# WELFARE AND REALLOCATION IMPACTS OF TAX POLICY IN MALTA: AN APPLIED GENERAL EQUILIBRIUM TAX MODEL

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# Abstract

This dissertation is intended to serve two goals. At first, it has the purpose to act as a guide to the steps involved in the specification and application of a computable general equilibrium model. Secondly, it is intended to provide insight into the current domestic tax structure and the impact of recent tax policy reform. The research is based on the premise that the multiplier analysis of changes in final demand under the fixed price model is not sufficient for analysis of impacts of taxes because the reallocation of resources between industries resulting from tax policy changes has implications for both the demand and supply sides of the economy. The results of the Malta General Equilibrium Tax Model (GETM) contained in this study confirm that tax rate reductions boost economic activity. The results also suggest that the gains are likely to be higher when the measures implemented are in the form of a reduction in consumption tax rates rather than income tax rates. On the other hand, investment appears to be more sensitive to changes in income tax. From the perspective of generating tax revenue, income and consumption taxes appear to be equally effective. In light of behavioural responses, results showed that while tax payer behaviour can offset substantial portions of estimated revenue loss, any tax rate cut that could completely pay for itself would be unusual. The robustness of the results was confirmed by means of sensitivity analysis, allowing for a significant degree of confidence in policy recommendations.

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| Keywords: | Computable General Equilibrium (CGE) modelling; Social Accounting Matrix (SAM); Tax Policy; Welfare Analysis; Reallocation of Resources. |

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# LIST OF ACRONYMS

| | |
|---|---|
| CES | Constant Elasticity of Substitution |
| CET | Constant Elasticity of Transformation |
| CGE | Computable General Equilibrium |
| CIF | Cost, Insurance and Freight |
| CPI | Consumer Price Index |
| CV | Compensation Variation |
| EV | Equivalent Variation |
| FISIM | Financial Intermediation Services Indirectly Measured |
| GAMS | Generalised Algebraic Modelling System |
| GATT | General Agreement on Tariffs and Trade |
| GDP | Gross Domestic Product |
| GETM | General Equilibrium Tax Model |
| GFCF | Gross Fixed Capital Formation |
| ITR | Implicit Tax Rate |
| LES | Linear Expenditure System |
| NAFTA | North American Free Trade Agreement |
| NSO | National Statistics Office |
| SAM | Social Accounting Matrix |
| SIOT | Symmetric Input Output Table |
| SUT | Supply and Use Tables |
| VAT | Value Added Tax |

# Chapter One

# INTRODUCTION

Malta's tax system is continuously changing as the government tries to align the tax system with evolving political and economic conditions. Successive government documents published over the past decade have considered the role of the local tax structure in terms of generating sufficient revenue for the government as well as its contribution towards – in one way or another – promoting economic growth. Though there is a longstanding debate as to the relative merits and demerits of different tax structures, very few studies have investigated the economic impact on welfare and the widespread reallocation and readjustment in both demand and supply of goods and factors explicitly. The majority of studies either use a partial equilibrium approach for simplicity or leave the general equilibrium analyses only at the abstract theoretical level.

The multiplier analysis of changes in final demand under the fixed price model is not sufficient for analysis of impacts of taxes in an economy. The reallocation of resources resulting from tax distortions has implications for both the demand and supply sides of the economy and distorts commodity prices and returns to factors of production. On a delegation visit to assist Russia's transformation from a planned to market economy, Greenspan (2007) writes:

*"... Western economists generally considered input-output matrices to be of limited use because they failed to capture the dynamism of an economy – in the real world, the relationships between inputs and outputs almost invariably shift faster than they can be estimated. Gosplan's[1] input-output model had been elaborated to Ptolemaic perfection. But judging by the top aide's remarks, I couldn't see that any of the limitations had been solved ... Without the immediate signals of price changes that make capitalists markets work, how was anyone to know how much of each product*

[1] Gosplan was the Soviet authority that set the type, quantity, and price of every commodity produced at every single factory and plant across 11 time zones.

*to manufacture? Without the help of a market pricing mechanism, soviet economic planning had no effective feedback to guide it."*

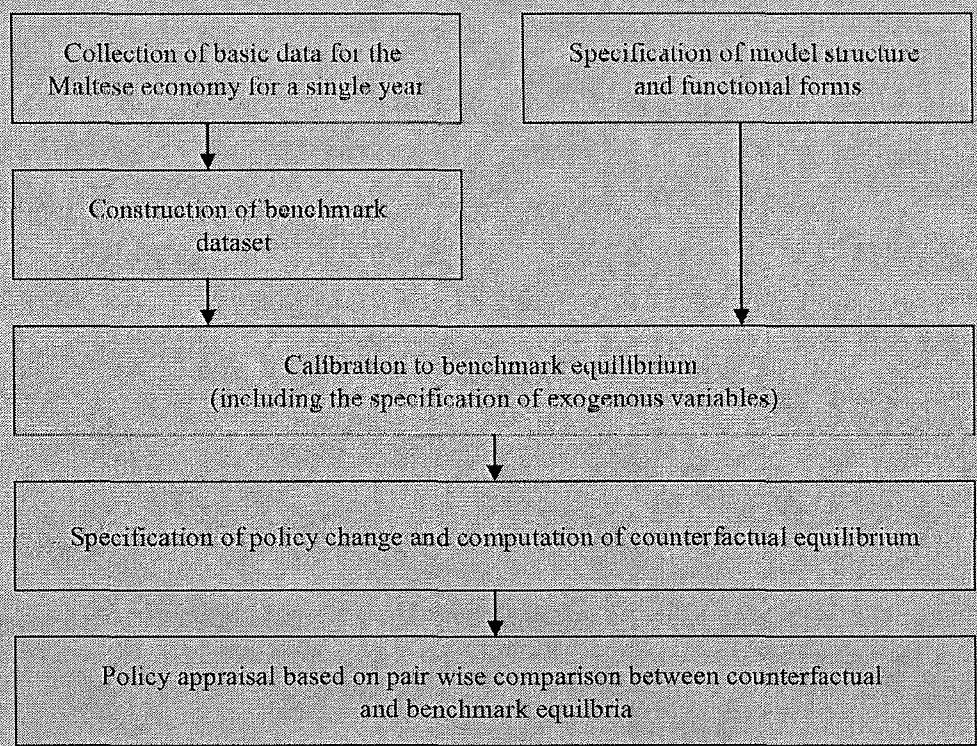
A complete analysis therefore requires a large scale general equilibrium approach capturing the numerous relationships between all interconnected markets with prices providing the common flow of information needed to coordinate the system.

Seen in this light the study is intended to serve two goals. At first, it has the purpose to act as a guide to the steps involved in the specification and application of a Computable General Equilibrium (CGE) model. Second, it is intended to provide insight into the current domestic tax structure and the impact of recent tax policy reform in Malta. Modelling is about establishing causal relationships between variables while analysis involves the examination and interpretation of data and other information to provide insight to improve the formulation of policy. Rigorous analysis and modelling are thus in the best interests of all decision makers if they would like to know which one of these taxes hurts the least and is a more efficient way of raising revenue.

The present study formulates a fairly standard static General Equilibrium Tax Model (GETM) for the Maltese economy. It is built in the tradition of applied general equilibrium models as in Harberger (1962), Shoven and Whalley (1972, 1984, 1992), Ballard et al. (1985) and Piggot and Whalley (1985). It incorporates the economic behaviour of households, industries, government and the foreign sector. All economic agents are assumed to adopt an optimising behaviour under relevant budget constraints and all markets operate under the perfect competition assumption. In line with Shoven and Whalley (1992), model construction and analysis follows the steps presented in Flow Chart 1.1.

More formally, the study attempts to analyse the impact of tax measures implemented by the Maltese government since 2001 (the year of the benchmark dataset). These mainly include an increase in taxes on consumption and changes in income and import taxes in the opposite direction. The Malta GETM is used to capture the widespread redistribution and reallocation in both demand and supply of goods and factors by households and industries in the process of shifting the burden of taxes until it settles down to the ultimate payers of these taxes.

**Chart 1.1 Steps used in computable general equilibrium analysis**




There are obviously significant data limitations and any estimates on behavioural responses and associated measures of welfare changes require strong assumptions to be made. It must also be acknowledged that there is a danger that estimates may be influenced more by apparently pragmatic assumptions than by the data. However, the scope of this study is to contribute to the tax policy debate by, as far as possible, making all assumptions explicit, stressing the qualifications and limitations of the analysis, and examining the implications of adopting alternative value judgements instead of simply reporting one set of results.

In an attempt to learn how CGE models have been used to study the affects of different tax policy measures, Chapter 2 gives an overview of the fundamentals of general equilibrium theory and its use in generating quantitative results for tax policy evaluation. It does so by providing a review of literature of studies addressing the issue of tax reform and further discusses the strengths and weaknesses of these models.

The database in the form of a Social Accounting Matrix (SAM) is prepared for convenience of model estimation in Chapter 3. One of the merits of CGE models is that necessary data for model estimation are input-output tables and national accounts data for *only* a single year. However, due to the unavailability of the former, the chapter deals with the construction process involving the transformation of Supply and Use Tables (SUT) into a Symmetric Input-Output Table (SIOT) and in turn the transformation of the SIOT into a balanced SAM. This represents a static overview of Maltese economy and is assumed to provide the benchmark equilibrium.

A detailed analysis of the structure of the Maltese economy and the existing tax policy in the year of the benchmark SAM is presented in Chapter 4. This is intended to provide insight into the varying shares in expenditure of different commodities as well as factor intensity use by the various institutions. The second part of the chapter estimates the effective tax rates on five different tax bases (income, consumption, imports, labour and capital) which represent the basic ad valorem tax rates in the benchmark economy. This invaluable information enables better understanding of results obtained at a later stage of the study.

Chapter 5 specifies the structure of the Malta GETM and its functional forms. Each institution's optimising behaviour is used to derive the demand and supply equations which are then used to generate the numerical solutions to the model. Since equilibrium in all markets is not necessarily guaranteed, the chapter also specifies the market clearing conditions in line with the constructed dataset.

Relying on the benchmark SAM, the process of calibrating the Malta GETM is explained in Chapter 6. This is understood as the requirement that the entire model specification be capable of generating the benchmark equilibrium observations as the model solution. The mathematical conditions necessary for the estimation as well as the implementation of the Malta GETM in the algebraic optimisation software (GAMS) are also discussed.

