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A MODEL OF THE MIXED HOUSEHOLD IN YUGOSLAVIA

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1. INTRODUCTION**

In nearly all developing economies the agricultural sector has been subject to extensive government intervention taking various forms, including price policy, investment policy and tax policy. The consistency and success of the policy measures are, however, highly dependent on the reaction of the economic agents to various incentives. In many cases, the mixed household is the relevant economic agent towards which the policy measures are directed.

The mixed household is a complex economic agent, uniting the features of both the household and an enterprise. In order to understand the complexity of simultaneous economic decisions made by the mixed household, and to prepare the ground for a theoretically based set of consistent policy measures, it is useful to model the household choice problem. In doing so, the rationality of household behavior is assumed. This assumption simply means that the household makes the best possible use of scarce resources subject to certain economic or institutional constraints. Empirical evidence of this rationality is a subject to be investigated.

Questions often arise about whether rationality can serve as a basis for understanding the behavior of a sector in which tradition plays an important role. But, tradition and rationality can be mutually consistent in the sense that the traditional reaction (or lack of reaction) by the household may be a rational response to the household's environment. Elaborating this assumption of rationality in a consistent manner, this study attempts to provide a comprehensive mod-

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el of the economic behavior of the Yugoslav mixed household, as an economic agent sui generis. The analysis may serve as a departure point of the formulation of practical policy measures regarding the expansion of agricultural output, one of the basic macroeconomic goals of a developing society.

The plan of the paper is the following: In the next two sections we present a brief literature survey and outline of the significance and reasons for growth and persistence of mixed households in Yugoslav agriculture; In the fourth section, we present an elaborate model of the economic behavior of the mixed household, taking into account its economic, technological and institutional constraints; The fifth section summarizes the results of the comparative static analysis of selected parameters; Finally, the last section contains policy implications of the theoretical model and conclusions.

2. THE TREATMENT OF THE MIXED HOUSEHOLD IN DEVELOPMENT ECONOMICS

Development economics has already recognized the important role of mixed households in world agriculture. By mixed household we mean a semi-commercial type of family farm earning income from several different sources. Most of the farm households, especially those in developing countries, belong to this category, "which is located on a continuum between a wholly commercial farm employing hired labor and marketing all output, and a pure subsistence farm using only family labor and producing no marketed surplus."[1] Specifically, the mixed household is a type of farm, producing agricultural output, but also participating in the free labor market and, perhaps, renting out a portion of the land it owns. It is this mixed character of the sources of income that makes the mixed household an extremely interesting and complex economic agent. However, the examination of the economic behavior of the mixed households is far from being just an academic exercise. It has direct practical and policy relevance since many Third World countries display the typical dual structure of the economy that is often associated with the emergence and growth of mixed households. Furthermore, the concept of a purely agricultural household, earning income exclusively from agriculture, is but a special case of the mixed household. Consequently, recognition of the reaction of the household to different changes in its institutional and economic environment is a crucial question for the successful design of policy measures in the agricultural sector, of a developing country.

The extensive literature on the theory of the farm household has recognized the complexity of economic effects within the household generated by changes in the economic environment. For example, a single exogenous change in the prices of agricultural output of the household would have far reaching consequences on the economic

[1] Barnum and Squire (1979), pp. 79—102.

behavior of the household. Namely, it could induce a change in the total farm output, marketed output, and the own consumption of agricultural output. However, these changes do not necessarily follow the strict logic of neoclassical production theory, according to which an increase in the price of output, ceteris paribus, results in the expansion of output. As noted by Behrman (1968, p. 9), "Produced quantities and marketed quantities need not respond identically to various incentives."

The relevant determinants of the output response to price changes are the share of own-consumption in the total output, the household's extent of self-sufficiency in agricultural products, household members' preferences, as well as the number and the age of household members. The greater the share of the own-consumption, the greater is the possibility of negative price-induced changes of the total and marketed output. The lower the self-sufficiency in agricultural products the greater is the chance for a price-induced increase in own-consumption, rather than only the marketed part of total output. The stronger are the household's preferences towards leisure, the lower will be the total output and marketed output response to the increase in prices of agricultural products. In addition, a price change may induce no change in total output but rather a recomposition of the total household's output. Also, the household's output response to price changes in the short run depends on the share of the one-year crops in the total output.

Finally, the size, sex and age characteristics of the household substantially affect the productive capacity of the household, the structure of preferences, and, hence, the consumption patterns. As a result, the final outcome of a price change with regards to the household's total output, marketed output and own-consumption is ambiguous and depends heavily on the characteristics of the household, but also on the macro features of the agricultural sector, such as the level of commercialization of agriculture, the level of technology and the amount of social overhead capital.

Through this simple example it seems clear that, in order to understand, explain and predict the behavior of mixed households, one cannot use the tools of the production theory alone, but must, instead, combine them with the tools of consumer choice theory, without ignoring the peculiarities of the economy in question.

The development economics literature contains a large number of models of household behavior with one aim: to understand and predict the economic reactions of the household to exogenous changes. Theoretical models vary from models of the representative household (Barnum 1979) to models of the whole agricultural sector in an agrarian economy (Hymer, Resnick 1969). Other authors focus more deeply on the empirical controversy about the supply response of households to price changes (Nerlove 1958, Krishna 1963, and Behrman 1968), while only a few authors have successfully tested the farm household model.[2]

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[2] Farm households have been extensively treated in Chayanov (1966), Krishna (1969) and Nakayima (1969).

Models of the agricultural household often are used as a basis for modeling the whole sector or even the whole economy of the LDC. Yutopoulos and Lau,[3] for example, have developed a methodology for construction of general equilibrium models of the agricultural sector which are flexible enough to be applied to different institutional frameworks. The starting point of this type of model is again the model of the household, based on the assumption of rational maximizing behavior.

A common feature of the most theoretical models of household behavior is the postulation of an objective function of the household, which typically contains the consumption of various goods and leisure. The constraints facing the household are usually recognized as the time constraint and the income-expenditure identity. The land constraint has been only occasionally taken into account, depending on the binding or non-binding character of this limit in countries under consideration. The production function of the household, if taken as a specific function, is usually assumed to be a Cobb-Douglas form with labor as a variable input while land and capital are held fixed (Yotopoulos, Lau 1974).

In comparative static analyses many authors focus on the exogenous change in agricultural prices and its effects on the production and consumption decisions of the household. Very little acount has been taken of taxes and their impact on the household's behavior. In development of both theoretical and econometric models of the agricultural household, two major difficulties arise. First, "predictions on the basis of comparative statics are nearly impossible because of the large number of interactions implicit in a model that incorporates both production and consumption behavior. Second, at the empirical level, the need to collect data covering the spectrum of major household activities (expenditures, farm management, and labor utilization) has severely limited the number of actual applications."[4] Consequently breakthroughs in this field are still expected.

In this paper we present a theoretical model of the mixed household, that differs from other models in several respects. First, we used the specific functional form (Cobb-Douglas) for the utility function and the production function, so as to derive the comparative static results about the impacts of changes in parameters on the variables of the model. Second, the model explicitly features three different types of taxes: wage tax, agricultural income tax and excise tax on nonagricultural goods. Third, and foremost, the model incorporates the alternative sources of incomes (from farm, from the work outside the farm, and from leasing the land), available to the mixed household, a crucial feature in understanding the reaction of the mixed household to various stimuli. The Yugoslav agricultural sector, in which private households represent the great underutilized resource for the expansion of agricultural output, has not been subject to extensive research based on this type of modeling approach.

