On OLG-GE Modelling in the Field of Pension Systems: An Application to the Case of Slovenia

The economic sustainability of social security systems is currently under extreme pressure due to decreasing fertility rates and increases in life expectancy. These factors contribute to an ageing populous whose share of workers is decreasing and share of social security recipients is increasing (*cf*. OECD, 2000.) These findings have lead to an anticipation of increases in traditional social security benefits and the introduction of new forms of old-age insurance. Therefore it is no surprise that among key topics of social security reform is the development of a sustainable, efficient and fair system of funding social security in the environment of expected further ageing of the population. Due to its weight in the system of public finances special emphasis is being placed on the pension system. As such it is also the focus of our research.

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In the 1990s it became apparent to the Slovenian government that, due to unfavourable forecasted demographic developments, the former pension legislation would leave the social security system ill-equipped to fulfill anticipated requirements. In 1996 this became distinctly obvious when, for the first time, the state pension fund needed additional financing from the central budget. This was sufficient to start intense preparations for Slovenian pension reform, which was adopted in the form of the 1999 Pension and Disability Insurance Act (PDIA) and implemented from the 1st of January 2000. With the gradual implementation of the PDIA, the second pension pillar becomes increasingly important. People will become less dependent on the first pension pillar at the point of their retirement. However, as the second pension pillar is mainly voluntary in Slovenia, there have been reservations in regards to whether the present amount of supplementary pension savings will be sufficient to compensate for the deterioration of rights of the first pension pillar. In particular, we were interested in the studying the effects on the welfare of different generations and on the sustainability of public finances that would be made by varying the parameters of the current Slovenian pension system and introduction of mandatory supplementary pension insurance.

Effective analysis of the consequences of economic policy on social development requires an appropriate tool; one that is capable of reflecting the complex consequences, to both household and national budget, of the impact from overall and individual social and tax policy measures. Overlapping-Generations General Equilibrium (OLG-GE) models currently represent the most advanced form of numerical general equilibrium models and were suitable for our research. The constructed model, SIOLG 2.0, is a dynamic OLG-GE model of the Slovenian economy. This model is based on the social accounting matrix (SAM), data on demographic structure of the population, expected future demographic developments, characteristics of Slovenian households, and the decomposition of households within generations (*cf*. Verbič, 2007). The model was developed for the explicit purpose of analysing the sustainability of the Slovenian public finances. However, the model may also be utilised more generally to analyse any part or sector of the economy.

The OLG-GE Modelling Framework

The starting points of the OLG-GE model are the life cycle theory of consumption by Modigliani and Brumberg (1954) and the permanent income hypothesis by Friedman (1957). These are in fact special cases of the more general theory of intertemporal allocation of consumption (Deaton, 1992). Unlike in the Keynes's theory of behaviour of consumption and savings, based solely on current income, the OLG-GE models consumption and savings by deriving them from intertemporal optimization behaviour which is dependent on total lifetime income. In the simplest case of unchanged income until retirement (*cf*. Modigliani, 1986), consumers save during their active lifetime and spend their savings after retirement in order to maintain current levels of consumption. Retirement is therefore the raison d'etre for saving.

OLG-GE modelling was first proposed by Samuelson (1958) and Diamond (1965). However, it did not become an established means of economic modelling until Auerbach and Kotlikoff (1987), who constructed a relatively large and detailed computable model of the American economy. It was based on a detailed decomposition of the consumption side of the model, which means that, unlike Ramsey-type models, the consumers live long enough to live at least one period with the next generation of consumers but have finite life-spans. The determination of consumers by their birth cohort enables analysis of inter-generational effects, making OLG-GE models especially valuable for the analysis of tax policies, pension policies and other social policies.

The dynamic SIOLG 2.0 model comprises not only the standard model structure of a national economy, but also the demographic and pension blocks. It is within this framework that the first and the second pillar of the Slovenian pension system were modelled. The model is built within the General Algebraic Modelling System (GAMS), which has become both the most widely used programming language and the most widespread computer software for construction and solving of large and complex general equilibrium models.