In Chapter 7, the Malta GETM is used to quantitatively analyse the distortionary impacts created by the presence of taxes in the Maltese economy and the affects of major tax policy measures implemented by the Maltese government since 2001. As most of the models to which reference has been made above, the analysis carried out uses a comparative static framework. As the name suggests, it is the mere comparison of the initial equilibrium state with the final equilibrium state (Chiang, 1984). The robustness of the results obtained is then tested by means of sensitivity analysis with respect to exogenous elasticity values.

The final chapter concludes by providing a constructive commentary on the results obtained and how they can be used for tax policy and planning in Malta. Identification of the limitations of the study is also provided with the aim of suggesting how the Malta GETM can be improved upon, and to encourage further research in relation to tax policy analysis from a general equilibrium perspective.

# Chapter Two

# GENERAL EQUILIBRIUM TAX MODELS: LITERATURE REVIEW

The tradition of general equilibrium started with Walras' "Eléments d'économie politique pure" (Elements of Pure Economics, 1847). It is nowadays understood that Walrasian equilibrium prevails when supply equals demand across all interconnected markets in an economy. Issues of existence and stability of general equilibrium were tackled throughout the 40s-70s period of the twentieth century, mainly by Arrow and Debreu. This enabled analysts to solve numerically for levels of supply, demand and prices that support the equilibrium across a specified set of markets. Since then, CGE models have become a standard tool of empirical analysis and are widely used to analyse impacts of policies whose effect may be transmitted through different markets.

This chapter lays the foundations of general equilibrium theory in Section 2.1 and treats its applied aspects in Section 2.2. Section 2.3 reviews studies dealing with tax reform from a general equilibrium perspective and proceeds to discuss the techniques' utilisation within Malta's policy debate in Section 2.4. Section 2.5 reviews the strengths and weaknesses of CGE models.

## 2.1 GENERAL EQUILIBRIUM THEORY

In an economy, there is something of a balance between the amount of goods and services that some individuals want to supply and the amounts that other individuals want to buy. Whilst the balancing of supply and demand is far from perfect, when all due allowances are made, the coherence among the vast number of individual and seemingly separate decisions about the buying and selling of commodities is remarkable. For example, prices of oil lead to lower American interest rates because the money the Saudis and the Russians make from crude oil is spent on American Treasury bonds. Similarly as income rises and demand shifts, say from food to cars to housing, the labour force follows suit. These phenomena show that in general the economic system adjusts with a considerable degree of smoothness and indeed of rationality.

In the 1870s, Leon Walras, gave a reasonably clear answer with regards to the problem of economic coordination amongst the infinite number of sellers and buyers in each market. It is the fact that all agents in the economy faced the same set of prices that provided the common flow of information needed to coordinate the system. There is a set of prices, one for each commodity, which would equate supply and demand for all commodities, and if supply and demand were unequal anywhere, at least some prices would change while none would change in the opposite case. The latter is what is nowadays referred to as 'equilibrium'. The adjective 'general' refers to the argument that we cannot reasonably speak of equilibrium with respect to one commodity since supply and demand in any one market depends on the prices of other commodities.

Hicks (1939) and Samuelson (1947) formalised Walras' general equilibrium theory as a system of differential equations, such that a general equilibrium model of an economy is one in which consumers maximise utility subject to their budget constraint (leading to the demand-side specification of the model) and where producers maximise profits (leading to supply-side specification). In equilibrium, market prices are such that supply equals demand for all commodities, and the constant returns to scale zero-profit conditions are satisfied for each industry.

Consider the case of a pure exchange economy where each consumer is described completely by his preference and his initial endowment of commodities $w_i$. The amount of good $j$ that agent $i$ holds will be denoted by $x_{ij}$, the consumption bundle will be denoted by $x_i$ and a feasible allocation is one that it physically possible, $\sum x_i = \sum w_i$

Each consumer takes the prices as given and chooses the most preferred bundle from his consumption set, that is, Max $U_i(x_i)$ such that $px_i = pw_i$. Given the consumer's demand function $x_i(p_i, pw_i)$ it shall be assumed that the consumer's wealth is the market value of his initial endowment The representation used for consumer $i$ can be used to represent aggregate demand $\sum_{A} x_i(p_i, pw_i)$ and aggregate supply $\sum_{A} w_i$.

This means that the most preferred bundle then is a function $x_{hi}(p_1 ... p_n)$ of all prices. From this point of view, all prices enter into the determination of demand for any one commodity. For one thing, the rise in any one price clearly diminishes the residual income available for all other commodities. More specifically, however, the demand for some commodities if closely interrelated with others. For example, the demand for petrol is perhaps more influenced by the use of automobiles and therefore by their price than it is by its own price showing the interrelation of all demands.

Further assumptions are for market demand functions to be non negative, continuous and homogenous of degree zero in prices. The latter implies that doubling all prices doubles incomes and hence the physical quantities demanded are unchanged, thereby allowing an arbitrary normalisation of prices, ordinarily set as $\sum p_i = 1$.

Based on Walras' law, there will be a set of prices such that each consumer is choosing his most preferred affordable bundle and all consumers' choices are compatible in the sense that demand equals supply in every market, $\sum x_i(p, pw_i) = \sum w_i$, that is, the value of market excess demands equals zero at all prices, $\sum px_i(p, pw_i) - pw_i = 0$. This condition must hold for any set of prices.

Extending the general equilibrium model to an economy with production requires the specification of a production technology. Assuming a number of firms that have a finite number of constant returns to scale activities, each denoted by $a_{ij}$, indicating the use of good $i$ in activity $j$. A negative sign indicates an input and a positive sign an output. The vector $x = x_1 ... x_N$ denotes levels of intensity of operation associated with each activity and is non-negative. Production is assumed to be bounded, that is, infinite amount of outputs from finite inputs are ruled out, such that $\sum a_{ij} x_j + w_i \geq 0$ for all $i$.

A general equilibrium for this model is given by a set of prices $p_i$ *and activity levels $x_j$ * such that demand equals supply $\sum(p_i, pw_i) = \sum a_{ij}x_j + w_i$ and no productive activity make positive profits, $\sum p_i a_{ij} \leq 0$.

Numerical applications of general equilibrium models of this form began with the work of Harberger (1962) and Johansen (1960). Harberger used a model with two production sectors, one corporate and one non-corporate, calibrated to U.S. data from the 1950s, to calculate the incidence of the U.S. corporate income tax. Johansen used a model with nineteen sectors, calibrated to Norwegian data from 1950, to identify sources of economic growth in Norway over the period 1948-1953. Both lenearised and solved the model analytically without analysing whether an equilibrium of the original non linear model actually existed. Neither study raised the possibility of multiple equilibria or attempted to check for multiplicity in any way.

It is essential knowing that equilibrium actually exists before attempting to compute it. Arrow and Debreu (1954), Debreu (1959) and McKenzie (1959) used mathematical general equilibrium theory to demonstrate the existence of Walrasian equilibria by showing the applicability of mathematical fixed point thermos to economic models. Further proof of the existence of equilibrium for cases with taxes is found in Shoven (1974). The application of fixed point theorems provides logical support for the subsequent use of this framework for policy analysis.

Arrow, Debreu and McKenzie also gave a careful definition of competitive equilibrium and a characterisation of equilibrium. The latter refers to the two fundamental theorems of welfare economics. The first established that the set of competitive allocations is a subset of Pareto efficient allocations. The second theorem shows that with lump sum redistributions, any Pareto efficient allocation can be sustained as a competitive equilibrium. Edgeworth (1881) developed the idea of the core as the set of allocations upon which no coalition of agents in the economy can improve, in the sense of making better off all of its members by an alternate allocation in the economy. The core is obviously a subset of Pareto efficient allocations. Debreu and Scarf (1963) proved a deeper result by showing that the core converges to the set of competitive allocations as the economy is replicated.

## 2.2 APPLYING GENERAL EQUILIBRIUM

The basic general equilibrium framework together with proofs of existence and characterisation of equilibrium, have set the stage for further computational advances. The breakthrough was the introduction of an algorithm for the solution of the general equilibrium problem which was developed by Scarf (1967). He thought that computation of competitive equilibria could be found by finding allocations in the core of an economy and then replicating it. It was the first rigorous approach to developing a computational algorithm that guaranteed to find equilibria, that is, to compute the prices that clear all markets and determine the allocation of resources and the distribution of incomes that result from this equilibrium.

The first applications of computable general equilibrium models using Scarf's algorithm were by Shoven and Whalley (1972, 1977 and 1984) and addressed policy issues in the area of tax reform and international trade. They developed calibration and computation techniques for an applied multi-sector general equilibrium model. The development of these models progressed from disaggregate production structure based on the Leontief (1941) input output approach, to flexible production and consumption structures, disaggregation of the household sector to handle distributional issues, the introduction of labour-leisure choice and the consideration of issues of expectation as well as departures from prefect competition.

Building on the Harberger model, but using for the first time a full general equilibrium approach, Shoven and Whalley (1972) identify the conditions under which capital bears the burden of the additional tax on corporate capital in the U.S. as opposed to the conditions under which the burden falls on labour. The demand side of the model was derived from a Cobb-Douglas utility function using ten rural/urban income groups, government and the rest of the world, whilst the production side was modelled in the form of constant-elasticity-of-substitution (CES) production functions for two industries. In subsequent versions of the model they studied proposals for the integration of capital income taxation with personal income taxation and evaluated the gains and the distributional consequences of each proposal.

The work of Whalley (1980, 1982) in international trade policy also contributed important results. Assessing the consequences of trade liberalisation as proposed in various rounds of GATT negotiations, he finds that gains are fairly small and concludes that non tariff barriers are far more important than tariffs. He also identifies gainers and losers for each of the liberalisation scenarios studied.

Other researchers developed models with properties similar to the Shoven-Whalley versions. Three main lines of research should be mentioned in this context. The first one is the multi-sector energy model of the U.S. economy, developed by Hudson and Jorgenson (1984) and later improved and extended by Jorgenson. Although initially not as close to the original Walrasian model, it made two substantial contributions: it introduced more sophisticated functional forms and thereby representing a better approximation of reality, and it was based on full econometric estimation of the parameters of the various sub-models.