[3] Yotopoulos and Lau (1974), p. 135.
[4] Barnum and Squire (1979) p. 4.

3. THE DEVELOPMENT OF THE MIXED HOUSEHOLD IN YUGOSLAVIA

Most authors dealing with the postwar economic development in Yugoslavia describe the tremendous structural changes within the economy over the last forty years. The most striking changes occured between the agricultural and industrial sectors of the economy. Rapid industrialization of the economy was adopted as a major development strategy. This strategy resulted in investment and price policies favouring the industrial, as opposed to the agricultural, sector of the economy. On the one hand, industry was viewed as an engine of economic growth and development, and consequently was given the highest priorities in all planning documents. Agriculture, on the other hand, was perceived as a supplier of inexpensive food and low-cost labor to the growing industrial sector.

Ideological and economic reasons have contributed to the imposition of a number of institutional constraints on peasants during the past several decades: tight restrictions on individual holdings of land, sharp taxation, price ceilings on agricultural products, etc. The negative effects of collectivization in the immediate postwar years on agricultural output have forced the government to find alternative means of bringing private farms under the umbrella of the social sector of the economy. Various forms of cooperatives have, however, not shown long-term viability. At the same time, the rise in economic and social amenities such as jobs, housing, education, health insurance and the social status, in the cities have worked as strong "pull" factors in the rapid rural-urban migrations in Yugoslavia. As a result of these trends, Yugoslavia experienced one of the most rapid transfers of rural population to urban areas. The agricultural share of the total population has dropped dramatically in little more than a generation.[5] The rural-urban migration was only one consequence of the changing structure of the Yugoslav economy. The share of the industrial output in the total social product grew from 18 percent in 1947 to 43 percent in 1985. At the same time, the share of agricultural output decreased from 39 percent to 13 percent in the same period.[6] Thus, the economy has taken the typical dual structure of the rapidly growing LDCs, with a dominant, growing industrial sector and an underdeveloped agricultural sector.

The agricultural sector also displayed a special duality. A highly capitalized social sector, organized through large-scale agroindustrial enterprises or combines *(kombinati)*, produces 30 percent of the total social product in agriculture, using only 17 percent of the total arable land. On the other hand, individual farmers, who own 83 percent of the arable land in Yugoslavia, produce slightly less than 70 percent of the

[5] The agricultural share of the total population has declined from 73 percent (12 million) in 1945 to only 19.9 percent (4.5 million) in 1981. (SGJ 1987, p. 124.). The extent of this change becomes clearer when one considers that the natural rate of increase of the rural population was higher than that of the urban population.

[6] Jugoslavija 1945—1985 (1986), p. 11.

total social product of agriculture.[7] The following table provides a glimpse of the dual structure of Yugoslav agriculture in 1986.

Table 1

THE STRUCTURE OF THE YUGOSLAV AGRICULTURE IN 1986	
SHARE IN THE SOCIAL PRODUCT (%)	
Agroindustrial enterprises	30
Private farms	70
SHARE OF THE ARABLE LAND (%)	
Agroindustrial enterprises	17
Private farms	83
SHARE OF SALES AND PROCUREMENTS (%)	
Agorindustrial enterprises	51
Private farms	49
SHARE OF THE LIVESTOCK (%)	
Agroindustrial enterprises	17
Private farms	83

Source: Calculated from *SGJ 1987*, tables 114—1 (p. 238) and 221—2 (p. 509).

The fact that the yields on private farms are on average 25 to 50 percent lower than those in the social combines was often interpreted as a proof that the social sector is inherently more productive than the individual farmers. However, if the institutional constraints under which private farmers have operated, are properly taken into account one may easily arrive at the opposite conclusion.[8]

The structural changes of the entire Yugoslav economy involving rural-urban migrations, and the rapid shift from an agricultural towards an industrialized society, have induced changes in the socio-economic composition of households. In particular, the emergence and growth of mixed households stands out as a remarkable characteristic of this change. The following table shows a steady increase in the percentage of mixed households in the total number of agricultural households.[9]

[7] SGJ 1987, p. 509.

[8] D. Veselinov has argued that the only reason for the higher productivity of social combines lies in the fact that they have been systematically supported by government policies over the entire postwar period. See Veselinov (1986), p. 26.

[9] The offical statistics in Yugoslavia distinguish between two main groups of land-owning agricultural households, according to the structure of income sources. First is the category of purely agricultural households who have no members that are permanently employed outside household. This means that income from the farm is the only permanent source of income for the household. Second is the category of mixed households who have at least one member permanently earning income (pensions included) outside the household.

Table 2

GROWTH OF MIXED HOUSEHOLDS

Year	Percentage Share of Mixed Households in Total Num. of Agr. H.
1931	9
1949	19
1955	32
1969	43
1986	54

Source: Stipetić, cited by Horvat 1976, p. 263 for years 1931 through 1969, and calculated from Pavlović 1987, p. 65 for 1986.

More recent studies indicate that this category of households has continued to increase its relative share in the total number of agricultural households, and that they already constitute more than 60 percent of all households owning land in Yugoslavia.[10] In addition, in the regular review of farm households for 1986, 72.3 percent of the households reviewed are mixed households.[11] These figures suggest that mixed households are not a temporary category that will quickly disappear over the course of economic growth. Consequently, better understanding of this important economic agent can contribute to the more effective selection and use of measures of agrarian policy.

The emergence, growth, and persistence of mixed households in Yugoslav agriculture can be explained by at least three groups of factors. First, "push" factors that narrowed the economic power of the purely agricultural households have played an important role. Among these, forced collectivization in the immediate postwar years, a low land maximum,[12] absence of legal restrictions on fragmentation of agricultural land,[13] sharply progressive taxation,[14] long absence of

[10] "From total number of farm households only about 32 percent are 'purely' agricultural, while the rest are 'mixed' (64 percent) and nonagricultural (4 percent)." (Ilijin 1988, p. 20). The similar figures can be found in *Ekonomska enciklopedija* 1984, p. 17.

[11] Calculated from *Anketa o potrošnji domaćinstava u 1986 — seoska domaćinstva* 1987, table 2—1, p. 11.

[12] The land maximum had been set at 25 hectares (61.7 acres) in 1945, and then reduced to 10 hectares (24.7 acres) in 1953. Recently, the land maximum has been relaxed again in Slovenia to 20 hectares, and proposals have been heard from some economists and politicians that it should be relaxed for the whole country.

[13] See Dirlam and Plummer (1971), p. 113, and Miller (1987), p. 24.

[14] See Horvat (1976), p. 223. Also, it is worht noting that in 1986 the average agricultural household paid 65 percent more taxes and contributions than its mixed counterpart. In Vojvodina, the single most important agricultural region in Yugoslavia, purely agricultural farms paid 131 percent more taxes and contributions than the mixed farms! (calculated from "Anketa o potrošnji domaćinstava u 1986 — seoska domaćinstva", 1987, p. 13.).

pension (introduced in 1972) and health insurance (introduced in 1959) plans for peasants, and the government's favouring social combines, as opposed to the individual farmers, have been among the most prominent factors. The second group of "pull" factors were associated with the industrial (and often urban) sector of the economy. The pull factors include the rapid growth of the university centres, and various economic and social amenities offered by the cities (jobs, housing, pensions, health insurance, social status etc.). Finally, the peasants' own rational instinct worked in favour of the mixed households. Peasants quickly realized that several sources of income (from the farm and from work outside the farm) can provide a more stable and higher stream of income than complete reliance on either the heavily constrained agricultural income or non-farm earnings. This strategy was reinforced by the growing unemployment in the economy, which showed the inability of the social sector to absorb the growing supply of labor. Therefore, rising uncertainty about economic prospects in either a purely agricultural or purely urban life-style, encouraged peasants to take advantages of both, in perfect correspondence with the principle of risk diversification. The natural consequence of these trends is that agriculture has ceased being the only source of income for most rural households. A special type of household has emerged: the mixed household, still owning land but earning incomes from several different sources (leasing of land, work in the social sector, and sale of agricultural products).