Within the GAMS framework, the dynamic general equilibrium model is written in Mathiesen's (1985) formulation of the Arrow-Debreu (1954) equilibrium model, i.e. as a mixed complementarity problem (MCP). The key advantage of this formulation is the compact presentation of the general equilibrium problem, achieved by treating variables implicitly, thus significantly reducing the computation time for higher-dimensional models. Namely, the mathematical program includes both equalities and inequalities, where the complementarity slackness holds between system variables and system conditions. Functions of the model are written in calibrated share form; a reasonably straightforward algebraic transformation, which nevertheless considerably simplifies the calibration of the model. A recent version of PATH solver, renowned for its computational efficiency, was used to solve the model and so achieve convergence.

The Building Blocks of an OLG-GE Model

The Households

In the model consumers are deemed to live the periods ascribed by their life expectancies at birth. On the basis of assuming that the life expectancy is approximately 80 years, and that the active lifetime period starts at the age of 20, there are 60 generations in each period of the model. There is a new cohort of consumers born in each such period, which increases the population size, while at the same time other consumers pass away and decrease the total population. Consumers are observed in five-year intervals within households. Households seek to maximise their expected lifetime utility, subject to income constraints influenced by the need to save for retirement and support children. Households are differentiated in the model according to consumers' year of birth, income and household size; within each cohort a distinction is made between a couple without children and the "nuclear" family, defined as a household with the standard two child average. Five income profiles representing different income brackets are also given. Consequently, in total there are ten versions of the model, facilitating analysis of intra-generational effects of different economic policies.

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The Labour Market

The factors of labour volume and labour productivity growth are given exogenously. Changes in wages are reflected in changes in labour supply. The consumption of households with children is additionally corrected for the extra costs per child, if the child is born within the 20-40 year age bracket of the household. Following retirement, households are modelled with two persons and then, from the 11th year onwards, one adult.
In the capital markets, saving decisions of households affect investment decisions of firms and so future production. The effects ascribed herein have recurrent effects on the product market via decreased prices and on the labour market via higher productivity, which in turn lead to higher wages and so higher household income. It is a straightforward procedure to analyse both effects with a dynamic OLG-GE model.

Perfect Foresight and the Demographics

The perfect foresight assumption in the forward-looking model specification implies that households perform intertemporal optimization of the present value of total future consumption. In other words, consumers have full information at their disposal, on average adopt the right decisions and, as espoused by rational expectations theory, are familiar with future modifications of key economic indicators. They are able to anticipate new policies and to prepare themselves for future changes. The assumptions of equilibrium in all markets and of achievable sustainable economic growth, enable analysis of different scenarios which cause deviations from the reference growth path and changes in macroeconomic and microeconomic indicators. This is especially important when analysing social security, because it makes projecting the effects of demographic changes on the social security system possible. For this analysis we have three variants of demographic projections available; the low variant, the high variant and the reference medium variant to which they are both relative. The low variant combines lower fertility with lower life expectancy and lower net migration than the reference variant, whilst the high variant combines higher fertility with higher life expectancy and higher net migration than the reference variant.

The Firms

The assumption of perfect foresight is also valid for firms, which maximise profits in the environment of perfect competition. The effects of technology are given by the constant elasticity of substitution (CES) production function. The number of production sectors in the model is dependent on availability of the input-output table for the base year, which means that there are 60 sectors of the standard classification of activities (SCA) available for discretionary aggregation. Government spending is dependent on economic and population growth and is financed by revenues from personal income tax, capital income tax, value-added tax and import duties. The different revenue sources of the Slovenian system of public finances provided a range of options for the funding of various economic policies in the simulation phase of the modelling.

The Pension System

The modelling of the first pension pillar, financed on a pay-as-you-go (PAYG) basis, was designed to capture the key pension system parameters that are usually the subject of modification with pension reforms. Emphasised in the model are the cash flow of the mandatory pension insurance institution, the relationship between the pension base and pensions, and the process of adjustment of pension growth with respect to wage growth. The modelling of the fully-funded (FF) second pillar is focused on the implementation of the liquidity constraint. Use was made of supplementary pension profiles and the ratio of premia paid to pensions paid out from supplementary pension insurance. The so-called "total pension" was introduced, representing the sum of the pension from the first and second pillars, where at every point households adjust the scope of their labour supply and their current consumption toward a target total pension. This creates a certain volume of supplementary pension saving which, if the target total pension is defined at a level dissimilar to the reference level, can be treated as mandatory supplementary pension insurance.

