labor supplies, L_t, then they allocate a share θ_t to market sector, and the remaining $1-\theta_t$ to non-market sector.*

2. *The family will choose total consumption C_t^{tot}.Then Mr. κ and Miss. l consumption will be $c_t^\kappa = \omega^* C_t^{tot}$ and $c_t^l = (1-\omega^*)C_t^{tot}$[18]. When agents have the same utility function for*

[15] Note that since working in the non-market sector is costly, as we can see from the third term of the instantaneous utility function, we rule out equilibria were all labor supply goes to the non-market sector. In other words, if $l_t^l \mapsto \infty$, then $\mu(l_t^l) \mapsto \infty$, making this decision too costly for the family.

[16] The choice of 1/2 is without loss of generality, it just simplifies the algebra.

[17] Danthine and Donaldson, 1995 first introduce a contract between shareholders and workers into an equilibrium growth model. Their contract is mean to smooth consumption via lump sum transfers. The contract presented in Definition 1 is meant to smooth consumption on a period by period basis (as in Danthine and Donaldson), but in addition our agent smooth income, too. The smoothing channel differs as well. Specifically, in our case it is represented by labor supply allocation.

[18] In this way individual consumption is disentangled from individual income. It may be interesting to note that this is the argument behind the risk sharing and consumption literature (see Deaton, 1992 for a survey).

consumption, $\omega^* = 1/2$[19].

3. *We assume that agents accept the contract, that it holds for each period in time, and that it is incentive compatible and perfectly enforceable*[20].

In this paper we do not consider strategic interaction among agents. The contract has the simple goal to pool together labor supply, and consumption, insuring the family against idiosyncratic shocks. In addition, its structure serves as foundation of Proposition 1.

Proposition 1 (Representative Agent Model and Heterogenous Agents Model) *Under the income smoothing contract, as in Definition 1, the Heterogenous Agent Model (Equations (1) to (3)) is equivalent to a Representative Agent Model characterized by instantaneous utility function* $U(c_t^j, \theta_t^j) = u(c_t^j) - v(\theta_t^j)(1-\theta_t^j) - \mu(1-\theta_t^j)$, *budget constraint* $w_t(1-\theta_t^j\tau_t) + R_t K_t^j = c_t^j + X_t^j$, *and capital accumulation constraint (3). Equivalence is in the sense of having the same First Order Conditions.*
Proof. *See Appendix A* ■

Remark 1 ("A Transparent Representative Agent Model") *By Proposition 1, we transform the HAM into a Representative Household model of a special kind*[21]*. The novelty of our approach consists in inspecting the composition mechanism of income and consumption flows occurring within the family, and across sectors.*

Specifically, our model generates, for both income and consumption, three series: two "pre-contract" or disaggregated series, and one "after-contract" or aggregated series. The former series refer to individual consumers, and we interpret them as consumption and income profile which arise without contract. The latter ones belong to the household. Then we can explicitly compare the stochastic properties of the different series. We may think to ours, as to a "Transparent Representative Agent Model"[22].

Relying on Proposition 1, and assuming that there exist a continuum of households, which are uniformly distributed over a unit interval, we specify a following functional form for the $j-th$ household momentary utility function[23]. Specifically (1) becomes

$$u\left(c_t^j, \theta_t^j\right) = \left\{ \frac{(c_t^j)^{1-q} - 1}{1-q} - h\frac{(\theta_t^j)^{1+\gamma}}{1+\gamma}(1-\theta_t^j) - f\frac{(1-\theta_t^j)^{1+\eta}}{1+\eta} \right\}. \tag{4}$$

In that context, optimal risk sharing is induces by financial market completeness. In our model, the insurance comes from the real sector.

[19]This claim can be showed quite easily, but for completeness we precise the argument in Appendix B.

[20]By definition, an implicit contract will need to be sustained as an equilibrium in the interaction between the parties (Salanie', 1997). The contract we present in this model has the very simple goal to provide insurance against production idiosyncratic risk. For this reasons we assume that agents accept the contract.

[21]Notice that this an application of an already known result. Indeed Rubinstein (1974) shows that when agents have homogenous beliefs, and time additive utility function with linear risk tolerance, and same exponent, these assumptions imply demand aggregation.

[22]We choose to end up with a representative agent model since the collected data on income and consumption refers, more or less implicitly, to a representative household. In other words, we harmonize the theoretical scheme with the data. If, for instance, we had chosen to calibrate directly the heterogenous agent model, we could not be sure anymore of equivalence between theory and data.

[23]The generalization to continuum of households is not necessary, but is consistent with the traditional set up of equilibrium growth models (see Mehra and Prescott (1985), or Danthine and Donaldson (1996)).

To have a well behaved utility function, we assume that $h, f \geq 0$, $\gamma, \eta > -1$, that all the parts of the momentary utility function are well behaved[24]. The terms $h\frac{(\theta_t^j)^{1+\gamma}}{1+\gamma}(1-\theta_t^j)$ and $f\frac{(1-\theta_t^j)^{1+\eta}}{1+\eta}$ has the interpretation already discussed in previous pages.

4.1.1 Productivity and Tax Rates.

Finally, we formalize productivity and tax rates as a stochastic vector of variables that follow univariate AR(1) processes in log:

$$\mathbf{A}_{t+1} = \mathbf{\Omega}\mathbf{A}_t + \epsilon_t$$

where $\mathbf{A}_t$ is a vector $[M_t, Z_t, t_t, \tau_t]'$ containing the productivity shocks, M_t, Z_t, the stochastic corporate tax rate, t_t, and the stochastic personal income tax rate τ_t. $\mathbf{\Omega} = diag\,(\rho_i)$, where $i = m, z, t, \tau$, is a 4×4 matrix describing the autoregressive components of the disturbances relative to each of the four shocks. The innovation, $\epsilon_t' = [\varepsilon_m, \varepsilon_z, \varepsilon_t, \varepsilon_\tau]$, is a vector of *i.i.d.* random variables.

4.1.2 The Stochastic Dynamic Programming Problem for Households.

Let $V_t(K_t^j, \mathbf{A}_t)$ be the value function for the household problem:

$$V_t(K_t^j, \mathbf{A}_t) = \max_{K_{t+1}^j, \theta_t^j} \left\{ u(c_t^j, \theta_t^j) + E\left[\beta V_{t+1}(K_{t+1}^j, \mathbf{A}_{t+1}) \mid \Im_t\right]\right\} \tag{5}$$

subject to momentary utility function (4), to budget constraint (A.5 in Appendix A), and the low of motion for the household capital stock (3). The optimality conditions for the problem are the Euler equation (6.1) and the intra-temporal consumption-labor allocation condition (6.2)[25]:

$$\begin{aligned} 1 &= \beta E\left(\left(\frac{C_{t+1}^j}{c_t^j}\right)^{-q} R_{t+1} \mid \Im_t\right) \\ 0 &= -w_t\tau_t\left(c_t^j\right)^{-q} - \left(\theta_t^j\right)^{\gamma} + h\left(\frac{2+\gamma}{1+\gamma}\right)\left(\theta_t^j\right)^{1+\gamma} + f\left(1-\theta_t^j\right)^{\eta} \end{aligned}$$

where $\left(1-\delta+(1-t_{t+1})M_{t+1}\alpha\left(K_{t+1}^i\right)^{\alpha-1}\left(\theta_{mt+1}^i\right)^{1-\alpha}\right) = (1-\delta+r_{t+1}) \equiv R_{t+1}$ from firm profit maximization (see below).

[24] Restriction on the utility function to make the inter-temporal optimization problem well defined are derived in Busato and Chiarini (2001).

[25] Appendix A characterizes in details the model, and states precisely the solution procedure.

4.2 The Firms.

There are I firms. Each firm $i \in I$ produces both in the market and in the non-market sector using two different production functions:

$$y^i_{mt} = M_t \left(k^i_t\right)^\alpha \left(l^i_{mt}\right)^{1-\alpha} \qquad \text{and} \qquad y^i_{ut} = Z_t l^i_{ut}. \tag{7}$$

The market output, y^i_{mt}, is the result of capital, k^i_t, and market labor, l^i_{mt}, applied to a Cobb Douglas production function. The non-market output, y^i_{ut}, is produced with a production function which uses only non-market labor, l^i_{ut}. Finally, M_t and Z_t are the idiosyncratic stochastic productivity shocks[26]. This formulation is consistent with the behavior underling the existence of a non-market sector. Indeed the firms have no incentive to invest capital in the non-market sector.