The emergence of mixed households in Yugoslavia has been recognized in the economic literature. Puljiz (1970, pp. 92—104) describes in detail the socioeconomic roots, position, and characteristics of mixed households, while Krašovec (1965, pp. 5—23) and Livada (1965, pp. 25—43) comment on the social desirability and the future of this economic agent. The same authors reveal controversial characteristics of worker-peasants (members of the mixed household) who tend neither to work efficiently in industry, nor to cultivate land intensively.

However, worker-peasants often appear as the carrier of economic progress to the village, bringing new knowledge and modern methods of cultivating the land. Horvat insists that the exodus of peasant from the village and the creation of the mixed households is proof that peasants do not have a conservative, unenterprising mentality. "When the opportunity is offered him, the peasant either improves his farm or accepts a more rewarding occupation."[15]

If one looks only at the money income from the farm production, the income is 130 percent higher in the purely agricultural household than in the mixed household.[16] However, multiple sources of income produce a higher standard of living for mixed households. In 1986, the total income of an average mixed household was 130 percent higher than that of a purely agricultural household. This difference is more striking when one takes into account the fact that an average mixed

[15] Horvat (1976), p. 17.

[16] Calculated from "Anketa o potrošnji domaćinstava u 1986 — seoska domaćinstva" (1987), p. 13.

household has only 3.3 members versus 4.5 for the purely agricultural household. This itself may prove to be a powerful factor contributing to the continued shift away from the purely agricultural farms towards mixed households.

Saving and investment patterns of the mixed households were found to be different from those of other socio-economic categories of households. In a recent paper, Miller, using the official data, shows that mixed farms tend to save less than the purely agricultural farms. Since saving is related to investment, Miller concludes that the propensity for investment in the farm will be lower in the mixed households.[17] This conclusion may seem intuitively correct, but the data do not support unambiguously such an assertion. In 1986, the mixed farms were investing 139 percent more than the purely agricultural farms. A closer look at the different regions reveals that in only two of six republics, namely in Slovenia and in Bosnia and Herzegovina, purely agricultural farms invested more than the mixed farms.[18] The explanation for this paradox may lie in the different abilities of different categories of farms to obtain bank loans for financing investments. This hypothesis would have to be tested using more disaggregated data on bank loans to various categories of households. However, such data may not be readily available.

Although many controversies about the mixed households in Yugoslavia are unresolved, policy makers should recognize their existence and offer methods for raising the productivity on mixed farms. Their significance in Yugoslav agriculture, as well as a number of distinct characteristics, are sufficient reasons for a more rigorous theoretical analysis of the mixed household. This paper is an effort in that direction. In the following section we present a mathematical model of the mixed household that attempts to capture its crucial features. Having solved the model, we performed comparative static analysis so as to trace the impact of various parameters and policy variables on the economic behavior of the mixed household. Finally, a number of policy implications are summarized and discussed in the last section.

4. THE MODEL

Various inquires into the character and working of the mixed household carried out in different countries suggest that the mixed household is a product of the historical process of economic development, regardless of the institutional framework of a given society. The relative economic importance of this economic agent, however, varies substantially across countries and in the economic history of the same country. Economic development, at least in stages that are relevant for developing countries, occurs through the process of a widening gap between a modern (typically industrial sector) and a lagging tradi-

[17] Miller (1987), p. 14.

[18] Calculated from "Anketa o potrošnji domaćinstava u 1986 — seoska domaćinstva" (1987), p. 19.

tional (typically agricultural) sector of the economy. The wider this gap, the greater the possibility for the land-endowed households to diversify their potential and actual sources of income, thus becoming neither purely agricultural, nor strictly urban households, but rather a mixture of the two. Therefore, it is fairly clear that the inevitable emergence of the mixed household is dictated by economic development in general. However, the actual size and specific form of the mixed household sector in a developing economy depend heavily on the rate of economic development, geographical and demographic characteristics, and the actual type of development strategy pursued by the particular country.

In certain countries, as in Yugoslavia, the economic importance of mixed household sector forces the policy makers to adjust policy goals to tap the potential in this sector. However, virtually all authors treat the problem of mixed households partially, focusing on the general features of agricultural development and its relationship with the overall development of the society. Attempts are being made, from the macroeconomic point of view, to deduce ready-made prescriptions for increasing productivity in agriculture and, hence, for the increasing productivity in the mixed households.

Macroeconomic policy measures, however, can yield desired outcomes only if the "reaction function" (i. e. the economic behavior of the economic agent) is sufficiently known to policymakers. For this reason, an understanding of the mixed household's economic response to changes in the economic environment can be a clue to the design of successful policy measures. Conversely, misunderstanding the economic agent's reaction function can be a basis for the implementation of an entirely wrong set of policy measures.

In the well-known thesis about Feuerbach, K. Marx states that it is not at issue to explain the world, but to change it. However, being a social analyst par excellence, he would probably agree that the former is the necessary condition for the latter.

A mixed household is a special type of economic agent for many reasons. It is an enterprise per se. It controls a limited amount of capital, labor, and land and combines them in the process of agricultural production, subject to the current state of technology. Hence, part of the household's economic activity is characterized by the production function, a technical relationship between inputs and the total agricultural output of the household. At the same time, the household represents a family-unit, and as such it consumes various products.

In both processes, the production of agricultural output and the consumption of various goods (both agricultural and nonagricultural ones), the household is assumed to act as an economic (i.e., a rational) agent. This simply means that the household produces and consumes products in the most advantageous way, given its goals and the economic and institutional constraints on its behavior.

In modeling the mixed household, several more constraints must be taken into account. Household members are limited in number and time and, hence, will distribute the total time available to agricultural production by the household, to leisure, and to work outside the

household, depending on the nature of the economic environment and on their own wealth and preferences. In much the same way, the household will distribute its total endowment of land to arable land, land devoted to leisure, and land leased to other uses. Also, total agricultural output of the household is allocated to a "marketable" output and the part of the total output consumed by he members of the household (own-consumption).

The relationship between incomes and expenditures of the household can be taken as an identity. This assumption greatly simplifies the mathematical solution of the problem without abandoning the realistic framework of the model. Saving is a postponed consumption. If the relationship between savings and investment is not the primary focus, it may be assumed that the total income of the household from the sale of the "marketable surplus", the provision of labor services to the industrial sector, and the leasing of land to other uses, is spent on various nonagricultural goods bought by the household. Obviously, an implicit assumption of the postulated income-expenditure identity is that the household is self-sufficient in agricultural products.

4.1 THE MODEL: FORMULATION

Assume that the household maximizes an objective function of the following form:

$$U = B\, T^{a}_{0}\, Q^{b}\, q^{c}_{0}\, L^{d}_{0}\, Z^{g} \qquad (1)$$

where a,b,c,d $\in$ (0,1) and B is a constant; T_0 is the daily number of hours that household members spend in leisure and non-work activities (leisure time); Q is the quantity of nonagricultural goods bought and consumed by the household; q_0 stands for the part of the total agricultural output of the household which is consumed by members of the household; L_0 represents the part of the land endowment of the household which is not used for income-yielding activities. This variable, which can be called non-farm land is the household's land that is used for housing, yards, other unproductive uses, and unused land. Finally, Z denotes the amount of public goods consumed by the household. Z is assumed to be exogenously determined by the government.