An interesting utilisation of Jorgenson's model was to study implications of energy price changes. He emphasised the degree of substitutability between energy and labour, and of complementarity between energy and capital, which is reflected in the parameter estimates he obtains from his production sub-models. He then argued that higher energy prices reduce the demand for capital, and increase the demand for labour, leading to lower rates of return on capital and higher real wages. Within this framework, he then studies the long term impact of these changes in relative prices on economic growth, concluding that the lower rates of return to capital may be one of the most important consequences of higher energy prices, leading to slower economic growth.

A second line of research was initiated by Manne (1983) and was also applied to the energy policy area. Its main novelty was the comprehensive treatment of dynamic issues, by basing the solution to the model on full inter-temporal optimisation and by specifying the constraints and costs associated with partial adjustment on part of the economic agents. His work was later extended to other areas but maintained simple functional forms and parameterisation, a low level of disaggregation and strong emphasis on dynamic issues. In particular, a three region model of trade and economic growth of Manne and Preckel (1983) stands out, which is based on a very simple structure but which provides many insights into key issues in trade between developed, less developed and oil-producing countries.

The third line of research which has contributed significantly to the applied general equilibrium approach has evolved from multi-sector planning models. The initial approach was based on extensions of the Leontief model, complemented with more or less sophisticated models of consumer expenditures and international trade. To achieve a fully consistent framework the research evolved the concept of social accounting matrices, a method of representing all transactions among every type of economic agent in a country. A comprehensive review of the development of social accounting matrices is given in Pyatt and Round (1985).

Since the 1980s, applications of CGE have broadened, mainly by building on the three lines of development mentioned so far. They include tax policy, international trade, development, energy, climate change, environmental policy, finance and business cycles. However, in light of the dissertation hypothesis, the next section will focus exclusively on reviewing studies relating to tax reform

## 2.3 CGE MODELS FOR TAX POLICY ANALYSIS

The first general equilibrium approach addressing tax reform remains Harberger's seminal paper on the distortionary effects of taxation. Whilst extremely simple in approach, it set the stage for more complex models. As pointed out earlier, Shoven and Whalley (1972, 1973) were the first to analyse taxes using a full general equilibrium computational procedure. The study used a method of simultaneously incorporating several tax distortions and was used by Whalley (1975) to examine the impact of the 1973 tax changes in the U.K. This work was further developed by Piggott and Whalley (1977, 1985) into a thirty-three product and one-hundred household-type model that has been used to evaluate structural characteristics of the U.K. tax/subsidy system.

Two models closely related to the Shoven-Whalley work are those by Piggott (1980) on Australia and Serra-Puche (1984) on Mexico. Piggott's model differs from the other tax models in using two-stage Constant Elasticity of Substitution (CES) production functions with differing types of capital and labour. At one stage, different types of labour 'produce' the aggregate labour input and, correspondingly, different types of capital services 'produce' the aggregate capital input. At the second stage, capital and labour combine to produce value added. Serra-Puche analyses tax incidence in Mexico in a model with three factors. Subsequent work by Kehoe and Serra-Puche (1983) has used a similar approach to analyse the 1980 fiscal reform in Mexico, incorporating unemployment generated by an exogenously specified, downward rigid real wage.

Keller's (1980) tax model for Holland differs from Shoven-Whalley work in using local linearization procedure to solve for the tax change equilibria. Ballentine and Thirsk (1979) use the same approach in their tax general equilibrium model on Canada. An interesting feature of the latter is the attempt to incorporate a degree of factor mobility, both domestically among regions and internationally.

The Ballard, Fullerton, Shoven and Whalley (1985) model of the U.S. is a good example of a large scale model of tax policy analysis. It incorporates all major distorting taxes and uses a sequential equilibrium approach to study dynamic behaviour in the economy, that is, a number of commodities and industries appear as in static models, but saving decisions in any period are made by households based on myopic expectations regarding the future rate of return to capital.

Perhaps, the most comprehensive effort in this area has been the work of Jorgenson (1997). He demonstrated the favourable effects of unifying corporate and personal income tax in the U.S. and of replacing capital taxation with consumption taxation. Rather than the simplistic approach of the stylised models, he used dynamic, multi-sectoral, multi-household model. The U.S. tax policy did move in this direction, but it has done so more slowly than the Jorgenson analysis would have deemed optimal.

Bovenberg's (1987) analysis of the difference in zero-rating and exemptions in a Value Added Tax (VAT) regime, and its implications for tax incidence had an effect on tax reforms in numerous countries, including Thailand. In the early nineties, the Philippine government, despite a looming budget deficit, was reluctant to increase energy taxes because the poor spent a larger fraction of their income on energy than the rich. However, a CGE analysis by Devarajan and Hossain (1998) showed that the rich actually consumed more energy intensive goods, rendering the overall incidence of energy taxes broadly neutral. In the event, the Philippine government raised energy taxes and proceeded to enjoy an unprecedented period of economic growth.

Computable general equilibrium models have been influential even when they represent a second generation of a well established model. In Australia, the ORANI model was first developed in 1977. By the late 1990s, its successor, ORANI/MONASH and derivative models have played an important role in public debates on sales taxes and many others (Dixon 2001).

Similarly, Bhattarai and Whalley (1998) have worked on general equilibrium tax modelling as part of a wider project on "General Equilibrium Analysis of UK Policy Issues". Bhattarai has since published extensively on the effects of consumption, income and capital taxes and their effects on variables such as labour supply (see for example Bhattarai, 2003 and 2004).

General equilibrium tax modelling is nowadays the foremost tool for tax policy analysis, typically applied by ministries of finance. Overall, it can be said that CGE models have had a modest, but significant influence on policy in the area of tax reform. They have, in some cases, played the role of uncovering particular mechanisms that had not been apparent before. Whilst the early models were essentially static and good for comparative static analysis, advances in computational technology in the 1990s (GAMS/MPSGE/PATH, Rutherford, 1995) have made possible the transitional affects of policy analysis on long run growth, investment, savings and capital.

## 2.4 CGE ANALYSIS FOR THE MALTESE ECONOMY

The only CGE analysis relating to the Maltese economy addressed issues of EU membership (Bayar, 2003) and the effects of EU membership on tourism (Blake, Sinclair, Sugiyarto and DeHaan, 2003).

Bayar's CGE model for Malta has as its central feature an input-output table that explicitly links industries in the value added chain. Consumers' demand for final-good sectors is generated from a representative regional household with Cobb Douglas preferences over sectoral composites. Each sector consisted of differentiated products and consumer and firm demand for these were generated by CES preferences. Each region's output is assumed to be differentiated. The model supports two-way trade in all traded sectors. Regional labour supplies are assumed to be fixed, but regional capital stocks are endogenous. Taxes in the model were included in the theory of the model at several levels. Production taxes were placed on intermediary or primary inputs, or on output. Taxes were also placed on exports, on primary factor income, and on final consumption where relevant. The overall conclusion of the EU-membership simulation analysis was that Malta's gross domestic product (GDP) would record significant increases per annum in the medium to long term.

In contrast with Bayar's model, Blake et al modelled aggregate consumption as a Linear Expenditure System (LES). Estimation is taken for the short run, in which factors are assumed to be in fixed supply, and the long run, in which there is factor mobility, with unemployment adjusting between the two periods according to a Phillip's curve relationship. The results showed that following EU membership a significant proportion of the effects of an increase in tourism demand would be crowded out through higher prices in the short run. In the long run, crowding out is lower but the increases in GDP and welfare are also lower than in the short run because of the constraints on labour availability.

The significance of these types of models within Malta's policy debate is dependent on the user's ability to interpret the model correctly. This cannot be the case without prior knowledge of the strengths and weaknesses of CGE models, which are the topic of the next section.

## 2.5 STRENGTHS AND WEAKNESSES

In general, the theoretical superiority of the general equilibrium approach has been accepted. However, as new applications and extensions are proposed, the results aren't always in line with expectations, and the fact that the approach has some limitations must not be overlooked.

In contrast with macroeconomic models, CGE models concentrate on the underlying structure of production, shedding light on long term repercussions of things such as a big tax reform or climate change. Lucas (1976) argued that it is naive to try to predict the effect of a policy experiment based purely on correlations in historical data, especially high-level aggregated historical data, because if the parameters of the model are not structural they would necessarily change whenever policy was changed. Any policy advice would then be potentially misleading. This argument called into question the prevailing large scale econometric models that lacked foundations in dynamic economic theory. The Lucas Critique implies that if we want to predict the effect of a policy experiment, one must model preferences, technology and resource constraints that govern individual behaviour. We can then predict what individuals will do conditional on the change in policy, and add up individual behaviours to calculate the macroeconomic outcome.

Indeed, computable general equilibrium models explicitly take account of optimising behaviours of consumers subject to budget constraints and of producers subject to technology constraints. Allocation of resources in such general equilibrium models is determined by the relative prices that are uniquely determined by the equilibrium mechanism. By building on a Symmetric Input-Output Table (SIOT) or a Social Accounting Matrix (SAM), CGE models compare the initial equilibrium condition with other equilibrium induced by changing exogenous shocks to the model.

John Maynard Keynes observed that "human decisions affecting the future, whether personal or political or economic, cannot depend on strict mathematical explanation, since the basis for making such calculations does not exist" (The Economist, 2006). Though not perfect, CGE models will often give a better clue than no model at all.

The possibility of including all interdependencies and feedbacks among the variables in a single model is obviously more attractive than the *ceteris paribus* assumption which is inevitable in partial equilibrium analysis. A good example of the importance of analytically integrating all aspects of policy decision is provided by the study of windfall profits tax in the U.S. Using their model of the U.S. economy, Borges, Goulder and Shoven (1982) study the distributional consequences of a tax on 'windfall' profits accruing to owners of energy resources as world prices increase. Since the tax falls exclusively on profits, it is expected that its impact on income distribution would be progressive. The general equilibrium approach, however, highlights the fact that the distributional effects depend on how the government uses the additional revenue. In fact, given that on average, American government expenditures are quite capital intensive, if the additional revenue is spent in the same way as all government expenditures, it will tend to increase the demand for capital and hence price of capital and may in the end worsen the personal distribution of income. This type of analysis is impossible under partial equilibrium assumptions.