In equilibrium each firm allocates a share, θ^i_t, of the total labor, L_t, to market production (therefore $l^i_{mt} = \theta^i_t L_t$) and the remainder, $1 - \theta^i_t$, to the other sector (therefore $l^i_{ut} = \left(1 - \theta^i_t\right) L_t$)[27]. Normalizing L_t to unity, we can rewrite (7) as

$$y^i_{mt} = M_t \left(k^i_t\right)^\alpha \left(\theta^i_t\right)^{1-\alpha} \qquad \text{and} \qquad y^i_{ut} = Z_t \left(1 - \theta^i_t\right). \tag{8}$$

When the firm produces in the market sector, its output is taxed with certainty at the stochastic rate t_t. When producing in the underground sector, the firm may be discovered, with probability p, and forced to pay the stochastic tax rate, t_t, increased by a surcharge factor, $s > 1$, applied to the standard tax rate.

Assuming that the firm produces in both the sectors, we can describe its revenues as follow:

$$\begin{aligned} y^i_{D,t} &= (1 - t_t) y^i_{mt} + (1 - s t_t) y^i_{ut} && \text{with prob } p \\ y^i_{ND,t} &= (1 - t_t) y^i_{mt} + y^i_{ut} && \text{with prob } 1 - p, \end{aligned}$$

where $y^i_{D,t}$ is the output when the firm's non-market activity is detected and $y^i_{ND,t}$ is the output produced when the firm's non-market activities go undetected. The expected value of the output is then given by $E\left(y^i_t | \Im_t\right) = p y^i_{D,t} + (1 - p)\, y^i_{ND,t}$.

The costs to the firm arises from the labor, hired in both sectors, and from renting capital.

[26] Notice that this structure is equivalent to a more general set up with two production functions which use both the inputs, like for example $y^i_{mt} = M_t \left(k^i_t\right)^\alpha \left(l^i_{mt}\right)^{1-\alpha}$ and $y^i_{ut} = Z_t \left(k^i_{ut}\right)^\beta \left(l^i_{ut}\right)^{1-\beta}$. According to Uzawa (1965) and Lucas (1988) if $\beta < a$ we can set the smaller elasticity to zero without loss of any generality. It follows that the share of capital in the labor intensive production function is null and therefore an optimizing firm would choose $k_{ut} = 0$ for each t. Because we assume that the underground sector is labor intensive, we rely on this argument.

[27] The use of the share is also consistent both with the fact that labor supply per person is approximately stationary in many economies although the real wage grows, and with the utility function, homogenous in consumption, that we adopt to model the household preferences. The aim is, therefore, to analyze the movement of resources between the two sectors, to understand how agents want to move inputs out of the market and into the underground. The reallocation of hours from market to informal sector rather than exclusively from leisure to labor, increases the volatility of the official labor input for a given technology shock.

The cost of market labor is represented by wage paid for hours worked, a wage that is augmented by social security taxes at a rate that we will assume is equal to the corporate income tax rate, t_t. In accordance with the rationale behind non-market activities, we assume that the firm does not pay social contributions for labor input employed in the non-market sector[28]. Formally we have firm costs defined by[29]:

$$CO\left(\theta_t^i, K_t^i\right) = w_t + w_t t_t \theta_t^i + r_t K_t^i. \tag{9}$$

At each date t, firm i maximizes period expected profits

$$\max_{\left(\theta_t^i, k_t^i\right) \geq 0} E\left(y_t^i | \Im_t\right) - CO\left(\theta_t^i, k_t^i\right)$$

to derive capital and labor demands $(\theta_t^i)^* = (k_t^i)^* (\frac{(1-t_t)(1-\alpha)M_t}{(1-pst_t)Z_t + w_t t_t})^{\frac{1}{\alpha}}$ and $(k_t^i)^* = (\theta_t^i)^* (\frac{(1-t_t)\alpha M_t}{R_t})^{\frac{1}{1-\alpha}}$.

4.3 The Government.

Finally, under Proposition 1 the flow government budget constraint is[30]:

$$w_t \tau_t \theta_t + (pst_t)\, y_{ut} + t_t y_{mt} = G_t \tag{10}$$

where $G_t = \bar{G}$[31].

4.4 Equilibrium

The equilibrium for the model presented in previous pages can be characterized as an Equilibrium of a Nonoptimal Economy (e.g. Danthine and Donaldson, 1995). Specifically, aggregate and individual quantities coincide, and equilibrium can be characterized as the F.O.C. of the Representative Household on which market clearing conditions have been imposed.

5 Calibration.

The fact that the data on the underground economy are difficult to obtain substantially complicates the calibration. Because we are not aware of other studies which calibrate the parameters of a general equilibrium model augmented with a non-market sector, we precisely detail our calibration procedure.

[28]Note that the tax structure is critical for the existence of non-market activities, and therefore for the source of risk sharing.

[29]Here we have already implemented the features of consumption and income smoothing contract into i-th firm objective. For details, see Appendix A, Proposition 1, Lemma 2.

[30]See Appendix A, Proposition 1, Lemma 3

[31]Notice that the Government balances its budget only in expectation, since with probability $1-p$ some firms and workers are evading. Hence equation (10) will not be satisfied on a state by state basis.

1. **The probability of being detected**, p. We calibrate this parameter by estimating the unconditional mean of the ratio of number of inspected firms to their total number, i.e. $p = \frac{Inspected\ Firms}{Total\ Number\ of\ Firms}$[32]. For Italy, as well as for the majority of countries, only a portion of these data are publicly available. For the Italian economy, the Ministry of Labor reports that the number of inspected firms has been 118,119 in 2000, 106,307 in 1999 and 95,676 in 1998. The overall number of firms in the Italian Economy has been 4,639,393 in 2000, 4,472,375 in 1999 and 4,311,369 in 1998. As suggested above, we first compute the probability of being detected in each year, p_t^*, and then we estimate the aggregate probability as $p = \frac{1}{T}\sum_{t=1}^{T} p_t^*$. For the Italian economy $p = 0.03$[33]. Even though this is not an efficient estimate, it represents the best possible calibration for this parameter, given the available data.

2. **The surcharge factor** s, **the income tax rate** t, and **the corporate tax rate** τ. The parameter s represents the surcharge on the standard tax rate that a firm, detected employing workers in non-market sector, must pay. According to the Italian Tax Law (Legislative Decree 471/97, Section 13, paragraph 1) the surcharge equals 30 percent of the statutory tax rate if the firm pays the fine when detected, or 200 percent when the firm refuses to pay[34]. We present results for both the values, $s = 1.3$ and $s = 2.00$.

   In Italy, corporations are subject to a progressive tax rate. A tax rate of 19 percent is applied to the share of profits that represents 7 percent of the firm's capitalization; the remaining portion is then subjected to an increased tax rate of 36 percent. We calibrate the steady state value of the corporate tax rate as the average of these two numbers, i.e. $t = 0.275$.

   The personal income tax system is more complex, since we have five tax rates, spanning from 18.5 percent to 45.5 percent. The calibration of the income tax rate may be undertaken in two ways[35]. It may be estimated as the average tax rate, weighted by the relative share of population in each income class. It may also be estimated as the tax rate associated with the average income of the working population (Adults 15-64 years old). We rely on the second procedure and since the average income equals 18,246 Euros we estimate the income tax rate at 33.5 percent.

3. **The share of non-market sector,** $1 - \theta$. To calibrate this parameter we refer to Schneider and Enste (2000) who estimate the share of the non-market sector for a panel

[32] Note that an inspected firm is not necessarily convicted of evasion and therefore fined. Since inspections are based either on private information of Institutions, or randomly, it may happen that behavior of a perfectly honest firm will be inspected.

[33] These data are available on line at the web site of the Italian Ministry of Labor, at the URL *http://www.minlavoro.it/Personale/div7-conferenzastampa_01032001.htm.*

[34] In this case the firm will prosecuted under Criminal Law perspective, and if condemned pay 200 percent.

[35] More precisely, the structure of the tax rates is the following as of 2001. For incomes less than 10,331 Euros tax rate is 18.5 percent, for incomes between 10,331 Euros and 15,496 Euros tax rate is 25.5 percent, for incomes between 15,496 Euros and 30,992 Euros tax rate is 33.5 percent, for incomes between 30,992 Euros and 63,283 Euros tax rate is 39.5 percent and, eventually, for incomes above 63,283 Euros tax rate is 45.5 percent

of OECD countries. The value for the Italian Economy, $1-\theta = 0.30$, is also consistent also with Mare's (1996) estimates.

4. **The preference parameters**, q **and** β, **the capital share**, α, and **the capital depreciation rate** δ. These parameters are set to values commonplace in this literature (e.g. Fiorito and Kollintzas, 1994, or Busato and Chiarini 2001). More precisely, we set $q = 1$, $\beta = 0.98$ and $\delta = 0.025$.