The model contains a set of constraints facing the household, first of which is the time constraint.

The time constraint simply states that the household members distribute their total daily time to different uses:

$$T = T_0 + T_1 + T_2 \qquad (2)$$

where T is the daily time limit of the household; T_0 is the time devoted to leisure; T_1 is the time used for agricultural production on the farm; and T_2 is the daily number of hours that the household members work outside the household.[19]

[19] T is not 24 hours, rather, it is a product of the daily time limit of the individual (24 hours) and the number of household members.

The land constraint, in a similar manner, states that the land endowment of the household is distributed among different uses:

$$L = L_0 + L_1 + L_2 \tag{3}$$

where L is the household's land endowment; L_0 is the land devoted to leisure; L_1 is the part of the land endowment used for agricultural production; and L_2 denotes the part of the land endowment leased by the household to other users of land.

The production identity states that the total agricultural output of the household consists of the part of the output consumed by the household members and the part of the output sold in the market:

$$q = q_0 + q_1 \tag{4}$$

where q stands for the household's total agricultural output; q_0 represents the part of the output consumed by the household members and q_1 denotes the "marketable surplus" sold in the market. It is assumed that the household is self-sufficient in food, but must earn additional income to cover other household outlays (personal consumption, capital goods, taxes, loan charges, etc.).

The fourth constraint facing the household is the income-expenditure identity stating that the entire amount of after-tax earnings of the household must equal the total nonagricultural expenditures by the household. More concisely:

$$(1 - t_w)\, wT_2 + (1 - t_i)\, P_1 q_1 + sL_2 = (1 + t_q)\, P_2 Q \tag{5}$$

where t_w, t_i and t_q stand for the wage tax, agricultural income-tax and sales tax, respectively; w denotes the wage rate; P_1 is the price index of agricultural products sold by the household; s is the lease price of land and P_2 is the price index of nonagricultural goods bought by the household. The equation (5) states that the household earns three different kinds of income (income from work outside the household, income from marketing the agricultural output of the farm, and income from leasing the land), and spends everything on nonagricultural goods it buys in the market. The implicit assumption in (5) is that the household is self-sufficient in food.

It is assumed that the household transforms the inputs into a given amount of agricultural output through the following production function of the Cobb-Douglas type:

$$q = A\bar{K}^{\alpha} T_1^{\beta} L_1^{\gamma} \tag{6}$$

where A is a technology parameter, $\bar{K}$ is the amount of capital stock (fixed in the short run); T_1 and L_1 are defined, as in the constraints, as time and land devoted to agricultural production; and the exponents α, β, γ represent elasticities of output with respect to capital, labor, and land, respectively. It is assumed that $\alpha + \beta + \gamma < 1$, which means

that the production function displays decreasing returns to scale. This assumption ensures the existence of a determinate level of output.

Combining the objective function and the set of constraints, the household's choice problem is to maximize (1) subject to constraints (2)—(6).

4.2 THE SOLUTION

Combining the constraints (4) and (6), the Lagrangian function becomes:

$$E = B\,T_0^a\,Q^b\,q_0^c\,L_0^d\,Z^g \tag{7}$$
$$+ \lambda_1\,[T - T_0 - T_1 - T_2]$$
$$+ \lambda_2\,[L - L_0 - L_1 - L_2]$$
$$+ \lambda_3\,[A\bar{K}^{\alpha}\,T_1^{\beta}\,L_1^{\gamma} - q_0 - q_1]$$
$$+ \lambda_4\,[(1 - t_w)\,wT_2 + (1 - t_i)\,P_1q_1 + sL_2 - (1 + t_q)\,P_2Q]$$

The model contains nine endogenous variables (T_0, T_1, T_2, L_0, L_1, L_2, q_0, q_1, Q) and four Lagrangian multipliers (λ_1, λ_2, λ_3, λ_4). The total agricultural output is implicitly defined as a sum of q_0 and q_1. Exogenous variables are T, L, w, Z, and all tax rates and prices (t_w, t_i, t_q, s, P_1, P_2).

The first-order conditions for the solution of (7) follow readily:

$$\frac{\partial E}{\partial T_0} = a\,B\,T_0^{a-1}\,Q^b\,q_0^c\,L_0^d\,Z^g - \lambda_1 = 0 \tag{8}$$

$$\frac{\partial E}{\partial T_1} = -\lambda_1 + \lambda_3\,\beta A\bar{K}^{\alpha}\,T_1^{\beta-1}L_1^{\gamma} = 0$$

$$\frac{\partial E}{\partial T_2} = -\lambda_1 + \lambda_4\,(1 - t_w)\,w = 0$$

$$\frac{\partial E}{\partial L_0} = dBT_0^aQ^bq_0^cL_0^{d-1}Z^g - \lambda_2 = 0$$

$$\frac{\partial E}{\partial L_1} = -\lambda_2 + \lambda_3\,\gamma A\bar{K}^{\alpha}\,T_1^{\beta}\,L_1^{\gamma-1} = 0$$

$$\frac{\partial E}{\partial L_2} = \lambda_2 + \lambda_4 s = 0$$

$$\frac{\partial E}{\partial q_0} = cBT^a{}_0Q^b q_0{}^{c-1}L^d{}_0Z^g - \lambda_3 = 0$$

$$\frac{\partial E}{\partial q_1} = -\lambda_3 + \lambda_4 (1 - t_i) P_1 = 0$$

$$\frac{\partial E}{\partial Q} = bBT^a{}_0Q^{b-1}q^c{}_0L^d{}_0\mathbf{Z}^g - \lambda_4 (1 + t_q) P_2 = 0$$

$$\frac{\partial E}{\partial \lambda_1} = T - T_0 - T_1 - T_2 = 0$$

$$\frac{\partial E}{\partial \lambda_2} = L - L_0 - L_1 - L_2 = 0$$

$$\frac{\partial E}{\partial \lambda_3} = A\bar{K}^{\alpha} T_1{}^{\beta} L_1{}^{\Upsilon} - q_0 - q_1 = 0$$

$$\frac{\partial E}{\partial \lambda_4} = (1 - t_w) wT_2 + (1 - t_i) P_1 q_1 + sL_2 - (1 + t_q) P_2 Q = \mathbf{0}$$

The system (8) can be solved for each of the endogenous variables as a function of the model parameters.[20]

The solution of the theoretical model thus consists of the following behavioral equations:

(9)

$$T^*_1 = \left\{ [A (1 - t_i) P_1] \bar{K}^{\alpha} \left[\frac{\beta}{w (1 - t_w)} \right]^{1-\Upsilon} \left(\frac{\Upsilon}{s} \right)^{\Upsilon} \right\}^{\left(\frac{1}{1-\beta-\Upsilon} \right)}$$

$$L^*_1 = \left\{ [A (1 - t_i) P_1)] \bar{K}^{\alpha} \left[\frac{\beta}{w (1 - t_w)} \right]^{\beta} \left(\frac{\Upsilon}{s} \right)^{1-\beta} \right\}^{\left(\frac{1}{1-\beta-\Upsilon} \right)}$$

$$q^* = \left\{ [A (1 - t_i) P_1)]^{\beta+\Upsilon} \bar{K}^{\alpha} \left[\frac{\beta}{w (1 - t_w)} \right]^{\beta} \left(\frac{\Upsilon}{s} \right)^{\Upsilon} \right\}^{\left(\frac{1}{1-\beta-\Upsilon} \right)}$$