Typically, a general equilibrium model specifies the behaviour of all economic agents. The model will use the standard methods to describe all relationships amongst the variables, which precludes ad hoc specification and makes the structure more transparent in this sense. The various interdependencies and feedbacks among the variables make it difficult to determine in advance what the results of a particular simulation will look like. This has led some economists to label these models as 'black boxes'. But the theoretical foundation of such models makes it possible to trace back the simulation results and determine which factors are crucial in explaining them. As with any other model, the results generated by CGE models will not go beyond what has been built into them, either in terms of assumptions or structure.

Advances in general equilibrium modelling have made possible the development of highly disaggregated models, which also contributes to their practical usefulness. It is well known that many policy actions or exogenous shocks will have an overall impact on the economy which is much smaller than their effect on the structure of the economy. In other words, focusing on the overall impact on output neglects the important and substantial changes in its structure which are induced by a policy decision. The interest in structural issues has led to general equilibrium models which often have many sectors of production, groups of consumers, types of goods, etc. The type of structural issues analysed include changes in the composition of output, with the necessary shift of resources from declining sectors to expanding sectors, changes in relative prices and their consequences, distributional issues, etc.

Disaggregated general equilibrium models also make possible the inclusion of structural aspects which correspond to distortions or market failures when the economy is specified in some detail. Consider the case of taxes. Their impact is sometimes crucial to other policy analysis, even those not related to taxes. This is because inefficiencies and distortions interact with each other in ways which are not obvious. It could very well be the case that removing one source of inefficiency does not necessarily lead to an overall improvement of the allocation of resources in the economy if other distortions persist. In fact, when many sources of inefficiency exist, the effects of some of them will tend to cancel out, and removing any one of them may actually worsen the situation. A case in point is the conclusion of a study by Ballard et al (1985), where they used a general equilibrium model to study the introduction of value added taxation in the U.S. They argue that the value added tax is less distorting than an income tax, and that replacing the latter by the former should improve the efficiency of resource allocation However, they also take into account that any realistic value added tax will probably include different rates for different products, given the usual attempt to use indirect taxation also to pursue redistributive objectives. Specifying a structure of rates similar to what is common in European member states they find that all efficiency gains are lost, and that the distortions caused by different rates for different products actually outweigh the gains inherent to the value added tax.

Another factor contributing to the attractiveness of the general equilibrium approach for certain types of studies is the fact that they are solved numerically not analytically. The approximation implicit in the use of calculus is acceptable if the policy changes contemplated are small. But very often policy issues involve substantial changes in absolute and relative terms. The numerical solution of general equilibrium models can handle these situations easily, since it does not depend on assumptions of small change.

A final advantage of CGE models is the possibility of deriving better measures of welfare, especially when distributional measures are associated with a new policy.

For example, the increase of labour income tax will typically reduce after tax wage rates. People will be induced to make less effort and total income will fall. If however the extra leisure time has some value, the impact on welfare will be smaller than what is measured by the fall in income. Another example relates to indirect taxation. In principle it leaves the income of consumers unchanged, but by changing the relative price of goods they buy, they may have a very substantial impact on the pattern of their consumption and hence on the welfare they derive from it.

One of the main weaknesses of CGE models is the lack of empirical validation of the models, in the sense that there is no measure of the degree to which the model fits the data or tracks the historical facts. Indeed, these models include a substantial number of parameters which are usually estimated independently, and then calibrated to a single data point, which is chosen to represent a situation close to general equilibrium. In light of these weaknesses, the results obtained from CGE models are not intended to forecast economic variables, but rather to indicate long term tendencies around which the economy will fluctuate. Its results should thus be interpreted in this context.

Ex-post performance evaluations of applied general equilibrium models are essential if policymakers are to have confidence in the results produced by these models. Kehoe, Polo and Sancho (1995) compared a static applied general equilibrium's predictions with the actual data on how Spain was affected on entering the European Community between 1985 and 1986[2]. It was found that, at least when exogenous effects are included, the model performed well in capturing the changes that actually occurred. However, Kehoe quickly points out that these models are not perfect. Whilst these models emphasise the impact of reallocating resources across sectors of the economy, they fail to capture the effect of a policy change on the dynamic aspects of an economy. Policy changes such as the North American Free Trade Agreement (NAFTA) are likely to directly affect dynamic phenomena, such as capital flows, demographics and growth rates. Indeed, Kehoe found that static

[2] The results of the actual analysis were issued as working papers or published in a variety of outlets (Kehoe, Manresa, Noyola, Polo, Sancho and Serra Puche, 1985, 1986a, 1986c; Kehoe, Manresa, Noyola, Polo and Sancho, 1988; Kehoe, Manresa, Polo and Sancho, 1989).

applied general equilibrium models[3] have drastically underestimated the impact of NAFTA on North American trade. Thus, good as they are, static applied general equilibrium models have their limitations.

[3] The actual models were constructed by Brown, Deardorff and Stern (1995), Cox (1995) and Sobarzo (1995).

# Chapter Three

# CONSTRUCTION OF BENCHMARK DATASET

This chapter presents the construction of the benchmark dataset used to calibrate the Malta GETM. It is based on the circular flow capturing the generation of income by industries in producing commodities, the mapping of these income payments to the factors of production, the factor and non-factor income to households, and the subsequent spending of households on commodities. These patterns of payments are manifested in the structure of a SAM and are modelled analogously to the input structure of activities.

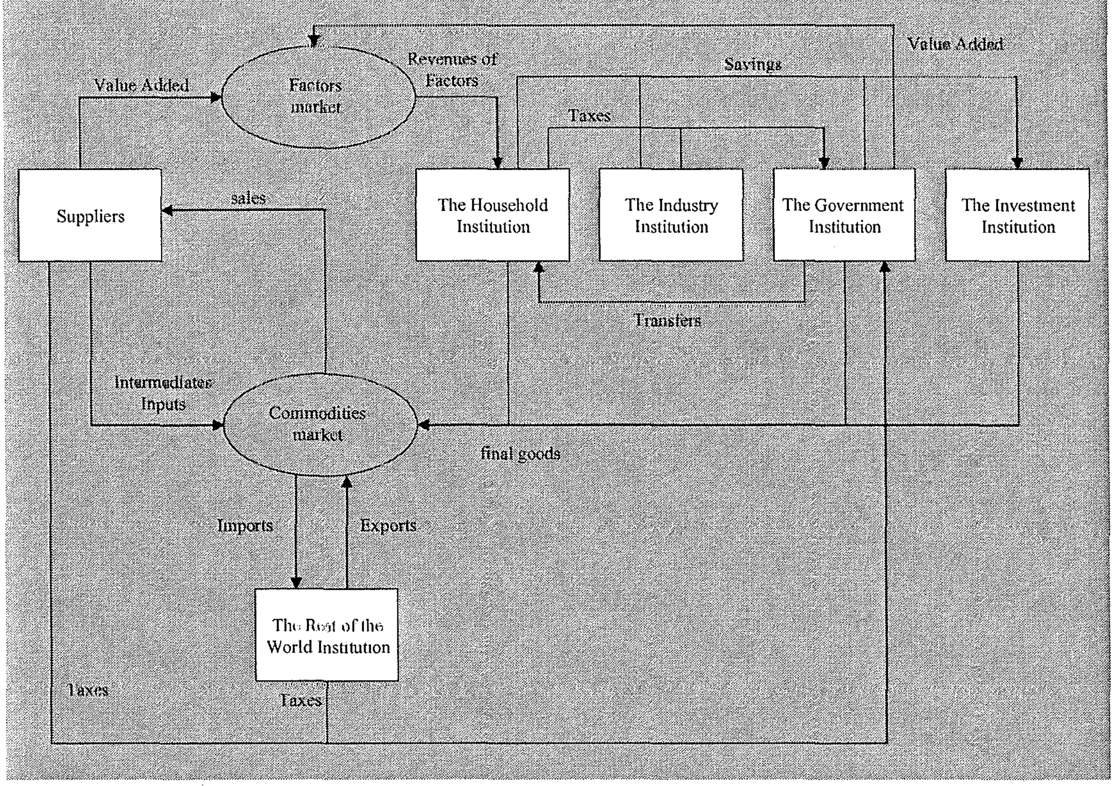
Since the detailed information published by Malta's National Statistics Office (NSO) is largely a by-product of the process of assembling macro-aggregates it does not aim at consistency in the various areas of detail that general equilibrium analysis requires. If equilibrium is to be reflected in an assembled SAM, four major set of equilibrium conditions must be satisfied: demand must equal supply for all commodities, non-positive profits are made in all industries, all domestic agents have demands that satisfy their budget constraints and the economy must be in external balance (Shoven and Whalley, 1992). Thus adjustments, modifications and additions to major blocks of data were necessary such that income equals expenditure in every account. This study uses the cross entropy approach to balance the Malta SAM.

The chapter proceeds by highlighting the link between the circular flow and Walrasian equilibrium in Section 3.1, describes the SAM characteristics in Section 3.2, gives an overview of the data compilation process in Section 3.3 and describes the balancing process in Section 3.4.

## 3.1 THE CIRCULAR FLOW

The fundamental starting point for a CGE model is the circular flow of commodities in the economy (shown in Figure 3.1). Equilibrium of economic flows is given by the conservation of both product and value. Conservation of product reflects the principle of material balance. In other words, the quantity of a factor with which households are endowed (or commodities which are produced by firms) must be completely absorbed by the firms (or households) in the rest of the economy. Conservation of value reflects the accounting principle of budgetary balance that for each activity in the economy the value of expenditures must be balanced by the value of incomes, and that each unit of expenditure has to purchase some amount of some type of commodity. The implication is that neither product nor value can appear out of nowhere. These rules lay the foundations of Walrasian general equilibrium (Wing, 2004).

**Figure 3.1 – Circular Flow**




Assuming a closed economy for simplicity, conservation of product implies the market clearing condition that firms' outputs are fully consumed by households, and that households' endowment of primary factors is in turn fully employed by firms. Thus for a given commodity the quantity produced must equal the sum of the quantities that are demanded by the other firms and households in the economy. Similarly, for a given factor the quantities demanded by firms must exhaust the aggregate supply endowed by the households.

The conservation of value implies that total revenue from the production of goods must be allocated either to households as receipts for primary product rentals, to other industries as payments for intermediate inputs, or to the government as taxes. The value of a unit of each commodity in the economy must then equal the sum of the values of all inputs used to produce it, including payments to primary factors of production. The principle of conservation of value thus reflects constant returns to scale in production and perfectly competitive markets for produced commodities. This implies that in equilibrium producers operate under the zero profit condition.