5. **Stochastic Shocks autocorrelation coefficients**, $\rho_m, \rho_u, \rho_t, \rho_\tau$ **and innovation amplitudes**, $\sigma_m, \sigma_u, \sigma_t, \sigma_\tau$. The $\rho's$ are set to .90 and the $\sigma's$ to 0.003. As we stress in Busato and Chiarini (2001) these values are much lower than the classical ones (see King and Rebelo, 1999). This means that the model has a particularly efficient amplification mechanism which allows us to employ very small shocks.

6. **The utility function parameters** h, f, η **and** γ. The calibration of these parameters is a not easy (see Cho and Cooley, 1994). We select them to match four moments: the ratio between standard deviation of total output $\sigma(Y_t^{tot})$, and the standard deviation of total consumption, $\sigma(C_t^{tot})$, the correlation between total output and total consumption $\rho(C_t^{tot}, Y_t^{tot})$, the correlation between non-market income and total consumption $\rho(C_t^{tot}, y_t^l)$, and the correlation between market income and total consumption $\rho(C_t^{tot}, y_t^\kappa)$. The calibrated values are $h = 0.55$, $f = 1.99$, $\eta = 1.40$, $\gamma = 3.00$[36].

6 Simulation Results.

PIH predictions for Italy (as well as for the United States, among the many other countries) indicate that consumption should be more volatile than income (e.g. Jappelli and Pagano, 1989). To the contraries, equilibrium growth models calibrated for Italy or the United States, generate consumption smoother than income, which is consistent with actual data (e.g. Fiorito and Kollintzas 1993, King and Rebelo, 1999).

Here we show that an equilibrium growth model which reconciles the two critical discrepancies between consumption theory and data (see Section 3), generates consumption and income series consistent both with smoothness properties of actual data, and with PIH predictions.

We show that "individual", "pre-contract", or disaggregated series (c_t^κ, y_t^κ, c_t^l and y_t^l) are consistent with PIH predictions, and that "family", "after-contract" or aggregated consumption and income profiles (C_t^{tot} and Y_t^{tot}) satisfy smoothness properties presented by actual data[37]. Note, however, that "pre-contract" series do not arise as actual income and con-

[36]Cho and Cooley (1994) calibrate these paramters for the United States, and choose $h = 6.0$, $f = 0.87$, $\eta = 0.62$, $\gamma = 2.00$. Note, however, that their formulation of the model addresses issues different from matching market and non-market moments. Specifically, they study the implications of this kind of utility function for the volatility of hours, employment and productivity in the United States.

[37]To precisely describe the series, we denote y_t^κ as "pre-contract" or "market income" earned from by Mr. κ from his job in the market sector, before pooling it together with Miss l "after-contract" or "non-market income", y_t^l. Then c_t^κ and c_t^l represent Mr. and Mrs, κ pre-contract individual consumption profiles, respectively. Finally

sumption profiles, because household smooth pre-contract income and consumption series on a period by period basis[38]. For this reason, these series have been generated by simulating the model. We refer to this procedure as to *simulation based approach*. Appendix D details construction procedure of these series.

Comparing the stochastic properties of these two sets of variables, we can explicitly capture the reallocation mechanism of consumption and income between agents and between sectors, which is usually implicit in data collection, and in previous consumption studies. We argue that this is the driving force that ties our results to the countercyclicality of non-market activities.

6.1 Numerical Results.

We present our results from four different perspectives. **First**, we show that c_t^κ and c_t^l exhibits a volatility greater than or equal to y_t^κ and y_t^l, respectively[39]. Moreover, the former variables exhibit larger impact-response after innovations in productivity and tax rates. **Second**, the previous relationship is reversed when looking at aggregated series: C_t^{tot} is smoother and less sensitive to innovations than Y_t^{tot}. **Third**, we compare volatility, sensitivity to innovations, and correlation among the three consumption definitions, and among the three income components generated in our model[40]. **Fourth**, we analyze correlations between consumption and income series to draw additional evidence on the volatility of disaggregated components, and on the smoothness of their aggregate counterparts.

Table 1 (see section 6.1.1) and Table 2 (see section 6.1.3), and Figures 1 to 5 present the main results.

6.1.1 Market Consumption is More Volatile than Market Income, and...

To show that disaggregated consumption-income patterns are consistent with the PIH implications, we analyze impulse response functions (Figure 1), and we present selected time-series properties (Table 1).

(Figure 1 about here)

Figure 1 shows the first 32 quarter response of y_t^κ, c_t^κ and X_t^{tot} to a one standard deviation innovation in market-sector productivity, non-market sector productivity, corporate and income tax rates. The curves are the quarterly percentage deviations from a baseline scenario where all innovations are set to zero. As the four figures show, the response of market consumption series is larger or equal than that of market income component, as predicted by PIH.

Y_t^{tot} and C_t^{tot} define total income and total, after contract consumption.

[38]Indeed, from consumption and income smoothing, Definition 1, point 2, it turns out that $c_t^\kappa = c_t^l = (1/2)C_t^{tot}$. See also Appendix B.

[39]Where volatility is measured as the standard deviation of the Hodrick-Prescott filtered series.

[40]What we do here differs from the first point. Here we compare time series properties among c_t^κ, c_t^l, C_t^{tot}, and among y_t^κ, y_t^l, Y_t^{tot}. In the first point, instead, we compare c_t^κ with y_t^κ, and y_t^l and c_t^l

Also Table 1 suggests that "individual" series (c_t^κ, y_t^κ, c_t^l and y_t^l) respect PIH predictions. The table shows that $\sigma_{c_t^\kappa} > \sigma_{y_t^\kappa}$, and that $\sigma_{c_t^l} = \sigma_{y_t^l}$. Precisely, $\sigma_{c_t^\kappa} = 2.96$, $\sigma_{y_t^\kappa} = 2.07$, and $\sigma_{y_t^l} = \sigma_{c_t^l} = 2.22$. It should be also noted that income components are quite volatile, consistently with the data[41]. Finally, Table 3 (see Appendix C) shows that this result is robust to sensitivity analysis.

Table 1: Standard Deviations

	$\sigma(y_t^\kappa)$	$\sigma(y_t^l)$	$\sigma(Y_t^{tot})$	$\sigma(c_t^\kappa)$	$\sigma(c_t^l)$	$\sigma(C_t^{tot})$
Actual Data	2.27	1.11	**1.44**	-	-	**1.25**
Simul. Data$(s = 1.3)$	2.07	2.22	**1.45**	2.96	2.22	**1.17**
	(0.22)	(0.23)	(0.15)	(0.28)	(0.23)	(0.14)
Simul. Data$(s = 2.0)$	1.99	1.94	**1.40**	2.71	1.94	**1.14**
	(0.24)	(0.25)	(0.14)	(0.29)	(0.25)	(0.17)

Notes: The model is calibrated for Italian economy within the sample 1970-1996. C_t^{tot} represent the consumption of non durable goods and services, c_t^κ and c_t^l represents the market and non-market component of consumption, respectively. Y_t^{tot} is the aggregate GDP, y_t^l is its underground component. Since market and non-market consumption data are not available, no statistics are available. The statistics are the means of 1000 simulations, of length 150 time periods. Each simulates series is detrended using Hodrick-Prescott filter before the statistics are calculated. The numbers in brackets are the small sample standard deviations. *Sources:* C_t^{tot} and Y_t^{tot} are withdrawn from Istat database, y_t^κ and y_t^l are from Bovi (1999), while c_t^κ and c_t^l are generated with our model.

6.1.2 ...Aggregate Consumption is Less Volatile than Aggregate Income

The analysis of aggregate variables presents a completely reversed picture.

(Figure 2 about here)

Figure 2 shows the first 32 quarter response of Y_t^{tot}, C_t^{tot} and X_t^{tot} to a one standard deviation innovation in market-sector productivity, non-market sector productivity, corporate and income tax rates. Notice that impulse response of aggregate consumption is smaller than or equal to that of aggregate income.

A further interesting result concerns volatility measures for both aggregate series, $\sigma_{C^{tot}}$ and $\sigma_{Y^{tot}}$ (see Table 1 in Section 6.1.1). Note how aggregate consumption and aggregate income are less volatile than disaggregated counterparts, and, more importantly, that the former is smoother than the latter. Precisely, $\sigma_{Y^{tot}} = 1.45$ and $\sigma_{C^{tot}} = 1.17$. Moreover, it is important

[41]As stresses in many contributions (e.g. Deaton 1992, Attanasio 1999, Attanasio and Rios-Rull 2000) both income and consumption are quite volatile, even though consumption smoothing is strong evidence across countries and data-sets.

to stress that we generate all these results with a low risk aversion coefficient, $q = 1$, consistent with empirical micro-studies (e.g. Dreze 19XX or Attnasio, 1999.).