[20] See Appendix.

$$L^*_0 = \left(\frac{d}{a+b+c+d}\right)\left(\frac{1}{s}\right)[\Gamma + (1-t_w)\,wT + sL]$$

$$q^*_0 = \left(\frac{c}{a+b+c+d}\right)\left[\frac{1}{P_1(1-t_i)}\right][\Gamma + (1-t_w)\,wT + sL]$$

$$T^*_0 = \left(\frac{a}{a+b+c+d}\right)\left[\frac{1}{w(1-t_w)}\right][\Gamma + (1-t_w)\,wT + sL]$$

$$Q^* = \left(\frac{b}{a+b+c+d}\right)\left[\frac{1}{P_2(1+t_q)}\right][\Gamma + (1-t_w)\,wT + sL]$$

$$q^*_1 = \left[\frac{1}{P_1(1-t_i)}\right] \times$$

$$\left\{\frac{\Gamma}{1-\beta-\gamma} - \left(\frac{c}{a+b+c+d}\right)[\Gamma + (1-t_w)\,wT + sL]\right\}$$

$$T^*_2 = T - \left(\frac{a}{a+b+c+d}\right)\left[\frac{1}{w(1-t_w)}\right][\Gamma + (1-t_w)\,wT + sL]$$

$$-\left\{[A(1-t_i)P_1]\,\bar{K}^{\alpha}\left[\frac{\beta}{w(1-t_w)}\right]^{1-\gamma}\left(\frac{\gamma}{s}\right)^{\gamma}\right\}\left(\frac{1}{1-\beta-\gamma}\right)$$

$$L^*_2 = L - \frac{d}{a+b+c+d}\left(\frac{1}{s}\right)[\Gamma + (1-t_w)\,wT + sL]$$

$$-\left\{[A(1-t_i)\,P_1]\,\bar{K}^{\alpha}\left[\frac{\beta}{w(1-t_w)}\right]^{\beta}\left(\frac{\gamma}{s}\right)^{1-\beta}\right\}\left(\frac{1}{1-\beta-\gamma}\right)$$

$$\lambda^*_1 = aB\,(a+b+c+d)^e\,a^{a-1}\,b^b\,c^c\,d^d\left[\frac{1}{w(1-t_w)}\right]^{a-1} \times$$

$$\left[\frac{1}{(1+t_q)P_2}\right]^b\left[\frac{1}{(1-t_i)P_1}\right]^c\left(\frac{1}{s}\right)^d Z^g\,[\Gamma+(1-t_w)wT+sS]^{-e}$$

$$\lambda^*_2 = dB\,(a+b+c+d)^e\,a^a\,b^b\,c^c\,d^{d-1}\left[\frac{1}{w(1-t_w)}\right]^a\times$$

$$\left[\frac{1}{(1+t_q)P_2}\right]^b\left[\frac{1}{(1-t_i)P_1}\right]^c\left(\frac{1}{s}\right)^{d-1} Z^g[\Gamma+(1-t_w)wT+sS]^{-e}$$

$$\lambda^*_3 = cB\,(a+b+c+d)^e\,a^a\,b^b\,c^{c-1}\,d^d\left[\frac{1}{w(1-t_w)}\right]^a\times$$

$$\left[\frac{1}{(1+t_q)P_2}\right]^b\left[\frac{1}{(1-t_i)P_1}\right]^{c-1}\left(\frac{1}{s}\right) Z^g\,[\Gamma+(1-t_w)wT+sS]^{-e}$$

$$\lambda^*_4 = \frac{bB}{(1+t_q)P_2}(a+b+c+d)^e\,a^a\,b^{b-1}\,c^c\,d^d\left[\frac{1}{w(1-t_w)}\right]^a\times$$

$$\left[\frac{1}{(1+t_q)P_2}\right]^{b-1}\left[\frac{1}{(1-t_i)P_1}\right]^c\left(\frac{1}{s}\right)^d Z^g$$

where e = 1 — a — b — c — d, and

$$\Gamma = (1-\beta-\gamma)\left\{[A(1-t_i)P_1]\,\bar{K}^{\alpha}\left[\frac{\beta}{w(1-t_w)}\right]^{\beta}\left(\frac{\gamma}{s}\right)^{\gamma}\right\}^{\left(\frac{1}{1-\beta-\gamma}\right)}$$

These equations describe the pattern of behavior of the household under the assumptions of the model.[21] The actual way in which changes in the parameters of the model affect the behavior of the household can best be understood means of comparative static analysis.

[21] The model contains four Lagrangian multipliers. The interpretation of these artificial variables is straightforward. Since $\lambda_1 = \frac{\partial E}{\partial T}$, λ_1 represents the marginal benefit to the household resulting from a small

5. COMPARATIVE STATIC ANALYSIS

The comparative static analysis is carried out for certain parameters that possess direct economic meaning. These include prices of agricultural goods, prices of nonagricultural goods, the lease price of land, taxes, and the land limit.

The comparative static analysis of exponential parameters in the objective function (a, b, c, d, g) is not included in the analysis since these parameters reflect the structure of household preferences, which are assumed to be given in the short run. Also, comparative static analysis of the partial output elasticities of the production function (α, β, γ) is not undertaken. An additional reason for excluding from consideration the effects of changes in these parameters is the extremely limited possibility for econometric testing of these effects.

Comparative statics of the technology parameter A reveal the impact of the state of technology on production and consumption decisions of the household. Comparative static derivatives for T, the total time available in the household, capture the influence of family size on the household's economic behavior.

The comparative statics of the relevant parameters can be expressed in the form of the following table.[22]

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relaxation of the time constraint due, for example, to an increase in family size. Similarly, $\lambda_2 = \frac{\partial E}{\partial L}$ is the marginal benefit to the household resulting from a small increase in the land limit of the household; $\lambda_3 = \frac{\partial E}{\partial q}$ is the marginal benefit to the household resulting from a small increase in the total agricultural output; and $\lambda_4 = \frac{\partial E}{\partial Y}$, where Y stands for the left-hand side of (5), is the marginal benefit to the household resulting from a small increase in the total income.

Each of these variables will be positive if constraints on time, land, production, and income are binding.

[22] Derivations of the comparative statics are available from the author. A sign + refers to a positive partial derivative of the variable at the optimum with respect to the corresponding parameter; the sign — signals a negative partial derivative; and 0 refers to a partial derivative equal to zero. The term am. is an ambiguous partial derivative which can take any sign.