The returns to households' endowment of primary factors accrue to household as income that households exhaust to purchase goods. This reflects the principle of income balance or balanced budget.

The three conditions of market clearance, zero profit and income balance (presented above and extended by the open economy assumption) are then employed by the general equilibrium model to solve simultaneously for the set of prices and the allocation of goods and factors that support general equilibrium In conformity with these conditions, the database presented in this study is in the form of a SAM describing all transactions in the economy between the various institutions.

## 3.2 SAM CHARACTERISTICS FOR THE MALTA GETM

A SAM is an invaluable tool for bringing together available data giving a quantitative description of the initial (static) equilibrium position of the Maltese economy. It is a matrix representation of transactions in an economic system. More technically, a SAM is a square matrix in which each account is represented by a row and a column. Each cell shows the payment from the account of its column to the account of its row. Thus the income accounts appear along its rows and expenditure along its columns. The underlying principle of double-entry accounting requires that for each account in the SAM, total revenue equals total expenditure. This is the main reason why the Malta GETM uses data organised in the form of a SAM as a representation of its initial equilibrium.

From a macro perspective the SAM shows the basic forms of economic activity corresponding directly to the flow chart shown in Figure 3.1. These include production, consumption, investment and transactions with the rest of the world. The distinctions between the commodities account and the industries account, between the factors account and the institutions account, and between the taxes account and the government account were thought necessary to draw a clear distinction between the different types of income of the various agents resulting from the redistributive process within the Maltese economy. Each account is discussed in detail in Chapter Four.

Because of the equality between 'row total' and 'column total' in the matrix, the SAM explicitly portrays some of the most important clearing conditions in the economy. Market clearing in the commodity market will be reflected in the commodity accounts, that is, the value of commodities supplied by industry has to be equal to what is demanded by the various demanders. The quantity of column total and row total of factor accounts in the SAM also records market clearing in the market of the factors of production. In addition, the other features of standard general equilibrium models are also satisfied by the SAM. The zero profit condition is met by the equality between industry costs and sales, and the household budget constraint is also satisfied. The SAM thus has the basic and necessary ingredients for a general equilibrium model. Technically, before any simulation is conducted, a balanced and consistent SAM ensures that all agents' income is spent, which in turn guarantees equilibrium, database balance and nominal homogeneity.

## 3.3 DATA COMPILATION

In constructing a benchmark SAM for the Malta GETM various adjustments were necessary to blocks of data that were available separately. The starting point was provided by the SUT simply because they contain the most detailed information on separate industries and products available in the system of national accounts. As SIOT are thought to be the most ideal source of information for the construction of a SAM, SUT were transformed into an industry-by-industry SIOT. Other sources included publications of Government Finance and calculations by Malta's NSO.

### 3.3.1 The Supply and Use Tables (SUT)

In 2004, the NSO published for the first time SUTs for the year 2000, followed by another in 2005 with data relating to 2001. The tax policy analysis carried out in this study was thus based on data relating to the latter publication.

The SUT framework mainly consists of two tables, namely, the supply table and the use table. The supply table lists all commodity outputs per production unit. It contains a matrix (92x60) of domestic production broken down by commodities and industries in *basic prices,* as well as vectors for imported goods (CIF), imported services and expenditure of Maltese abroad. The supply table also includes data in the form of vectors for VAT, import duties, import levies, taxes and subsidies on products and trade and transport margins, thereby enabling the transformation of supplies from basic into purchasers' prices. On the other hand, the use table is in *purchasers' prices* and gives the input requirements of the various institutions. It includes a matrix (92x61) of intermediate consumption of domestic and imported goods and services by commodities and industries. Other vectors (92x1) included in the table are private household consumption, government consumption, Gross Fixed Capital Formation (GFCF), exports of goods, re-exports, tourism expenditure and export of services. The table also includes rows showing value added, broken down into compensation of employees, operating surplus, consumption of fixed capital and other taxes and subsidies on production.

The two are closely linked in the sense that the supply of every product must be equal to the use of that product when measured in the same price, and the output of an industry must be equal to its cost of production (that is, total supply of an industry at basic prices must equal total industry use at purchaser's prices). Upon purchasing goods and services an industry pays a price including taxes and trade margins, whilst the industry's available revenue is equal to the price it charges upon the sale of its products net of taxes and trade margins. This makes the SUT an ideal framework for the compilation of a SIOT for Malta.

### 3.3.2 The Symmetric Input-Output Table (SIOT)

In similar fashion to a SAM, the SIOT presents a static image of the economy as originally developed by Wassily Leontief in 1936. The last SIOT for the Maltese economy was published in the 'National Statistics 1998' and related to 1996 data. However, the table focused mainly on direct production and is not in line with Eurostat classifications. Furthermore, developments in the Maltese economy since 1996 must be framed in context of the restructuring process that the economy has been undergoing for a number of years. Given the circumstances, a new SIOT for the Maltese economy for 2001 was constructed from SUT.

The conversion from SUT to SIOT was undertaken in two main steps. First, purchasers' prices of uses were decomposed into basic prices, taxes (including VAT, import duties and levies, taxes and subsidies on products) and trade and transport margins. Second, the rows and columns of SUT were expressed in an industry by industry SIOT.

**Box 3.1 – Relationship between different prices**

Purchasers' prices (excluding deductible VAT)
- Non-deductible VAT
- Trade and transport margins
= Producers' prices
- Taxes on products
+ Subsidies on products
– Basic prices

Since the SUT are valued in different prices, conversion into *similar* prices was necessary (see Box 3.1). Valuation at basic prices was preferable because it is a more homogenous option. The differences between the valuation of the use table at purchasers' prices and its valuation at basic prices have been bridged by means of valuation matrices for trade and transport margins and product taxes less subsidies. Box 3.2 shows in more detail the list of all use-side valuation matrices compiled. Each element in these matrices shows the amount that needed to be deducted from purchasers' prices in order to achieve a valuation at basic prices.

**Box 3.2 - List of use-side valuation matrices**

| | |
|---|---|
| i. | Use-side valuation matrix for trade and transport margins |
| ii. | Use side valuation matrix for value added tax (VAT) |
| iii. | Use side valuation matrix for taxes/subsidies on products |
| iv. | Use-side valuation matrix for import levies and import duties |
| v. | Use-side valuation matrix for FISIM allocation |

*(i) Use-side matrix for trade and transport margins*

Since a trade margin is defined as the difference between the price realised on a good purchased for resale and the price paid by the trader to replace it at the time it is sold (Eurostat, 1995), there are trade margins on most goods (not on services). Wholesalers and retailers are treated as supplying these services. The supply table gives only the total trade margins for each commodity without further distinction. It is also noticeable that transport margins in the Maltese economy are negligible. Thus this subsection will focus on the compilation of a trade margins matrix.

This matrix has the same dimension of the use table. For each good, it gives the trade margins paid by its purchasers. Due to the lack of data availability about trade margins paid by industry, the calculation of the matrix has been based on a number of assumptions and balanced with the estimated total supply of the trade margins. It has been assumed that in intermediate consumption only wholesale trade services are involved, whilst almost all retail expenditure has been allocated to private consumption expenditure. Wholesale services have also been connected with private consumption and GFCF.

*(ii) Use-side valuation matrix for Value Added Tax (VAT)*

According to Eurostat (1995), VAT in the SUT has been recorded 'net' in the sense that output of goods and services and imports are valued excluding invoiced VAT and that purchases of goods and services are recorded inclusive of non-deductible VAT. VAT is recorded as being borne by the purchasers, not sellers, and then only by those purchasers who are not able to deduct it. Thus it is assumed that the greater part of VAT is recorded as being paid on final uses, mainly household consumption and tourism expenditure. A part of VAT, however, is paid by enterprises and other institutions which are exempted from charging VAT.

Thus, the calculation of non-deductible VAT required the identification of those industries and final users that are exempted from VAT and to relate the various VAT rates to the products. This was based on the Value Added Tax Act as at 2001. The identification of industries exempt from VAT was based on the assumption that large businesses are allowed to deduct VAT from their purchases but are not exempt from charging VAT on their sales, whilst small businesses are not allowed to deduct VAT from their purchases but are exempt from charging VAT on their sales. Thus, when a portion of revenue from VAT was allocated to industry, this was charged to those industries with a significant market share of small businesses. Commodities exempt from VAT were easily identified by a zero entry in the VAT vector of the supply table. Taxes charged on non exempt/non zero rated commodities were identified as per legislation.

Mainly the VAT has been allocated on the following rules: final consumption expenditure of households and tourists are fully taxed (unless the actual VAT collected from that product is lower than applicable rates); exports were not taxed at all, except in the case of financial services; intermediate uses were mostly exempt, but where applicable (that is, in cases when a residual results following the allocation of VAT to private household and tourism) tax has been allocated on a pro-rata basis; and some VAT was allocated to GFCF. In order to obtain the use table at basic prices, the use-side valuation matrix of VAT has to be deducted from the use table.

*(iii) Use side valuation matrix for taxes/subsidies on products*

Taxes/subsidies on products are taxes/subsidies that are payable per unit of some good or services produced. The tax/subsidy may be a specific amount of money per unit of quantity of a good or service, or it may be calculated ad valorem as a specific percentage of the price per unit or value of the goods and services. The attribution of each product tax/subsidies to the respective product items is given in the supply table. Mainly, the taxes included are licences of motor vehicles and motor vehicle registration tax, duty on documents and airport tax. Subsidies were given on products of agriculture, water distribution and supporting and auxiliary transport services.

Allocation across industries and final users of major taxes was attributed to the respective uses and allocated on a pro-rata basis between industries, private households and tourists. Other taxes were mainly allocated on a pro-rata basis between private households and tourists. Subsidies were allocated either on industry or consumers, or both. The use valuation matrix for taxes/subsidies on products was also deducted from the use table at purchasers' prices to obtain the use table at basic prices.

*(iv) Use-side valuation matrix for import levies and import duties*

Import levies and import duties are attributed to the respective products in the supply table. The use-side valuation matrix for import levies and import duties was constructed by allocating duties and levies on imports across industries and final users for the various products. These were in most cases allocated on a pro rata basis according to uses by private households and tourists. In exceptional cases duties and levies were allocated to particular industries. As with all other valuation matrices, the use valuation matrix of import levies and duties was deducted from the use table at purchaser's prices.