These results are consistent with the widespread empirical evidence that aggregate consumption is smoother than aggregate income, which is one of the most robust empirical evidences matched by equilibrium growth models.

However, they are not consistent with PIH implications. In the light or our analysis, we argue, that this fact should not be considered puzzling, but consistent with consumption smoothing. We support this view by proposing the following interpretation, which harmonizes both PIH implications and empirical stylized fact. In addition to inter-temporal substitution effects, typical of general equilibrium models, our framework explicitly incorporates an *inter-personal reallocation effect*, formalized as the consumption and income smoothing contract (Definition 1)[42]. Reallocating consumption and income according to this contract, each household, and thus its members, is able to smooth aggregate income, even though disaggregated (i.e. market and non-market) income and consumption components are more volatile. For instance, we may imagine that households redistribute consumption and income from their "richer" members to the "poorer" ones, according to a benevolent perspective.

We could conclude, roughly speaking, that PIH seems to hold, but consumers are smart enough to reallocate resource and labor supply over time and across sector so to smooth income, consumption, and create the puzzle.

6.1.3 Smoothing and Correlations.

Table 2 presents correlations for consumption and income series, at a disaggregated and aggregated level.

It is worth to notice that the correlation between aggregate consumption and output, $\rho(C_t^{tot}, Y_t^{tot}) = 0.69$, decomposes into correlations between total output and the two disaggregated consumption components, $\rho(c_t^{\kappa}, Y_t^{tot}) = 0.95$ and $\rho(c_t^{l}, Y_t^{tot}) = -0.96$, respectively. Total and market consumption are both procyclical, but the former presents a weaker (positive) correlation with aggregate income[43]. In the logic of our model, this comes from the fact that consumers allocate a share of income to non-market consumption, which is countercyclical. Since we calibrate the weight of market sector (0.725) to be larger than that of underground sector (0.275), total consumption ends up being procyclical.

Second, Proposition 2 shows that a sufficient condition for aggregate consumption smoothing, is that correlation between market and non market consumption, $\rho(c_t^{\kappa}, c_t^{l})$ should be smaller, in absolute value, than correlation between market and non-market output, $\rho(y_t^{\kappa}, y_t^{l})$[44].

[42] Precisely, it defines the reallocation of income and consumption which takes place, for each point in time, between consumer, and by this end between firms. Notice that firms smooth production, too. Since each firm lives just one period, production smoothing refers to the reallocation of production and inputs between sectors, for each point in time. Figure 3 and Figure 5 Panel B confirm this claim.

[43] Pro-cyclicality and Counter-cyclicality are defined in this contest with respect to total income, Y_t^{tot}.

[44] The proof is trivial, but for completeness we present it in Appendix A.

TABLE 2: CORRELATIONS

	y_t^κ	y_t^l	Y_t^{tot}	c_t^κ	c_t^l	C_t^{tot}
y_t^κ	1.00	-0.81	0.89	-	-	**0.77**
y_t^l		1.00	-0.45	-	-	**-0.54**
Y_t^{tot}			1.00	-	-	**0.80**
y_t^κ	1.00	-0.98	0.950	0.95	-0.97	**0.70**
		(0.01)	(0.01)	(0.02)	(0.01)	(0.11)
y_t^l		1.00	-0.96	-0.94	1.00	**-0.51**
			(0.01)	(0.02)	-	(0.12)
Y_t^{tot}			1.00	0.95	-0.96	**0.69**
				(0.02)	(0.01)	(0.11)
c_t^κ				1.00	-0.91	0.75
					(0.02)	(0.10)
c_t^l					1.00	0.42
						(0.13)
C_t^{tot}						1.00
y_t^κ	1.00	-0.97	0.99	0.96	-0.97	**0.68**
		(0.01)	(0.01)	(0.02)	(0.01)	(0.11)
y_t^l		1.00	-0.97	-0.95	1.00	**-0.61**
			(0.01)	(0.02)	-	(0.12)
Y_t^{tot}			1.00	0.96	-0.97	**0.69**
				(0.02)	(0.01)	(0.11)
c_t^κ				1.00	-0.91	0.72
					(0.02)	(0.10)
c_t^l					1.00	-0.39
						(0.13)
C_t^{tot}						1.00

Notes: The first block of the table contains the correlations estimated for the actual data; the second blocks presents the correlations estimated on the simulated data. The first one refers to the case $s = 1.3$, the second to the case $s = 2.0$. The moments matched in the calibration of utility function parameters are presented in boldface. See Table 1 notes.

Proposition 2 (Smoothing and Correlation) *Aggregate consumption smoothing requires the correlation between market and non-market consumption,* $\left|\rho\left(c_t^\kappa, c_t^l\right)\right|$*, to be smaller, in absolute value, than correlation between market and non-market production,* $\left|\rho\left(y_t^\kappa, y_t^l\right)\right|$*.*
Proof. *See Appendix A* ■

Table 2 shows how the model matches this restriction, since $\left|\rho\left(c_t^\kappa, c_t^l\right)\right| = 0.91$ and $\left|\rho\left(y_t^\kappa, y_t^l\right)\right| = 0.98$. In words, this means that market consumption reacts less to innovations, than market income does. We may interpret this as additional evidence supporting PIH, within the context of our model. Note that this argument parallels the key concept of the of risk sharing arguments discussed by Mace (1991) or Abel and Kotlikoff (1989). The difference is that in this case the insurance comes from income smoothing contract (i.e. a "real side" of the market) while in the works quoted above insurance originates from investing in financial securities.

6.1.4 Consumption and Income Smoothing: Inspecting the Composition

Here we complete the characterization of consumption and income smoothing, inspecting the composition mechanism operating before aggregation of consumption and income series. Specifically, we compare impulse response functions and volatility measures for all income definitions, Y^{tot}, y^κ, y^l, and for all consumption components C^{tot}, c^κ, c^l.

(Figure 3 about here)

In Figure 3 the impact on the endogenous variables of a one-standard-deviation shock to market sector productivity, directly increases capital investment, market output and market consumption. Note that total consumption rises only gradually. In particular, the household composed of Mr. and Mrs. κ does not choose to adjust consumption completely after an innovation. This is due to inter-temporal substitution and wealth effects, as in a traditional Robinson Crusoe economy, but in addition we see the redistribution effect within the family, previously defined. Indeed, market and non-market consumption components move always in opposite directions, and the former is much more responsive than aggregate variables[45].

Productivity shocks in the non-market sector, and increases in tax rates, reverse the picture, yielding opposite effects. Now aggregate consumption and production are reduced, together with investment. In spite of the remarkable jumps in non-market output and consumption, a rise in income and corporate taxes reduces market consumption, total consumption and investment, thereby impoverishing the economy and causing a recession.

Notice that these patters are consistent with a traditional equilibrium growth model (e.g. Christiano, 1989 or King and Rebelo, 1999). The new insight of our approach consists in the opportunity to understand the composition of aggregate in terms of disaggregated variables. Concluding, the most interesting results we observe from the four panels of Figure 3 is that c_t^κ responds to innovations more than C_t^{tot} does, and, in absolute terms, also more than c_t^l. In addition, total consumption presents a highly persistent response after the shocks.

(Figure 4 about here)

Impulse response functions of production series (Figure 4) display an analogous picture, where y_t^κ and y_t^l are always negative correlated, and y_t^κ is more sensitive to innovation than Y_t^{tot} and y_t^l. These results are robust, consistent with time series behavior of income and consumption, and support volatility and correlation measures already presented.

These results are confirmed by the graphical inspection of Hodrick-Prescott filtered series for consumption and income (Figure 5). The model generates procyclical market consumption movements, which are positively correlated with market output. Non-market consumption, instead, is countercyclical with respect to total consumption, and to market consumption. Note that total consumption is always in between its market and non-market component. Analogous comments hold for production series.

(Figure 5 Panel A and Panel B about here)

[45]We are suggesting that market and non-market consumption profiles, which are defined both as a pre-contract series, are highly negatively correlated. Table 2 (see section 6.1.3) shows that correlation between market and non-market consumption equals -0.91. To see more clearly forces' interaction, consider the following example. Suppose we have a positive productivity innovation in market sector: market income and labor demand increase, and, since we know the two sectors have negative correlation, non-market income and labor demand fall. Then the family reallocates its labor supply to the more productive sector, subtracting it from the less productive. Since labor supply cannot be traded (e.g. we cannot short sell H hours worked in one the sector), consumption would follow approximately income dynamic.

7 Conclusions.

The purpose of this paper is to provide a new interpretation for consumption and income smoothing, and suggest a solution of Deaton Paradox. We argue that excess smoothness of consumption to current income often shown in the empirical consumption literature may be related to the partial equilibrium framework adopted by these studies, and to the lack of an appropriate institutional or behavioral context which characterize many countries.