Table 3

THE SUMMARY OF THE COMPARATIVE STATICS

Parameter	P_1	w	s	t_i	t_w	t_q	P_2	L	A	T
variable										
T^*_1	+	—	—	—	+	0	0	0	+	0
L^*_2	+	—	—	—	+	0	0	0	+	0
q^*	+	—	—	—	+	0	0	0	+	0
q^*_1	+	—	—	am.	+	0	0	—	+	—
T^*_2	—	+	+	+	—	0	0	—	—	+
T^*_0	+	—	am.	—	+	0	0	+	+	+
L^*_0	+	am.	am.	—	am.	0	0	+	+	+
q^*_0	+	am.	am.	—	am.	0	0	+	+	+
Q^*	+	am.	am.	—	am.	—	—	+	+	+
L^*_2	—	am.	am.	+	am.	0	0	+	—	—

The effects of a change of prices of agricultural goods (P_1) on variables at the optimum are as might be expected. An increase in the price of agricultural goods, ceteris paribus, yields an increase in the time devoted to agricultural production (T_1). In the same way, an increase in the price of agricultural goods causes an increase in the time devoted to leisure (T_0), other things being constant. However, an increase in the price of agricultural goods results in a decrease in the time devoted to work outside the household (T_2). The increase in the price of agricultural goods, while nonagricultural wages (w) are constant, works as an incentive for the household to reduce T_2 for more T_1 and T_0. The various uses of time, thus, follow the logic of economic rationality: more time is devoted to activities yielding higher benefits for the household (psychic or monetary).

A similar substitution, resulting from an increase in prices of agricultural goods (P_1) occurs in the household's distribution of land to different uses. Namely, an increase in P_1 is an incentive for the household to reduce the land leased (L_2) and to increase the land used for production (L_1) and for leisure (L_0). In both cases (time distribution and land distribution) the household reallocates its time and land toward the activity with the rising value.

The effects of the prices of agricultural goods on the total agricultural output (q), on the part of the total output flowing to the market (q_1), and on the total amount of nonagricultural goods consumed (Q) also follow economic logic. An increase in P_1 yields an increase in q_1 and q, q_0 and hence, through the income expenditure-identity (5), an increase in Q. This is a familiar result in neoclassical economics, and the one that is often misinterpreted. Namely, the mere statement that an increase in prices leads to an increase in output is, sometimes, interpreted that the *only* thing needed for stimulating output is an increase in prices. The latter, obviously, does not follow from the former. Moreover, to use this result for design of policy measures, additional information on the *degree* of the household supply response to changes in relative prices must be known to policymakers. The

experience of the developing countries, however, suggests that, in general, liberalization of agricultural prices is not sufficient to stimulate the agricultural output substantially. Price policy, therefore, must be combined with credit policy, investment policy etc.

An increase in non-farm wages (w) works as an incentive for the household to decrease the amount of time (T_1) and land (L_1) used for agricultural production, as well as to decrease the total (q) and marketable (q_1) agricultural output. Also, an increase in non-farm wage (w) increases the time devoted to outside work (T_2), but decreases the time for leisure (T_0). Therefore, as non-farm wages increase, the household redistributes the time available away from the agricultural production and leisure towards more work outside the household. However, partial derivatives of land for leisure (L_0), own consumption (q_0), nonagricultural goods (Q), and land for lease (L_2) with respect to non-farm wage (w) are ambiguous.

The negative relationship between the price of land (s) and T_1, L_1, q, q_1, suggests that, in general, an increase in the lease price of land will decrease the productive use of land by the household and, therefore, will decrease the agricultural output of the household. This relationship strongly coincides with the observed fact that in Yugoslavia parcels of land with rising prices, due to the expansion of urban areas and infrastructure, are very often withdrawn from agricultural use. Indeed, it stands to reason that the household, the primary owner of land, will prefer to build houses or simply to sell the more valuable land rather than use it for agricultural production.[23] The model predicts that an increase in the price of land will result in an increaase in the time for leisure (T_2). The impacts of the change in the price of land (s) on T_0, L_0, q_0, L_2 and Q are ambiguous.

The income tax (t_i), i. e., the tax levied on the agricultural output sold in the market, reduces the agricultural use of time and land (T_1, L_1) and the total agricultural output of the household (q). However, the marketable output (q_1) can either increase, remain constant or decrease as t_i is increased. The impacts of an increase in the income tax on the own consumption (q_0) and land for leisure (L_0) are negative. If the income tax is increased, ceteris paribus, Q may decrease, increase or remain the same, depending on changes in (5). The effects of change in t_i on the remaining variables (L_2, T_0) are definite: $\frac{\partial L_0}{\partial t_i} < 0$;

$$\frac{\partial T_0}{\partial t_i} < 0; \quad \frac{\partial L_2}{\partial t_i} > 0.$$

[23] "In the last two decades there has been a continuous decline in agricultural and arable land. Moreover, land is unarranged and parceled while existing hereditary law and trade have been continuously enhancing further parceling. Agricultural and arable land are diminished also because of the permanent and unorganized building of roads and airports, plants and towns, weekend-houses and other objects on the highest quality arable land". — Dugoročni program razvoja agroindustrijske proizvodnje (1983), p. 15.

Therefore, the impact of the agricultural income tax on the behavior of the household can be summarized as follows: An increase in the income tax works as an incentive to reduce the productive use of time and land, the total agricultural output, and own consumption. It may, however, increase, decrease or leave marketable output unchanged.

A wage-tax increase induces an increase in the productive use of land (L_1) and time (T_1) and both total (q) and marketable output (q_1). As expected, an increase in t_w reduces the time that the household members devote to work outside the household (T_2). While the relation between t_w and T_0 is positive, an increase in t_w can have various impacts on L_0, q_0, Q, L_2. Therefore, the increase in non-farm wage-tax reduces income earned outside the household, and stimulates the greater use of land and time for agricultural production in the household (L_1, T_1).

An interesting outcome of the model is that various uses of time (T_0, T_1, T_2) and land (L_0, L_1, L_2), as well as the agricultural output and the product distribution of the household (q, q_0, q_1) are entirely neutral with respect to the sales tax (t_q), and the price of nonagricultural goods (P_2). An increase in the sales tax (t_q), or an increase in prices of nonagricultural goods (P_2) has the same effect: a decrease in the quantity of nonagricultural goods bought by the household (Q), leaving terms on the left-hand side of (5) intact. This result stems from the constant (post-tax) expenditure share properties of the Cobb-Douglas utility function.

The most interesting result of the comparative statics is certainly the impact of the change of the land limit (L) on different uses of land and agrciultural production by the household. The model predicts that the productive use of time and land (T_1, L_1), as well as the total agricultural output (q) are entirely neutral with respect to the endowment of land. More simply ,the size of the farm does not matter. An increase in the land endowment will, however, cause a redistribution among different uses of land and output. Namely, the increase in L results in a decrease of the marketable agricultural output (q_1), but also an increase of the agricultural output consumed by the household members (q_0). This surprising result, however, may be dependent on the specific functional form of the utility function, as well as the production function in this model.[24]. The time and the land for leisure (T_0, L_0) increase and the amount of land leased (L_2) also increases as a result of the increase in the land endowment.

Improvements in technology work as a clear incentive for the household to utilize the land for agricultural production, and to reduce the amount of land leased (L_2) and the amount of time devoted to

[24] On the other hand, it is not entirely clear that a mere relaxation of the land maximum is sufficient for stimulating the output on private households. See. for example, Ilijin (1988), p. 22 or Miller (1987), p. 24. Fragmentation of the land holdings into small parcels, and the absence of legal restrictions on the abandonment of the use of land for agricultural production, may have been more detrimental for the agricultural production on private farms.

work outside the household. (T_2). The relaxation of the time constraint (T), which could be viewed as an increase in the size of the family, leaves the total agricultural output (q) intact, but increases the own consumption (q_0) at the expense of the marketed output (q_1).

6, POLICY IMPLICATIONS AND CONCLUSIONS

This model of the economic behavior of the mixed household as an economic agent sui generis illustrates the household's response to changes in its environment. These changes are symbolized by changes in selected parameters, and their impacts on the household response are defined by comparative statics. Some of the parameters can be affected by economic policymakers. Prices of agricultural products (P_1) can be affected by various means such as eliminating price ceilings or even subsidizing the prices of agricultural products.