*(v) Use-side matrix for FISIM allocation*

The Financial Intermediation Services Indirectly Measured (FISIM) enter the use table as a single element. Because the aggregate matrix should have a symmetric dimension these services were allocated across industries along with other financial intermediation services. The allocation was based on ratios for the various industries and final users provided by the NSO.

After all use valuation matrices were deducted from the use table at purchasers' prices, the use table at basic prices was obtained. The database for the transformation of SIOT from SUT was thus complete.

SIOT are obviously square and can have either a product-by-product (PxP) or an industry by industry (IxI) dimension. The intermediate part of the former describes, for each product, the amounts of products that were used to produce this product, irrespective of the producing industry. An industry-by-industry table, on the other hand, describes inter-industry relations. Because the product-by-product SIOT is theoretically more homogenous, ESA 1995 requires Member States of the European Union to transmit product-by-product SIOT. However, because the issue being tackled concerns a major tax reform, an industry-by-industry SIOT has been preferred. The main advantage of this approach is that it preserves to a high degree the micro-macro link so that current national accounts data and detailed basic statistics can be used in combination with the SIOT.

However, it should be noted that the more secondary production is reported in the SUT, the larger the difference between product-by product tables and industry-by-industry tables, because the latter becomes more heterogeneous. For Malta a relatively low level of secondary production is reported in the supply table for 2001. The share of secondary product output in total output of industries stood at 5.7 percent, whilst the EU average, which is also relatively low, stood at 6.3 percent. Insofar, the difference between the product-by-product SIOT and the industry-by-industry SIOT would be relatively small. Thus both transformations can be regarded as valid options for impact analysis.

The industry-by-industry SIOT was derived by transferring inputs and outputs over the rows. The product classification of the rows was transformed into the industry classification of the columns. The transformation was done by assuming a fixed industry sales structure, whereby each industry has its own specific sales structure irrespective of its product mix. The more homogenous a product actually is the easier it will be to determine the allocation of its uses. The term 'sales structure' indicates the proportions of the output of a product in which it is sold to the respective intermediate and final users. This model is widely applied, notably in Denmark, Hungary, the Netherlands, Finland, Canada and Norway (Eurostat, 2008).

The transformation from SUT to SIOT was done by defining the various sections of the SUT as matrices and then making the necessary mathematical calculations by means of transformation models based on the fixed product sales structure assumption as shown in Box 3.3.

**Box 3.3 – From SUT to SIOT**

This box describes the mathematical relationships for the transformation of SUT into a SIOT. The methodology proposed here is based of the 'fixed product sales structure' assumption (see Eurostat, 2008)

| | |
|---|---|
| Transformation Matrix | $T = V(diag(q))^{-1}$ |
| Intermediates | $B = TU$ |
| Input Coefficients (intermediaries) | $A = TU(diag(g))^{-1}$ |
| Final Demand | $F = TY$ |
| Value Added | $W = W$ |
| Input Coefficients (value added) | $R = W(diag(g))^{-1}$ |
| Output | $g = (I - A)^{-1} y$ |

where $T$ is the transformation matrix, $V$ is the transpose of the supply matrix, $q$ is the column vector of the product output, $B$ is the matrix of intermediates in the industry by industry SIOT, $U$ is the use matrix of intermediates, $A$ are input coefficients, $g$ is the column vector of industry output, $F$ is the final demand matrix in the industry-by-industry SIOT, $Y$ is final demand matrix in the use table, $W$ is the value added matrix, $I$ is an identity matrix and $y$ is the vector of final demand

The industry-by-industry SIOT was derived from the supply and use system by pre-multiplying the use matrix and the final use matrix with the transformation matrix reflecting the fixed product sales structure. The transformation matrix reflects the inverse of the product-mix of an industry. An advantage of the fixed product sales structure assumption is that it does not generate any negative entries in the input-output table, unlike other assumptions. Once completed, it was the major source of information for the compilation of the Malta SAM.

### 3.3.3 Deriving the Unbalanced SAM

The Malta SAM includes all the accounts specified in Section 3.1. Since the ultimate aim is general equilibrium tax policy analysis, the SAM incorporates substantially more detail on taxes. Using data available in SUT and SIOT for 2001, the data were allocated to the various blocks of Table 3.1.

**Table 3.1 - A Basic Social Accounting Matrix (SAM)**

| | | 1 | 2 | 3 | | 4 | 5 | 6 | | | | | 7 | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Commodities | Industries | Capital | Labour | Household | Government | Taxes on commodities | Taxes on labour | Taxes on capital | Taxes on imports | Taxes on income | Investment | Rest of the world | Total |
| 1 | Commodities | | A | | | B | C | | | | | | D | | |
| 2 | Industries | E | | | | | | | | | | | | F | |
| 3 | Capital | | G | | | | H | | | | | | | | |
| | Labour | | I | | | | J | | | | | | | | |
| 4 | Household | | | K | | | L | | | | | | | | |
| 5 | Government | | | | | | | | | M | | | | | |
| 6 | Taxes on commodities | N | | | | | | | | | | | | | |
| | Taxes on labour | | O | | | | | | | | | | | | |
| | Taxes on capital | | P | | | | | | | | | | | | |
| | Taxes on imports | Q | | | | | | | | | | | | | |
| | Taxes on income | | | | | R | | | | | | | | | |
| 7 | Savings | | | | | S | | | | | | | | | |
| 8 | Rest of the world | T | | | | | | | | | | | | | |
| | Total | | | | | | | | | | | | | | |

Data for blocks *A, B, C* and *D* of the SAM were obtained from the intermediate matrix and the final demand vectors of the SIOT, respectively. Supply data (block *E*) was obtained by subtracting the value of indirect taxes (taxes on products, including VAT, specific taxes on products net of subsidies, import duties and import levies) and imports from the value of gross output. Data for exports (block *F*) was reconciled from the export demand vector of the Malta SIOT

Blocks *G, H, I* and *J* represent data on labour and capital used by the various industries and by the government, data for which was obtained from the value added matrix of the Malta SIOT. Labour data relates to compensation of employees reduced by the amount of tax on labour, whilst data for capital consists of consumption of fixed capital as well as operating surplus. Since each industry's operating surplus is net of income tax charges on companies, the entire value of operating surplus was included. Government use of labour and capital stems from the inclusion of public administration in the government account.

Households' income from factors of production was assumed to equal the sum of total payments for the factors of production by industries and government. Thus data for block *K* was equal to the sum of *G, H, I* and *J*. Data for other household income in the form of transfers from government was obtained from Government Finance data published by the Malta NSO.

Government's income is represented by block *M* and is the sum of tax revenues from commodities, labour, capital, imports and income. The blocks relating to the various tax accounts are five. Data for taxes on commodities as represented by block *N* was obtained from the use table. It is an aggregation of VAT and taxes on products net of subsidies. Data for block *O* (showing taxes on labour) was obtained from the Government Finance publication and includes social security contributions paid by the employer and the employee. In light of the government's passive role in the circular flow of income, social security contributions paid by the government have not been included. Data for tax on capital as given by block *P*, was partly obtained from the value added matrix of the SIOT in the form of other taxes/subsidies on products, and partly from the Government Finance publication in the form of income tax paid by companies and corporations. Since no sectoral breakdown was available for labour and capital taxes, these were assumed to be proportional to labour and capital use respectively. Data for block *Q* was obtained from the vectors of import duties and import levies in the supply table. Data for block *R* was also obtained from the Government Finance publication and relates to income tax paid by individuals.

Data for block *S* was assumed to equal the summation of block *D* as savings are assumed to equal investment, with both government and foreign savings amounting to zero. After the compilation of the unbalanced SAM was completed, the remaining inconsistencies in the dataset required major data blocks to be readjusted so as to satisfy the equilibrium conditions.

## 3.4 BALANCING THE SAM

Since the principle of a SAM is nothing more than that of double-entry bookkeeping in accounting, what is incoming into one account must be outgoing from another account. However, because the data used to compile the SAM for Malta was obtained from diverse sources, the column totals and the row totals did not necessarily match. This study uses the cross-entropy approach, first applied to SAM balancing by Robinson (Robinson and El Said, 2000) to balance the Malta SAM.

Whilst it is a natural desire to make the model as detailed as possible in the belief that it will increase its realism, much of it may prove superfluous to the issue at hand. In particular, one would want to manipulate the data with relative ease. Therefore, the sixty-by-sixty (60x60) intermediate part of the original industry-by-industry SIOT developed for purposes of this study was aggregated to a nine-by-nine industry-by-industry SIOT, such that the entire matrix dimension was thirty-by-thirty.

It was assumed that the initial macro and square SAM $M_0$ was made of several elements $a_{ij}$ with $i=1...30$ (rows) and $j=1...30$ (columns). Each element $a_{0ij}$ consists of a transfer from an account $j$ of uses (column) to a resource (row) account $i$. The final balanced SAM $M_1$ is regarded as a matrix estimated by the method of entropy. It is also made of several elements with $a_{1ij}$ where $i=1...30$ (rows) and $j=1...30$ (columns). The balance between the totals in rows and columns is represented mathematically by equation (3.2) below.

The Entropy method applied to the unbalanced SAM consisted of minimising the objective function of the entropy between $M_0$ and $M_1$ subject to the constraint of the equation of the equality principle. This is represented mathematically by:

Minimise $$z = \sum_{i=1}^{45}\sum_{j=1}^{45} a^0{}_{ij}\left(\log\left(\frac{a^1{}_{ij}}{a^0{}_{ij}}\right) - 1\right) \quad (3.1)$$

Subject to: $$\sum_{i=1}^{45} a^1{}_{ij} = \sum_{j=1}^{45} a^1{}_{ij} \quad (3.2)$$

The optimisation problem was solved using the mathematical software GAMS which stands for 'Generalised Algebraic Modelling System'. To give a clear overview of the aggregate transactions governing the circular flow in the Maltese economy, the results are presented in Table 3.2 in the form of a macro SAM. The disaggregated SAM for the Maltese economy used as a database for the Malta GETM is shown in Table A.1.1 in Appendix 1.