In the light of the analysis of Busato and Chiarini (2001), where a non-market sector has been incorporated in a dynamic general equilibrium framework, the smoothness of consumption does not seem puzzling. The non-market economy produces a *second cycle* which gives to households the opportunity to ensure themselves against bad times, by entering the income smoothing contract. However, introducing the non-market sector alters a variety of conventional macroeconomic implications, making booms less bright, and recessions less dark.

For a given institutional and productive structure, firms smooth production across sectors, and households smooth consumption inter-temporally and across sector. By this end, they diversify both economic activities and labor input between sectors and insulate the consumption path from income volatility. We argue that, in the logic of our model, these results come from having the interest rate endogenous combined with an explicit reallocation mechanism across sectors and among workers (that is the income smoothing contract). By entering into their contract, workers belonging to same extended family can insure themselves against fluctuations in market and non-market income. Relying on this hedging mechanism, consumer-worker-investor are able to smooth aggregate income, even though disaggregated income and consumption components are more volatile.

Our income smoothing contract represents, however, one out of many different way to model income smoothing. It turns out that in this model, the contract formulation has the ability to transform an heterogenous agent model into a representative agent model. Even though this results is specific to this model and to this contract, the implications for consumption, income and production smoothing are quite striking. These effects are completely ignored in the conventional consumption studies as well as in the dynamic equilibrium model literature.

Appendix A: Proofs of Propositions in the Text

Proof of Proposition 1 (Representative Agent and Extended Family).

Lemma 1 (Households and Extended Families) *The consumer side of the heterogenous agent model is represented as the following three equations:*

$$U\left(C_t^{\kappa}, c_t^l, l_t^{\kappa}, l_t^l\right) = (1/2)u\left(C_t^{\kappa}\right) + (1/2)u\left(c_t^l\right) - v\left(l_t^{\kappa}\right)l_t^l - \mu\left(l_t^l\right) \tag{A.1}$$

$$w_t(1-\tau_t)l_t^{\kappa} + w_t l_t^l + R_t K_t^{tot} = C_t^{tot} + X_t^{tot}. \tag{A.2}$$

$$K_{t+1}^{tot} = (1-\delta)K_t^{tot} + X_t^{tot} \tag{A.3}$$

Then consumption and income smoothing contract (Definition 1) dictates following two conditions:

1. ***Income Pooling**: $l_t^{\kappa} = \theta_t L_t$ and $l_t^l = (1-\theta_t)L_t$.*
2. ***Consumption Pooling**: $c_t^l = c_t^{\kappa} = (1/2)c_t^j$ (see Appendix B).*

Now, normalizing L_t to unity and implementing these features into $(A.1) - (A.3)$, we rewrite them as:

$$U\left(c_t^j, \theta_t^j\right) = u\left((1/2)c_t^j\right) - v\left(\theta_t^j\right)\left(1-\theta_t^j\right) - \mu\left(1-\theta_t^j\right). \tag{A.4}$$

$$w_t\left(1-\theta_t^j\tau_t\right) + R_t k_t^j = c_t^j + X_t^j. \tag{A.5}$$

$$K_{t+1}^{tot} = (1-\delta)K_t^{tot} + X_t^{tot} \tag{A.6}$$

Specifying functional forms $v(\theta_t^j)(1-\theta_t^j) = h\frac{(\theta_t^j)^{1+\gamma}}{1+\gamma}(1-\theta_t^j)$ and $\mu(1-\theta_t^j) = f\frac{(1-\theta_t^j)^{1+\eta}}{1+\eta}$ into Equation $(A.4)$ we derive equation (4) in text. Notice $(A.3) \equiv (A.6)$.

$$u\left(c_t^j, \theta_t^j\right) = \left\{\frac{(c_t^j)^{1-q}-1}{1-q} - h\frac{(\theta_t^j)^{1+\gamma}}{1+\gamma}\left(1-\theta_t^j\right) - f\frac{(1-\theta_t^j)^{1+\eta}}{1+\eta}\right\}. \tag{A.7}$$

Concluding, after introduction of consumption and income smoothing contract, the consumers' side of the model is represented by equations $(A.5), (A.6), (A.7)$.

Lemma 2 (Firms) *Firms are characterized by a production function, and a cost function.*

$$Y_{mt}^i = M_t\left(K_t^i\right)^{\alpha}\left(L_{mt}^i\right)^{1-\alpha} \quad \text{and} \quad Y_{ut}^i = Z_t L_{ut}^i. \tag{A.8}$$

$$w_t\left(1+t_t\right)L_{mt}^i + w_t L_{ut}^i + r_t K_t^i. \tag{A.9}$$

Now, implementing consumption and income smoothing contract, we rewrite $(A.8)$ and $(A.9)$ as:

$$Y_{mt}^i = M_t\left(K_t^i\right)^{\alpha}\left(\theta_t^i\right)^{1-\alpha} \quad \text{and} \quad Y_{ut}^i = Z_t\left(1-\theta_t^i\right) \tag{A.10}$$

$$CO\left(\theta_t^i, K_t^i\right) = w_t + w_t t_t \theta_t^i + r_t K_t^i. \tag{A.11}$$

To derive A.11, which equals equation (9) in the text, just simplify the following: $w_t\left(1+t_t\right)\theta_t^i + w_t(1-\theta_t^i) + r_t K_t^i$. Hence firms' problem is represented by equations $(A.10)$ and $(A.11)$.

Lemma 3 (Government) *Government budget constraint is:*

$$w_t\tau_t l_t^{\kappa} + (pst_t)Y_{ut} + t_t Y_{mt} = G_t$$

Implementing consumption and income smoothing contract, it becomes

$$w_t \tau_t \theta_t + (pst_t) Y_{ut} + t_t Y_{mt} = G_t \tag{A.12}$$

which is equation (10) *in the text.*

Finally, the decentralized model we study in this paper is represented by equations $(A.5), (A.6), (A.7)$ for j-th household, $(A.10), (A.11)$ for i-th firm, and $(A.12)$ for government.

The solution method used to solve this artificial economy is that suggested by King, Plosser and Rebelo (1988a,b). To this end we transform the equilibrium characterization of the economy into an approximating first order autoregressive linear system, applying linear approximations (e.g. Campbell 1994; Uhlig 1999).

■

Proof of Proposition 2 (Smoothing and Correlations). Assume $\sigma^2\left(c_t^l\right) = \sigma^2\left(y_t^l\right)$ (Assumption 1), and $\sigma^2\left(c_t^\kappa\right) > \sigma^2\left(y_t^\kappa\right)$ (Assumption 2)[46]. Let $C_t^{tot} = c_t^\kappa + c_t^l$, and let $Y_t^{tot} = y_t^\kappa + y_t^l$. Then $\sigma^2\left(C_t^{tot}\right) = \sigma^2\left(c_t^\kappa\right) + \sigma^2\left(c_t^l\right) + 2\sigma\left(c_t^\kappa; c_t^l\right)$ and $\sigma^2\left(Y_t^{tot}\right) = \sigma^2\left(y_t^\kappa\right) + \sigma^2\left(y_t^l\right) + 2\sigma\left(y_t^\kappa; y_t^l\right)$, where $\sigma^2(x)$ represents the variance of x, and $\sigma(x, y)$ the covariance between x and y. Aggregate consumption smoothing implies $\sigma^2\left(C_t^{tot}\right) < \sigma^2\left(Y_t^{tot}\right)$, or equivalently $\sigma^2\left(c_t^\kappa\right) + \sigma^2\left(c_t^l\right) + 2\sigma\left(c_t^\kappa; c_t^l\right) < \sigma^2\left(y_t^\kappa\right) + \sigma^2\left(y_t^l\right) + 2\sigma\left(y_t^\kappa; y_t^l\right)$. Rewrite $\sigma\left(c_t^\kappa; c_t^l\right)$ as $\rho\left(c_t^\kappa; c_t^l\right)\sigma\left(c_t^\kappa\right)\sigma\left(c_t^l\right)$ and $\sigma\left(y_t^\kappa; y_t^l\right)$ as $\rho\left(y_t^\kappa; y_t^l\right)\sigma\left(y_t^\kappa\right)\sigma\left(y_t^l\right)$, where $\rho(x; y)$ stands for the correlation between x and y, and $\sigma(x)$ is the standard deviation of x. Therefore: $\sigma^2\left(c_t^\kappa\right) + \sigma^2\left(c_t^l\right) + 2\rho\left(c_t^\kappa; c_t^l\right)\sigma\left(c_t^\kappa\right)\sigma\left(c_t^l\right) < \sigma^2\left(y_t^\kappa\right) + \sigma^2\left(y_t^l\right) + 2\rho\left(y_t^\kappa; y_t^l\right)\sigma\left(y_t^\kappa\right)\sigma\left(y_t^l\right)$. By construction we have $\sigma^2\left(c_t^l\right) = \sigma^2\left(y_t^l\right)$ and obviously $\sigma\left(c_t^l\right) = \sigma\left(y_t^l\right)$. Since $\sigma^2\left(c_t^\kappa\right) > \sigma^2\left(y_t^\kappa\right)$ and obviously $\sigma\left(c_t^\kappa\right) > \sigma\left(y_t^\kappa\right)$. Consumption smoothing now implies that $\rho\left(c_t^\kappa; c_t^l\right)\sigma\left(c_t^\kappa\right) < \rho\left(y_t^\kappa; y_t^l\right)\sigma\left(y_t^\kappa\right)$, or equivalently $\frac{\left|\rho\left(c_t^\kappa; c_t^l\right)\right|}{\left|\rho\left(y_t^\kappa; y_t^l\right)\right|} < \frac{\sigma\left(y_t^\kappa\right)}{\sigma\left(c_t^\kappa\right)} < 1$. Therefore $\frac{\left|\rho\left(c_t^\kappa; c_t^l\right)\right|}{\left|\rho\left(y_t^\kappa; y_t^l\right)\right|} < 1$ or $\left|\rho\left(c_t^\kappa; c_t^l\right)\right| < \left|\rho\left(y_t^\kappa; y_t^l\right)\right|$. ■