The model predicts that the household responds to the increase in prices of agricultural products (P_1) by expanding total output and marketable surplus. Comparative static analysis, unfortunately, cannot give the answer to another, equally important question: how much will the household increase the production as a result of the price increase? The answer to this essentially empirical question would be very useful in evaluating the efficiency of the agricultural price policy with respect to its effect on the supply response of mixed households. Another direct implication of the model is that the total agricultural output of the household could be increased by reducing income taxes. It is worth noting that taxes (t_i) and prices (P_1), simultaneously affect the level of the marketed output (q_1). That is why changes in marketed output (q_1) are the result of a change in the combination of taxes and prices $[(1 - t_i) P_1]$ rather than just the change in the price level. The policy should combine income tax policy and price policy in order to affect the agricultural output in the households.

The model implies that an increase in the land limit (L) of the household does not yield any increase in the total agricultural output (q) and the productive use of land (L_1). Instead, the additional land is used for leisure and to increase the amount of land leased to other uses. This suggests that the key to increasing household productivity is not necessarily in relaxation of the land limit, but rather in more efficient use of the existing land endowment. Again, this result may not hold for the more general functional forms.

An increase in nonagricultural wages (w) decreases the productive use of land (L_1) and the agricultural output of the household. At the same time, it causes an increase in the household's willingness to work outside the household (T_2). The wage-tax works in exactly the opposite direction. An increase in the after-tax wage income from work outside the household provides incentives for the households to increase the use of land for agricultural production, and consequently to increase total and marketed output of the household. This suggests that the current economic crisis with declining real wages and high unemployment, that has hit especially hard the social (industrial and

agroindustrial) sector, may provide some incentives for the mixed households to turn to the greater use of land for agricultural production.

The model states that the rising lease price of land works as a clear disincentive for the expansion of agricultural output in the household. Since the rising price of land can be considered as a general tendency, supported by the construction of infrastructure and broadening of the metropolitan areas, i.e., by economic development in general, policy makers should at least be aware of this fact. One way to avoid the loss of the high-quality arable land in the vicinity of the urban areas is to use a comprehensive system of urban planning in which the preservation of the productive use of the high-quality agricultural land would be one of the planning targets. In practice this could be achieved by placing restrictions on the use of this land (zoning). Also, tax incentives for the agricultural use of land, or implementing newer land-use controls which compensate owners for relinquishing their development rights, may prevent decline in the use of land for agricultural production.

The agricultural sector in developing countries has always been a bottleneck of overall economic development. Part of the reason for the stagnation of this sector of the economy lies in the lack of knowledge about the actual workings of the farm household as producer and consumer of goods and services. As a result there has been a considerable discussion among economic theoreticians as well as practitioners about the actual way in which the household responds to various incentives.

The discussion, at the theoretical level, has focused on the question whether or not the household is a rational economic agent, as well as on the formulation of models explaining various aspects of the household's behavior.

The importance of the mixed household sector in Yugoslav agriculture creates the need for a better understanding of the economic behavior of these households. More rigorous, versus purely descriptive, analysis seems to be necessary in order to explain the complex reaction function of the households. The practical relevance of such an analysis is in its direct policy implications for the desired expansion of agricultural output.

The theoretical model developed in this study has attempted to present the economic objectives, constraints and reactions of the household in a more rigorous manner, so as to derive qualitative conclusions about the household economy, which would, in turn, serve as a basis for the promotion of successful policy measures. This analysis does not pretend to give final answers to the questions addressed. The results of the theoretical model are tentative and should serve as a basis for future theoretical and empirical research. Further exploration of the degree of the household response, on the basis of more disaggregated cross-section data, would certainly throw more light on the empirical puzzles concerning the economic behavior of Yugoslav mixed households.

The model developed in this study also may serve as a basis for the construction of a more complete, multisectoral model of the economy, which could address questions concerning the origin, directions, and magnitudes of structural changes in the economy.

APPENDIX

Derivation of Reduced Form Equations

After suitably rearranging the equations, the system (8) becomes system (10)

$$\lambda_1 = aBT_0^{a-1}Q^b q_0^c L_0^d Z^g \tag{10}$$

$$\lambda_1 = \lambda_3 \beta A \bar{K}^{\alpha} T_1^{\beta-1} L_1^{\gamma}$$

$$\lambda_1 = \lambda_4 (1 - t_w) w$$

$$\lambda_2 = dBT_0^a Q^b q_0^c L_0^{d-1} Z^g$$

$$\lambda_2 = \lambda_3 \gamma A \bar{K}^{\alpha} T_1^{\beta} L_1^{\gamma-1}$$

$$\lambda_2 = \lambda_4 s$$

$$\lambda_3 = cBT_0^a Q^b q_0^{c-1} L_0^d Z^g$$

$$\lambda_3 = \lambda_4 (1 - t_i) P_1$$

$$\lambda_4 (1 + t_q) P_2 = bBT_0^a Q^{b-1} q_0^c L_0^d Z^g$$

$$T = T_0 + T_1 + T_2$$

$$L = L_0 + L_1 + L_2$$

$$q_0 = -q_1 + A \bar{K}^{\alpha} T_1^{\beta} L_1^{\gamma}$$

$$(1 - t_w) wT_2 + (1 - t_i) P_1 q_1 + sL_2 - (1 + t_q) P_2 Q = 0$$

In order to solve the system (10), we shall first divide the third equation in (10) by sixth and eight equations, respectively.

$$\frac{\lambda_1}{\lambda_2} = \frac{(1 - t_w) w}{s} \tag{11}$$

and

$$\frac{\lambda_1}{\lambda_3} = \frac{(1 - t_w) w}{(1 - t_i) P_1} \tag{12}$$

Then from the third equation in (10):

$$\frac{\lambda_1}{\lambda_4} = (1 - t_w)\, w \tag{13}$$

From the sixth equation in (10):

$$\frac{\lambda_2}{\lambda_4} = s \tag{14}$$

and from the eighth equation in the (10):

$$\frac{\lambda_3}{\lambda_4} = (1 - t_i)\, P_1 \tag{15}$$

Therefore:

$$\frac{\lambda_2}{\lambda_3} = \frac{\lambda_2}{\lambda_1}\,\frac{\lambda_1}{\lambda_3} = \frac{s}{(1 - t_i)\, P_1} \tag{16}$$

Also, dividing first equation in (10) by the fourth, seventh, and ninth equations, we get:

$$\frac{\lambda_1}{\lambda_2} = \frac{aL_0}{dT_0} \tag{17}$$

$$\frac{\lambda_1}{\lambda_3} = \frac{aq_0}{cT_0} \tag{18}$$

$$\frac{\lambda_1}{\lambda_4 (1 + t_q)\, P_2} = \frac{aQ}{bT_0} \tag{19}$$

and substituting (11) into (17), (12) into (18), and (13) into (19) respectively, we get:

$$\frac{(1 - t_w)\, w}{s} = \frac{aL_0}{dT_0} \tag{20}$$

$$\frac{(1 - t_w)\, w}{(1 - t_i)\, P_1} = \frac{aq_0}{cT_0} \tag{21}$$

$$\frac{(1 - t_w)\, w}{(1 + t_q)\, P_2} = \frac{aQ}{bT_0} \tag{22}$$

Let us divide now the second by the fifth equation in (10), and substitute (11) on the left hand side to get:

$$\frac{(1-t_w)\,w}{s} = \frac{\beta L_1}{\gamma T_1} \tag{23}$$

Therefore, we have:

$$L_1 = \frac{(1-t_w)\,w\gamma T_1}{s\beta} \tag{24}$$

After substitution of (24) in the second equation of (10), we get:

$$\frac{\lambda_1}{\lambda_3} = \beta A \bar{K}^{\alpha} T_1^{\beta-1}\left[\frac{(1-t_w)\,w\gamma T_1}{s\beta}\right]^{\gamma} \tag{25}$$