**Table 3.2 - Balanced Macro SAM** *Lm millions*

| | Commodities | Industries | Capital | Labour | Household | Government | Taxes on commodities | Taxes on labour | Taxes on capital | Taxes on imports | Taxes on income | Investment | Rest of the world | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Commodities** | | 1344.0 | | | 1107.6 | 267.6 | | | | | | 315.0 | | 3034.1 |
| **Industries** | 1732.5 | | | | | | | | | | | | 1138.9 | 2871.4 |
| **Capital** | | 715.7 | | | | 15.8 | | | | | | | | 731.5 |
| **Labour** | | 569.0 | | | | 80.6 | | | | | | | | 649.6 |
| **Household** | | | 731.5 | 649.6 | | 134.5 | | | | | | | | 1515.7 |
| **Government** | | | | | | | 121.1 | 119.0 | 123.7 | 41.6 | 93.1 | | | 498.5 |
| **Taxes on commodities** | 121.1 | | | | | | | | | | | | | 121.1 |
| **Taxes on labour** | | 119.0 | | | | | | | | | | | | 119.0 |
| **Taxes on capital** | | 123.7 | | | | | | | | | | | | 123.7 |
| **Taxes on imports** | 41.6 | | | | | | | | | | | | | 41.6 |
| **Taxes on income** | | | | | 93.1 | | | | | | | | | 93.1 |
| **Savings** | | | | | 315.0 | | | | | | | | | 315.0 |
| **Rest of the world** | 1138.9 | | | | | | | | | | | | | 1138.9 |
| **Total** | 3034.1 | 2871.4 | 731.5 | 649.5 | 1515.7 | 498.5 | 121.1 | 119.0 | 123.7 | 41.6 | 93.1 | 315.0 | 1138.9 | |

*Source: Author's calculations*

# Chapter Four

# THE STRUCTURE OF THE MALTESE ECONOMY AND ITS TAX POLICY

The scope of this chapter is to provide a static overview of the structure of the Maltese economy and its tax policy as presented in the Malta SAM (see Table A.1.1 in Appendix 1). Since the benchmark data has been obtained with respect to the year 2001, the analysis relates to this specific year in view of its role in the calibration of the Malta GETM. It should also be noted that the data presented in this chapter are the author's own calculations and should be interpreted with care. Since the dataset has been balanced using the cross-entropy method (see Chapter 3), calculations based on the Malta SAM might differ from calculations based purely on national accounts data.

A detailed overview of relative shares in expenditure as well as the intensity with which the various factors are used is important for the tax policy analysis conducted at a later stage of the study and reported in Chapter Seven. Hence, Section 4.1 presents a detailed overview of income and expenditure of the different institutions in the Malta SAM. At the same time, the direct impact of changes in taxation has to be evaluated in terms of Implicit Tax Rates (ITR) for the various tax bases. Thus, the subsequent section gives an overview of the tax policy governing the Maltese economy during the benchmark year and provides insight with respect to developments in the local tax structure since 2001. Comparisons with the EU average were based on Eurostat data.

Numerical references to sectors and commodities in this and subsequent chapters are defined according to Table A.1.1 in Appendix 1.

## 4.1 THE STRUCTURE OF THE MALTESE ECONOMY

Following a deep recession during the eighties that was provoked by falling international demand and inward-looking economic policies, during the nineties the

Maltese economy experienced strong economic growth with real Gross Domestic Product (GDP) changes ranging between 4 percent and 6 percent. This was the result of heavy government expenditure, investment and export activity. However, the impact of the general economic slowdown in world economic growth after the year 2000 and the impact of the September 11th attacks on the tourism industry contributed to a marginal contraction in real GDP in 2001. The slowdown was mostly reflected in terms of exports of goods and services, largely due to a significant slowdown in demand for electronic components produced by one of Malta's largest employers. Thus, any analysis of data presented in the benchmark SAM must be framed within this context.

A detailed description of the data relating to the accounts of the various institutions is given in Box 4.1. Using this data, Malta's GDP amounted to around Lm1.6 billion, with a per capita GDP estimated at around 55 percent of the EU-15 average.

**Box 4.1 – Accounts constituting the Malta SAM**

This box describes the accounts of the various institutions included in the Malta SAM. Thus data relates to Table 3.2 in Chapter Three.

*The Commodities Accounts (1st row, 1st column)*

The first row corresponds to the resources of the products account which is composed of intermediate consumption paid from the industries account (Lm1.3 billion), household consumption paid from the household account (Lm1.1 billion), government consumption paid from the government account (Lm0.3 billion) and investment demand paid from the investment savings account (Lm0.3 billion). The first column corresponds to the uses of the account of the commodities and is composed of payments to the accounts of the industries (Lm1.7 billion), imports paid from the rest of the world account (Lm1.3 billion) and the government account in the form of taxes on commodities and imports (Lm0.2 billion)

*The Industries Institution Account (2nd row, 2nd column)*

The second column describes the uses of the industries account whose total corresponds to the total cost of production. In other words, this account translates the behaviour of the producers in the Maltese economy. They carry out payments for intermediate consumption to the commodities account (Lm1.3 billion), factors of production (Lm1.3 billion) and payments to the government account in the form of taxes on labour and capital (Lm0.2 billion). The second row, describes the resources of the industries account which corresponds to total domestic production. These resources amount to the value of products sold on the domestic (Lm1.7 billion) and foreign market (Lm1.1 billion).

*The Factors of Production Account (3rd row, 3rd column)*

The third column corresponds to payments made to households with labour and capital endowments (Lm1.4 billion), whereas the third row represents payments to factors of production from the various industries (Lm1.3 billion) as well as government (Lm1.0 billion).

*The Household Institution Account (4th row, 4th column)*

The fourth row shows income received by households in the form of total sectoral wages of the work poured by the labour account (Lm0.7 billion), of capital yield poured by the capital account (Lm0.7 billion) and of transfers from the government (Lm0.1 billion). The fourth column shows the household's income broken down by expenditure on goods and services (Lm1.1 billion), direct taxes paid on income paid to the government account (Lm0.9 billion) and savings (Lm0.3 billion).

*The Government Institution Account (5th row, 5th column)*

A shown in row five, the financial resources of the government consist of revenues from the various taxes in the Maltese economy (Lm0.5 billion). These are then utilised for purchases of goods and services (Lm0.3 billion), payments for the factors of production (Lm1.0 billion) and transfer to households (Lm0.1 billion).

*The Taxes Accounts (6th row, 6th column)*

The taxes accounts simply show the collection of taxes either from the commodities account in the form of taxes on commodities (Lm0.1 billion) and taxes on imports (Lm0.04 billion), or from taxes on industries corresponding to taxes on labour (Lm0.1 billion) and capital (Lm0.1 billion). Other taxes include taxes on income (Lm0.09 billion). The column relating to the taxes account shows that total tax revenue collected, which in turn constitutes the government's entire income (Lm0.5 billion).

*The Saving Investment Account (7th row, 7th column)*

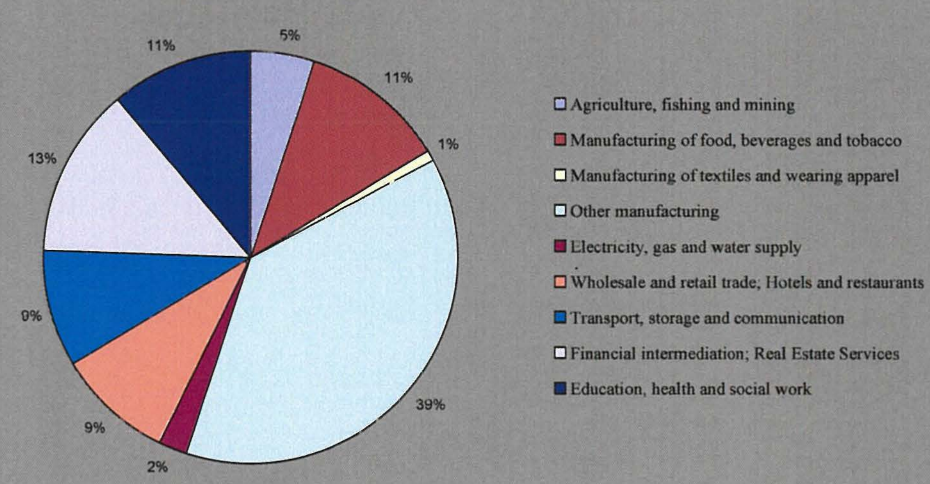
The row representing the savings account contains savings of the household institution (Lm0.3 billion). The seventh column represents the uses of this account which consist of investment demand for the various commodities (Lm0.3 billion).

*The Rest of the World Institution Account (8th row, 8th column)*

The resources of the rest of the world account are represented by row eight and are solely composed of imports paid by the commodities account (Lm1.1 billion). The uses of the rest of the world are shown in column eight, consisting of payments related to exports by the various industries (Lm1.1 billion).

The supply side of Malta's economy was fairly diversified, with a sound manufacturing base and services sectors which were expanding rapidly albeit accounting for only small shares of GDP (see Figure 4.1). Primary activity, consisted of 'agriculture, fishing and quarrying', contributed less than 10 percent of GDP. The manufacturing sector accounted for around half of GDP, with 'manufacturing of food, beverages and tobacco' contributing around 15 percent, 'manufacturing of textiles and wearing apparel' contributing 5 percent and 'other manufacturing' sectors contributing around 30 percent. In the services sector, 'wholesale and retail trade (including hotels and restaurants)' contributed around 7 percent of GDP while the 'transport and communications' sector and the 'financial services (including real estate services)' each contributed around 6 percent. Meanwhile, the share of 'education, health and social work' in GDP stood at around 18 percent.

**Figure 4.1 - Supply of commodities**




From a demand-side perspective, household consumption expenditure constituted over 60 percent of GDP, with manufacturing of 'food, beverages and tobacco' products accounting for 23 percent of total consumption expenditure. Other significant shares were accounted for by 'other manufacturing' commodities (19 percent) and 'financial intermediation (including real estate services)' (11 percent). The remaining commodities accounted for approximately a share of 9 percent each with the exception of 'electricity, gas and water supply' (1 percent). The government's dominant role in the Maltese economy was attested by the share of its expenditure in GDP which stood at a hefty 17 percent. Almost 75 percent of this was accounted for by expenditure on commodities of 'education, health and social work'.

Meanwhile private investment accounted for only 19 percent, most of it directed towards 'other manufacturing' products.