Remark 2 *Notice that since* $y_t^l = c_t^l$, *we may rewrite proposition 2 statement as follows* $\left|\rho\left(c_t^\kappa; y_t^l\right)\right| < \left|\rho\left(y_t^\kappa; y_t^l\right)\right|$, *or analogously as* $\left|\rho\left(c_t^\kappa; c_t^l\right)\right| < \left|\rho\left(y_t^\kappa; c_t^l\right)\right|$.

[46] Both assumptions are derived from empirical evidences, robust across countries and data sets, and matched by our model, see Deaton (1992), Attanasio (1999), Schneider and Enste (2000).

Appendix B: Perfect Risk Sharing Scheme

After entering the contract, consumers agree on a perfect risk sharing scheme, in the sense that they set ratio between marginal utilities equal to a constant, i.e.

$$\frac{u_{\kappa}^{'}\left(C_{\kappa,t}\right)}{u_{l}^{'}\left(C_{l,t}\right)} = \frac{\phi_{\kappa}}{\phi_{l}}.$$

Since $u_{\kappa}^{'}\left(c_{t}^{\kappa}\right) = u_{l}^{'}\left(c_{t}^{\kappa}\right) = u'\left(C_{t}\right)$, we have:

$$c_{t}^{\kappa} = \frac{\phi_{\kappa}}{\phi_{l}} c_{t}^{l}.$$

Assuming, that both consumers have same importance, we can set $\phi_{\kappa} = \phi_{l}$, and therefore $c_{t}^{\kappa} = c_{t}^{l}$. The two consumers will have an equal consumption profile. In terms of total consumption, we have $c_{t}^{\kappa} = c_{t}^{l} = \frac{1}{2} C_{t}^{j}$, where C_{t}^{j} represents consumption chosen by j-th household at time t.

Appendix C: Sensitivity Analysis

Table 3: Sensitivity Analysis

	$\sigma_{Y_{tot}}$	$\sigma_{C_{tot}}$	$\frac{\sigma_{C_{tot}}}{\sigma_{Y_{tot}}}$	$\rho(Y_{tot}, C_u)$	$\rho(Y_{tot}, C_{tot})$
$h = 0.35$	1.05	0.96	0.91	-0.97	0.45
$h = 0.38$	1.02	0.91	0.90	-0.93	0.32
$h = 0.44$	1.27	0.97	0.76	-0.94	0.68
$h = 0.46$	1.32	1.20	0.91	-0.98	0.77
$h = 0.48$	2.03	1.86	0.92	-0.98	0.71
$\eta = 1.25$	1.67	1.30	0.78	-0.98	0.71
$\eta = 1.27$	1.34	1.21	0.90	-0.95	0.74
$\eta = 1.29$	1.1	0.90	0.82	-0.94	0.54
$\eta = 1.31$	1.13	1.11	0.98	-0.93	0.58
$\eta = 1.33$	1.35	1.25	0.92	-0.95	0.57
$\eta = 1.40$	1.26	1.10	0.87	-0.95	0.17
$f = 1.90$	1.36	1.18	0.86	-0.94	0.45
$f = 1.92$	1.41	1.19	0.84	-0.94	0.52
$f = 1.94$	1.25	1.13	0.90	-0.96	0.55
$f = 1.96$	1.25	1.04	0.83	-0.95	0.71
$f = 1.98$	1.49	1.36	0.90	-0.96	0.73
$f = 2.00$	1.10	1.05	0.95	-0.98	0.70

Notes: $\sigma_{Y_{tot}}$ represents the total production standard deviation, $\sigma_{C_{tot}}$ is total consumption standard deviation, $\rho(Y_{tot}, C_u)$ is the correlation coefficient between total production and non-market consumption, and $\rho(Y_{tot}, C_{tot})$ is the correlation coefficient between total production and total consumption.

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Appendix D: Figures

Figure 1: Innovation in Market Consumption and Market Income

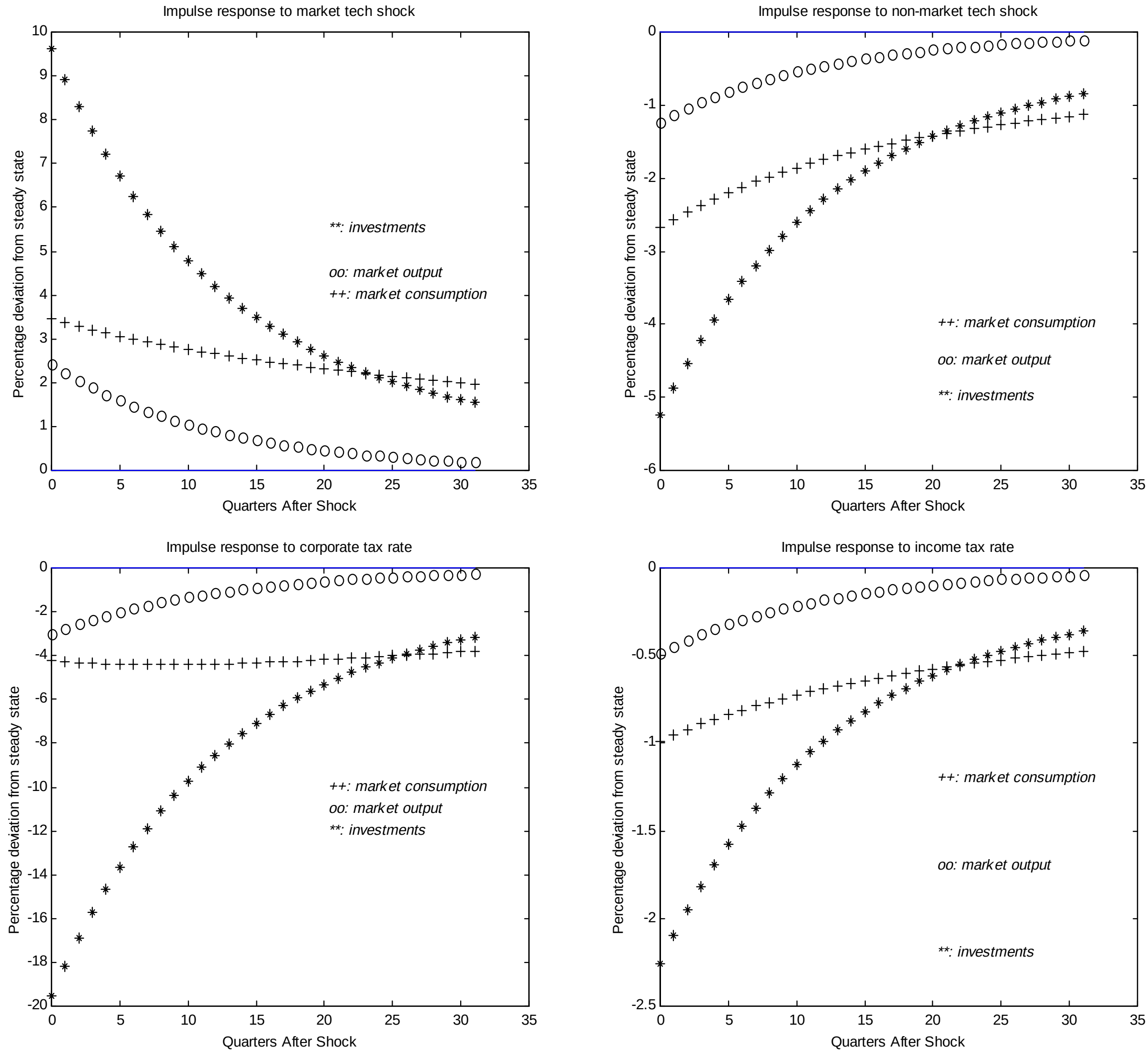


Figure 1: the figure shows the first 32 quarter response of y_t^κ (market income), c_t^κ (market consumption) and X_t^{tot} (total investment) to a one standard deviation innovation in market-sector productivity, non-market sector productivity, corporate and income tax rates. The curves are the quarterly percentage deviations from a baseline scenario where all innovations are set to zero.