Finally, after substitution of (12) in (25) and rearranging, we get the reduced form equation for T_1:

$$T^*_1 = \left\{[A(1-t_i)P_1]\,\bar{K}^{\alpha}\left[\frac{\beta}{w(1-t_w)}\right]^{1-\gamma}\left(\frac{\gamma}{s}\right)^{\gamma}\right\}^{\left(\frac{1}{1-\beta-\gamma}\right)} \tag{26}$$

By making use of (24) the reduced form for L_1 follows readily:

$$L^*_1 = \left\{[A(1-t_i)P_1]\,\bar{K}^{\alpha}\left[\frac{\beta}{w(1-t_w)}\right]^{\beta}\left(\frac{\gamma}{s}\right)^{1-\beta}\right\}^{\left(\frac{1}{1-\beta-\gamma}\right)} \tag{27}$$

Upon the substitution of (26) and (27) in the twelfth equation of (10) we get:

$$q^* = \left\{A[(1-t_i)P_1]^{\beta+\gamma}\bar{K}^{\alpha}\left[\frac{\beta}{w(1-t_w)}\right]^{\beta}\left(\frac{\gamma}{s}\right)^{\gamma}\right\}^{\left(\frac{1}{1-\beta-\gamma}\right)} \tag{28}$$

Substituting (26) and (27) in the tenth and eleventh equations of (10), making use of (20), (21), (22) and the twelfth equation of (10), the

income-expenditure identity (thirteenth equation in 10) can be expressed in terms of T_0 and parameters only. After rearrangement, the reduced form equation for T_0 follows:

$$T^*_0 = \left(\frac{a}{a+b+c+d}\right)\left[\frac{1}{w(1-t_w)}\right][\Gamma + (1-t_w)\,wT + sL] \tag{29}$$

where

$$\Gamma = (1-\beta-\gamma)\left\{[A(1-t_i)\,P_1]\,\bar{K}^{\alpha}\left[\frac{\beta}{w(1-t_w)}\right]^{\beta}\left(\frac{\gamma}{s}\right)^{\gamma}\right\}^{\left(\frac{1}{1-\beta-\gamma}\right)}$$

Upon substitution of (29) in (20) and solving for L_0, it follows that:

$$L_0^* = \left(\frac{d}{a+b+c+d}\right)\left(\frac{1}{s}\right)[\Gamma + (1-t_w)\,wT + sL] \tag{30}$$

Also, after substitution of (29) into (21) and solving for q_0 we get:

$$q_0^* = \left(\frac{c}{a+b+c+d}\right)\left[\frac{1}{P_1(1-t_i)}\right][\Gamma + (1-t_w)\,wT + sL] \tag{31}$$

Substituting (29) into (23) and solving for Q:

$$Q^* = \left(\frac{b}{a+b+c+d}\right)\left[\frac{1}{P_2(1+t_q)}\right][\Gamma + 1 - t_w)\,w\,T + s\,L] \tag{32}$$

Making use of the third constraint (3),

$$q^*_1 = q^* - q^*_0$$

we get:

$$q^*_1 = \left[\frac{1}{P_1(1-t_i)}\right] \times$$

$$\left\{\frac{\Gamma}{1-\beta-\gamma} - \left(\frac{c}{a+b+c+d}\right)[\Gamma + (1-t_w)\,wT + sL]\right\} \tag{33}$$

The remaining two reduced form equations follow readily from the two constraints in (2) and (3):

$$T^*_2 = T - \left(\frac{a}{a+b+c+d}\right)\left[\frac{1}{w(1-t_w)}\right][\Gamma + (1-t_w)wT + sL]$$

$$-\left\{[A(1-t_i)P_1]\bar{K}^{\alpha}\left[\frac{\beta}{w(1-t_w)}\right]^{1-\gamma}\left(\frac{\gamma}{s}\right)^{\gamma}\right\}^{\left(\frac{1}{1-\beta-\gamma}\right)} \tag{34}$$

and

$$L^*_2 = L - \frac{d}{a+b+c+d}\left(\frac{1}{s}\right)[\Gamma + (1-t_w)wT + sL]$$

$$-\left\{[A(1-t_i)P_1]\bar{K}^{\alpha}\left[\frac{\beta}{w(1-t_w)}\right]^{\beta}\left(\frac{\gamma}{s}\right)^{1-\beta}\right\}^{\left(\frac{1}{1-\beta-\gamma}\right)} \tag{35}$$

The optimal values of Lagrangian multipliers follow from the first order conditions. Upon substitution of T^*_0, Q^*, q^*_0, and L^*_0, into the first equation in (10), we get:

$$\lambda^*_1 = aB(a+b+c+d)^e a^{a-1} b^b c^c d^d \left[\frac{1}{w(1-t_w)}\right]^{a-1} \times$$

$$\left[\frac{1}{(1+t_q)P_2}\right]^b \left[\frac{1}{(1-t_i)P_1}\right]^c \left(\frac{1}{s}\right)^d Z^g [\Gamma + (1-t_w)wT + sL]^{-e} \tag{36}$$

From fourth equation in (10) we also get:

$$\lambda^*_2 = dB(a+b+c+d)^e a^a b^b c^c d^{d-1} \left[\frac{1}{w(1-t_w)}\right]^a \times$$

$$\left[\frac{1}{(1+t_q)P_2}\right]^b \left[\frac{1}{(1-t_i)P_1}\right]^c \left(\frac{1}{s}\right)^{d-1} Z^g[\Gamma + (1-t_w)wT + sL]^{-e} \tag{37}$$

By the same token, from the seventh equation in (10):

$$\lambda^*_3 = cB\,(a+b+c+d)^e\,a^a\,b^b\,c^{c-1}\,d^d\left[\frac{1}{w\,(1-t_w)}\right]^a \times$$

$$\left[\frac{1}{(1+t_q)\,P_2}\right]^b\left[\frac{1}{(1-t_i)\,P_1}\right]^{c-1}\left(\frac{1}{s}\right)^d \lambda^g[\Gamma + (1-t_w)\,wT + sL]^{-e} \tag{38}$$

Finally, from the ninth equation in (10):

$$\lambda^*_4 = \frac{bB}{(1+t_q)\,P_2}(a+b+c+d)^e\,a^a\,b^{b-1}\,c^c\,d^d\left[\frac{1}{w\,(1-t_w)}\right]^a \times$$

$$\left[\frac{1}{(1+t_q)\,P_2}\right]^{b-1}\left[\frac{1}{(1-t_i)\,P_1}\right]^c\left(\frac{1}{s}\right)^d Z^g \tag{39}$$

where e = 1 — a — b — c — d, and

$$\Gamma = (1-\beta-\gamma)\left\{[A\,(1-t_i)\,P_1]\,\bar{K}^{\alpha}\left[\frac{\beta}{w\,(1-t_w)}\right]^{\beta}\left(\frac{\gamma}{s}\right)^{\gamma}\right\}^{\left(\frac{1}{1-\beta-\gamma}\right)}$$

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