The Foreign Sector

The dynamic SIOLG 2.0 model is made complete using Armington's (1969) assumption of imperfect substitutability, where commodity products are separated based on whether they were produced domestically or abroad. Demand for imported products is derived from the firm cost minimization and the consumer utility maximization criteria. With regard to exports, domestically produced products are sold at home and abroad but are nevertheless treated as imperfect subsititutes. Slovenia is assumed to be a small open economy, implying that the changes in the volumes of imports and exports do not affect the terms of trade. Given the intertemporal balance of payments constraint, international capital flows are endogenous.

Concluding Remarks

The model presented herein involves a dynamic framework of a national economy, which includes household utility maximisation under the assumption of perfect foresight. This model allows for distinctions according to size of household, income level, household lifespan, and overlapping generations within households. This kind of modelling framework facilitates the monitoring and forecasting of complex short-term and long-term consequences of demographic changes, such as an ageing population, on individual categories of public finance. Furthermore, it allows for analysis of the impact of changes in the taxation and social security system on the flexibility, competitiveness and so growth of the economy.

The advantages that OLG-GE models offer in comparison to other modelling tools, such as actuarial models of pension reforms and generational accounting models, are not in modelling specific socio-economic phenomena such as demographic slowdown of GDP. They are in the their ability to model general equilibria which, being closer to the true functioning of the actual economy, make the results of the model more realistic. This entails modelling mutual interactions and feedback effects between macroeconomic aggregates which simpler models are not able to capture. This is seen in the analysis of the pension system, where a link has to be established between labour endowment and labour price. Unfavourable demographic changes will lead to a reduction in the active working population and hence the labour endowment, which in turn leads to an increase in labour price (wages) above the steady state growth. Since pension dynamics depend on the dynamics of wages, this also means higher pension expenditure. It can be seen that modelling such relationships is vital for ensuring a realistic and accurate analysis produced using a model of this kind.

Naturally, we are aware that economic models are merely tools intended to replicate and analyse a specific economic theory or a part thereof. As such they will always be an incomplete and deficient representation of reality. The same applies to our dynamic OLG-GE model. However, with regards to its capacity to capture socio-economic reality and in terms of currently available levels of socio-economic analysis, it can be concluded that at present there is no more complete deterministic instrument than a dynamic OLG-GE model to meet the objectives set herein.

References

Armington, P.S. (1969). A Theory of Demand for Products Distinguished by Place of Production. *IMF Staff Paper*, **16**. International Monetary Fund, Washington, DC.

Arrow, K.J. and Debreu, G. (1954). Existence of an Equilibrium for a Competitive Economy. *Econometrica*, **22**(**3**), 265-290.

Auerbach, A.J., and Kotlikoff, L.J. (1987). *Dynamic Fiscal Policy*. Cambridge, NY: Cambridge University Press.

Deaton, A. (1992). *Understanding Consumption*. Oxford: Clarendon Press.

Diamond, P.A. (1965). National Debt in a Neoclassical Growth Model. *American Economic Review*, **41**, 1126-1150.

Friedman, M. (1957). *A Theory of the Consumption Function*. Princeton: Princeton University Press.

Mathiesen, L. (1985). *Computation of Economic Equilibria by a Sequence of Linear Complementarity Problems*. In Economic Equilibrium: Model Formulation and Solution, ed. A.S. Manne, 144-162. Amsterdam: North-Holland.

Modigliani, F. and Brumberg, R. (1954). *Utility Analysis and the Consumption Function: An Interpretation of Cross-Section Data*. In Post Keynesian Economics, ed. K.K. Kurihara, 388-436. New Brunswick, NJ: Rutgers University Press.

Modigliani, F. (1986). Life Cycle, Individual Thrift, and the Wealth of Nations. *American Economic Review*, **76**(**3**), 297-313.

Organisation for Economic Co-operation and Development (OECD) (2000). *Reforms for an Ageing Society*. Paris: Organisation for Economic Co-operation and Development.

Samuelson, P.A. (1958). An Exact Consumption-loan Model of Interest With or Without the Social Contrivance of Money. *Journal of Political Economy*, **66**, 467-482.

Verbič, M. (2007). *A Dynamic General Equilibrium Model of the Slovenian Economy with Emphasis on the Pension System*. Ljubljana: University of Ljubljana.