Figure 2: Innovation in Total Consumption and Total Income

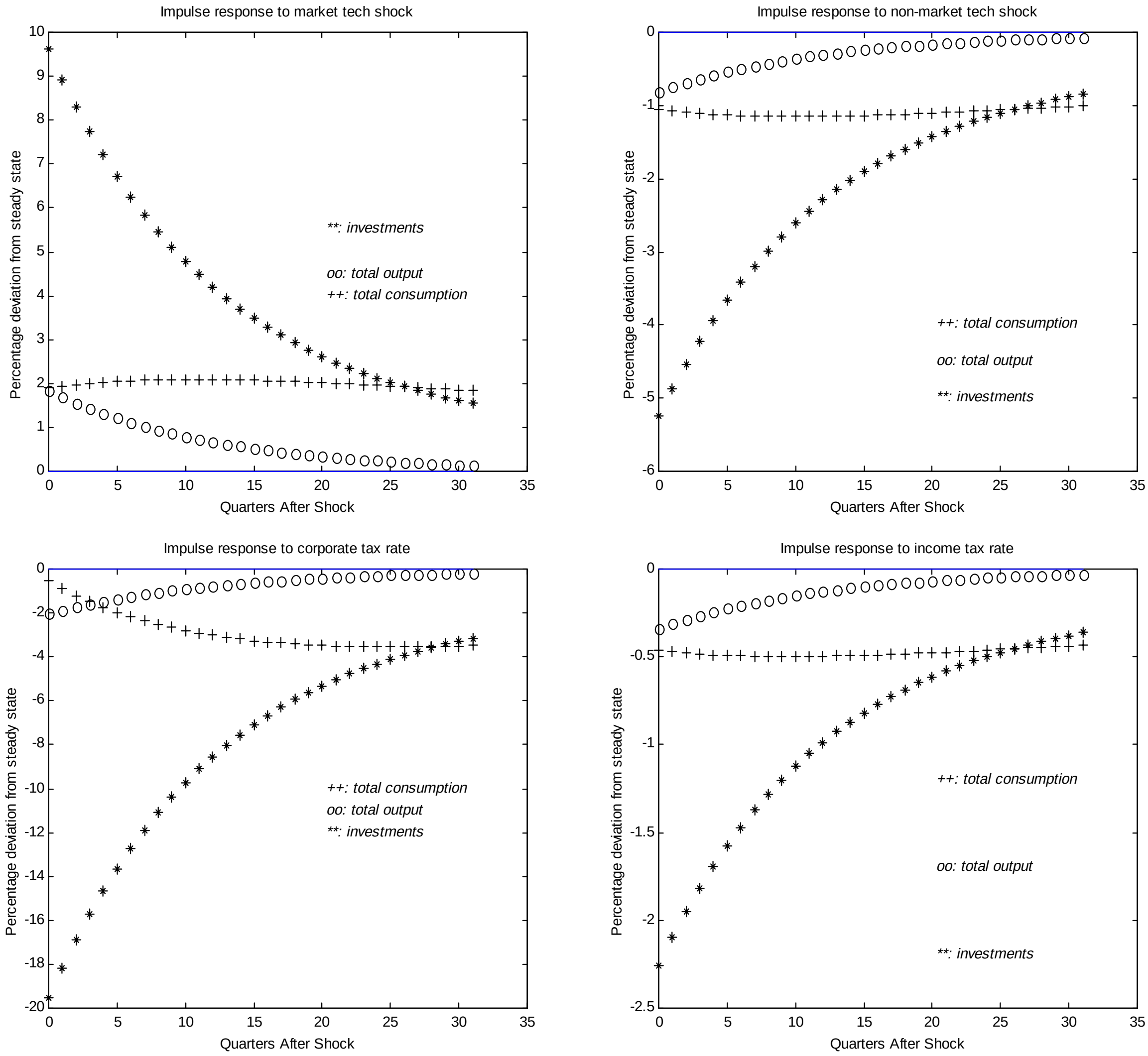


Figure 2: the figure shows the first 32 quarter response of Y_t^{tot} (total income), C_t^{tot} (total consumption) and X_t^{tot} (total investment) to a one standard deviation innovation in market-sector productivity, non-market sector productivity, corporate and income tax rates. The curves are the quarterly percentage deviations from a baseline scenario where all innovations are set to zero.

FIGURE 3: CONSUMPTION SMOOTHING

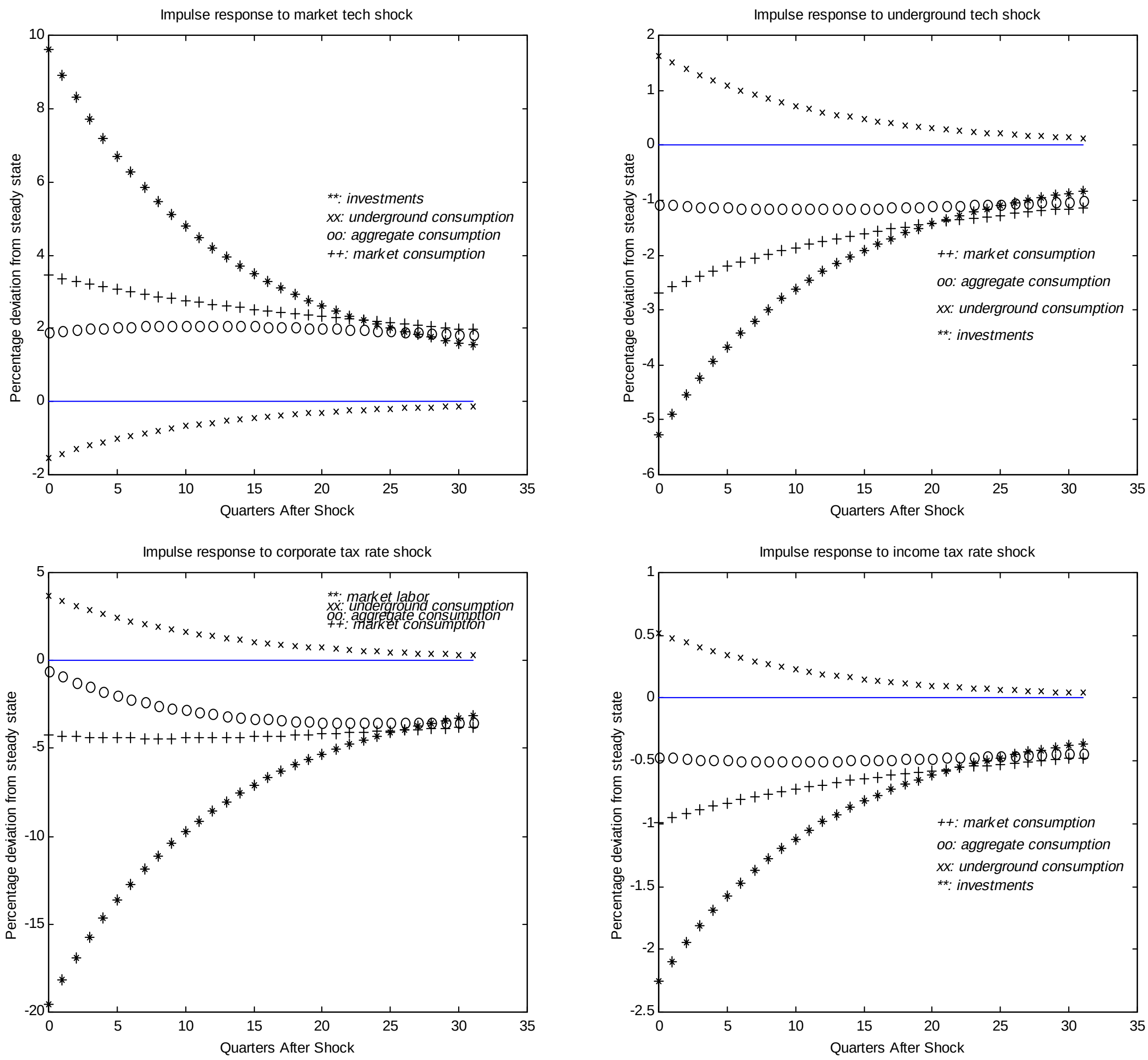


Figure 3: the figure shows the first 32 quarter response of c_t^{κ} (market consumption), c_t^{l} (non-market consumption), C_t^{tot} (total consumption) and X_t^{tot} (total investment) to a one standard deviation innovation in market-sector productivity, non-market sector productivity, corporate and income tax rates. The curves are the quarterly percentage deviations from a baseline scenario where all innovations are set to zero.

Figure 4: Production Smoothing

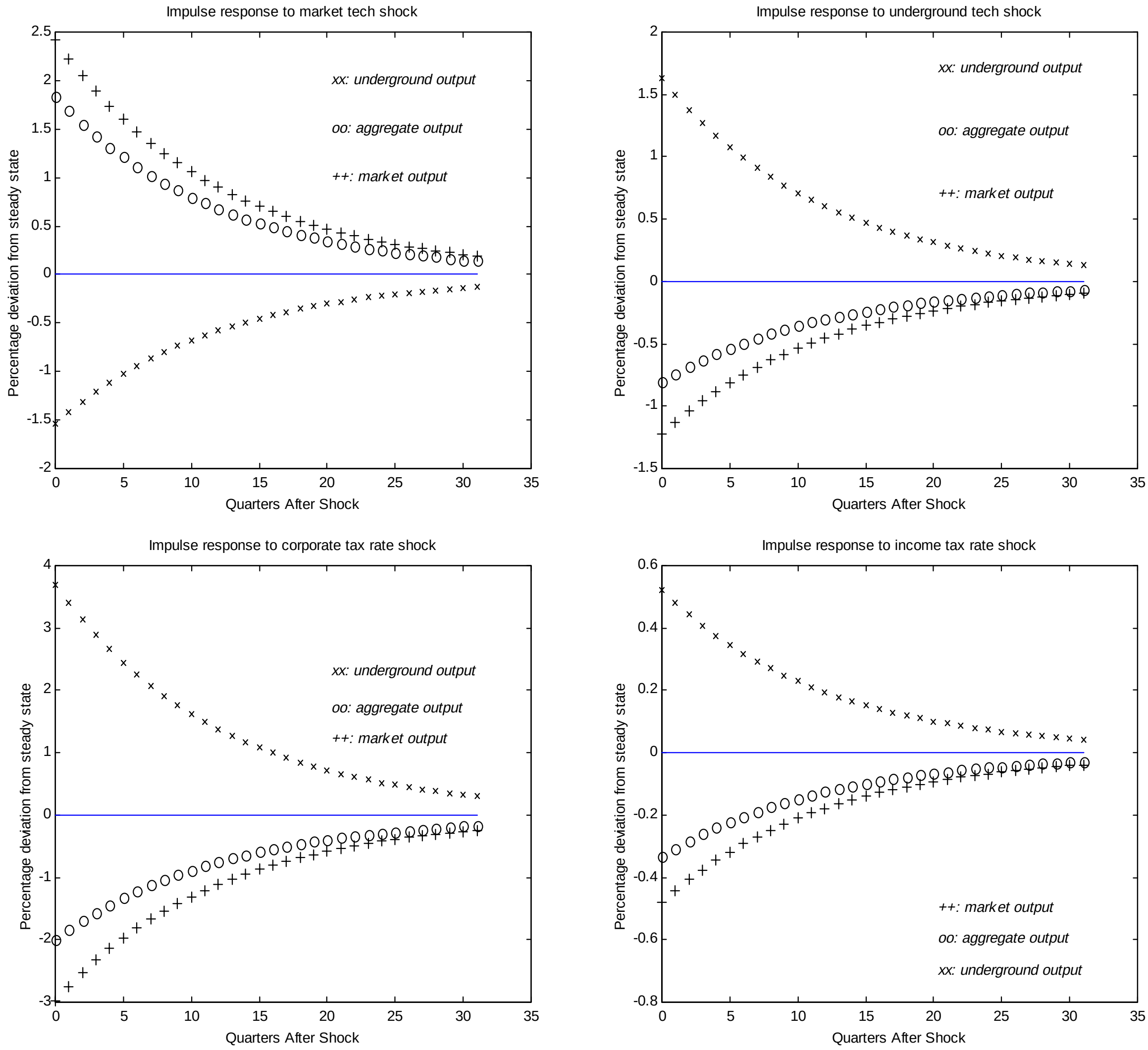
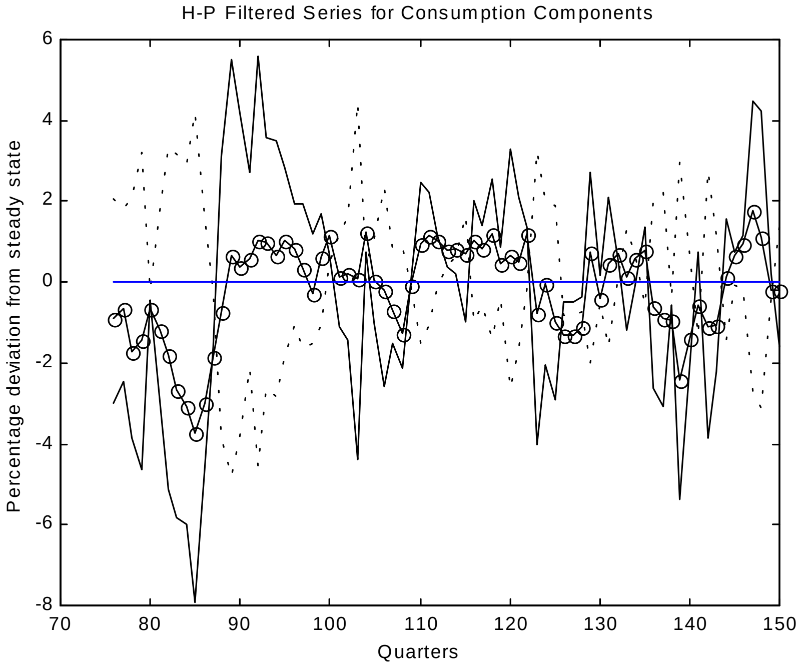
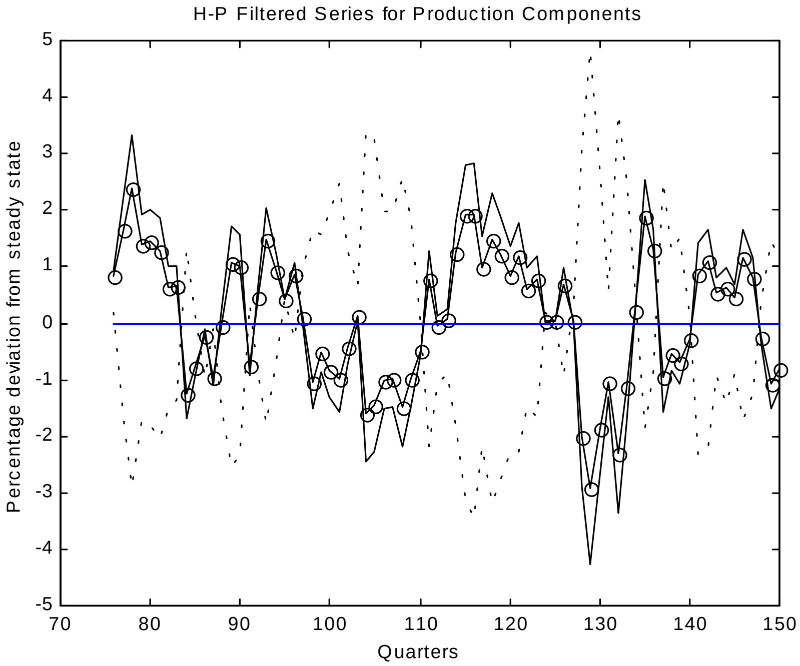


Figure 4: the figure shows the first 32 quarter response of y_t^{κ} (market income), y_t^{l} (non-market income), and Y_t^{tot} (total income) to a one standard deviation innovation in market-sector productivity, non-market sector productivity, corporate and income tax rates. The curves are the quarterly percentage deviations from a baseline scenario where all innovations are set to zero.

FIGURE 5: COMPOSITION MECHANISM FOR
CONSUMPTION AND PRODUCTION COMPONENTS



Panel A



Panel B

Figure 5: *Panel A*: solid line represents market production component y_t^κ, dashed line represent non-market production component, y_t^l, and the starred line the aggregate production component, Y_t^{tot}. *Panel B*: solid line represents market consumption component c_t^κ, dashed line represent non-market consumption component, c_t^l, and the starred line the aggregate consumption component, C_t^{tot}.

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