It is evident that insularity and a general lack of natural resources have made the Maltese economy highly dependent on transactions with foreign economies to earn income and meet the demand for goods and services. Indeed, exports and imports each amounted to around 70 percent of GDP. The larger part of Malta's intermediate consumption, household consumption and investment are imported, with the higher marginal propensities belonging to the 'other manufacturing' sector. Meanwhile, 50 percent of total exports were also accounted for by the 'other manufacturing' sector, mostly driven by exports of electronic components.

In spite of the poor growth performance registered throughout the year, the unemployment rate stood as low as 5.1 percent. Overall, Malta registered an acceptable rate of employment, with the larger shares being accounted for by the 'education, health and social work' sector (27 percent), the 'other manufacturing' sector (23 percent) and the 'wholesale and retail trade (including hotels and restaurants)' sector (16 percent). The sectors with the highest capital-labour ratio were 'agriculture, fishing and mining' (3.4 percent) and 'financial intermediation (including real estate services)' (2.5 percent). Meanwhile, the 'education, health and social work sector' and the 'manufacturing of textiles and wearing apparel' sector had the lowest capital-labour ratio standing at 0.5 and 0.8 respectively.

The overall tax burden in 2001 stood at 30.7 percent of GDP, substantially lower than the EU-25 average. The Maltese economy has since experienced major tax reform such that Malta's overall tax burden has now converged to that of the EU Since the Malta GETM is intended to address specific issues relating to tax policy, a detailed analysis of tax data is presented separately in the next section.

## 4.2 AN OVERVIEW OF MALTA'S TAX POLICY (2001)

Like most tax systems in the world, the Maltese government relies on revenues from direct taxes on income (including social security contributions) and indirect taxes on consumption. The latter accounted for around 32.6 percent of total taxation whilst direct taxes accounted for 67.4 percent. Studies have shown that Malta tends to rely more heavily on indirect taxation than the rest of the EU. However, it should be pointed out that as the Maltese are on the whole, relatively lightly taxed, indirect taxes absorbed a proportion of GDP comparable to the EU average (European Commission, 2005). On the other hand, direct taxes absorbed a proportion of GDP much lower than the EU average, mainly reflecting the lower proportion of social security contributions.

More specifically, the Maltese government collects revenue from personal income tax, corporate income tax, value-added tax, import duties, import levies and social security contributions. The main features of each of these taxes are discussed in Box 4.2. The multiplicity of tax instruments results from a set of multiple objectives of the tax system. Though the most important objective of any tax instrument is to raise revenue for the government while affecting the optimal choices of households and industries as little as possible, each tax is often designed to meet specific objectives. Household income taxes aim to raise revenue while correcting income distribution as taxes from high income households finance transfers to low income households. Similarly, some excise duties have the additional objective of reducing consumption of "harmful" commodities as well as consumption spending of households. More recently attention has been shifted towards the stimulation of personal initiative and economic growth.

**Box 4.2 – Features of Malta's tax system**

This Box gives a brief overview of the features governing Malta's tax system in 2001. It includes a short description of when and how personal income tax, corporate income tax, VAT, excise duties and social security contributions apply

*Personal income tax*

Personal income tax was levied on every individual's worldwide income from business, profession, employment, interest, pensions, annuities, rents, royalties, capital gains and dividends. It was levied at progressive rates applied by means of brackets with rates ranging from 15 percent to 35 percent. A basic personal relief of Lm3,100 was allowed for every individual.

*Corporate income tax*

With a rate of 35 percent, Malta exhibited a high corporate tax rate relative to EU countries. Corporate capital gains were also taxed at a 35 percent rate. Tax incentives in the form of reduced income tax rates, accelerated depreciation, relief from stamp duty and investment tax credits were available for enterprises involved in shipping, targeted industrial sectors and Freeport activities.

*VAT and Excise*

The standard VAT rate was 15 percent with reduced rates of 5 percent and 0 percent. VAT was introduced in 1995, replaced with sales tax following a government change, following which revenues dropped by more than 1 percent of GDP. A further change in government, led to its reintroduction in 1999. Since then repeated modifications have attempted to widen the base and reduce the list of exempt goods. Excise duties were moderate on fuels and light alcoholic beverages, but relatively high on strong liquors and tobacco. Both VAT and excise duties take in a proportion of GDP comparable with the EU average, but other indirect taxes are well in excess. This was due to high levels of import duties, stamp duty and car registration tax. By contrast taxes on energy and pollution were quite low.

*Social security contributions*

Malta has a social security system under which the employee, the employer and the government each contribute 10 percent of an employee's basic salary. The self employed contribute at a rate of 15 percent, which is matched by the government, with contributions capped at a maximum of Lm6,750.

In order to improve the understanding of the tax burden and to facilitate the application of the Malta GETM, taxes have been classified in terms of five major resource bases on which they are levied, that is, consumption, labour, capital, income and imports as presented in the Malta SAM. This classification has inevitably led to certain simplifications and hybrid categories. A number of borderline cases and approximations had to be taken into account to arrive at the final classification of taxes. Two key problems to the reclassification process were the insufficient detail to identify individual taxes to allocate them to the corresponding categories and the relation to multiple tax bases of some taxes.

*Taxes on consumption* are defined as taxes levied on transactions between final consumers and producers on the final consumption of goods. They therefore include VAT and taxes on products (including excise duties), such that they accounted for around 24 percent of total tax revenue (see Figure 4.2).

*Taxes on labour*, which compromise another 24 percent of total tax revenue, are taxes directly linked to wages (mostly withheld at source) paid by the employers and the employees. Thus, these were assumed to be made up of social security contributions paid by both the employer and the employee. However, personal income tax paid by the employee upon receipt of his salary was not included with taxes on labour.

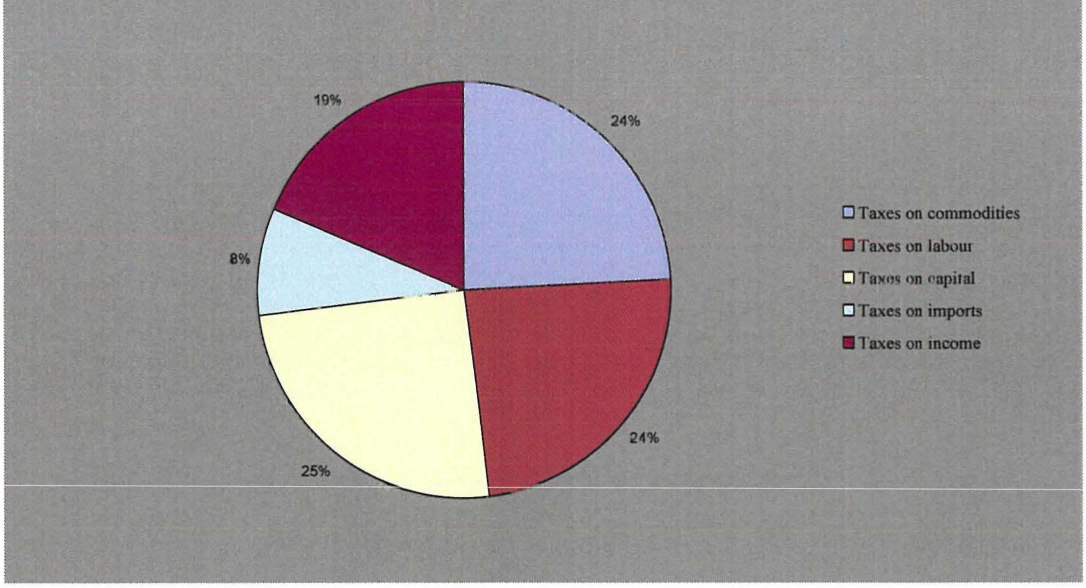
*Capital taxes* include taxes on business income in a broad sense, that is, not only taxes on profit but also taxes and levies that could be regarded as a prerequisite for earning profit. It was thus assumed that they include corporate income tax as well as other taxes on production, such that they accounted for another quarter of total tax revenue.

*Taxes on imports* were treated separately from taxes on consumption so as to enable a distinction between marginal tax rates paid on domestic consumption and marginal tax rates paid on foreign consumption. They were assumed to include import duties and import levies, thereby accounting for around 8 percent of total tax revenue.

While *income tax* is usually assumed to include the income of both individual and businesses, the Malta SAM distinguishes between the two types of revenue bases Taxes on businesses' income were included with the taxes on capital. Taxes on income are thus composed of any personal income tax paid by individuals (that is, excluding income tax paid by companies and corporations) and accounted for approximately 19 percent of total tax revenue.

The distinction between taxable bases had as its major objective the calculation of ITR on consumption, labour, capital, income and imports, such that these are used in both the calibration of the Malta GETM and to act as benchmark (initial) effective tax rates for the tax policy simulations. They were computed as the ratio of total tax revenues of their respective category to a proxy of the potential tax base defined by the production and income accounts in the Malta SAM.

**Figure 4.2 - Shares in Total Tax Revenue**




In other words, ITR measure the actual or effective average tax burden directly or indirectly levied on different types of economic income or activity that could potentially be taxed. However, it should be noted that the final economic incidence of the burden of taxation can often be shifted from one tax-payer to another through the interplay of demand and supply. For example, when firms increase sales prices in response to a hike in corporate income tax, to a certain extent, firms' customers end up bearing part of the increased tax burden. The ITR cannot take these effects into account. These behavioural effects can only be captured in a general equilibrium framework, which is after all the scope of the construction of the Malta GETM.

Revenues from taxes levied on consumption, labour and capital each accounted for more than 7 percent of GDP. However, the ITR for consumption was significantly lower (12.3 percent) than the ITR on labour and capital (18.3 percent and 19.9 percent respectively). The rate remains very low by EU standards, a function in part of the high ratio of consumption to GDP. The ITR on labour was amongst the lowest in the EU, driven by low rates of social security contributions reflecting the fact that the Maltese tax system has its origin in the former British system. On the other hand, the ITR on capital was quite high relative to the EU average. Taxes on income have an ITR of 6.1 percent, marginally lower than the EU average, whilst the ITR on imports was significantly high at 3.7 percent.

**Table 4.1 - Taxes classified by Resource Base**

| | % of GDP | ITR (%) |
|---|---|---|
| Taxes on commodities | 7.5 | 12.3 |
| Taxes on labour | 7.3 | 18.3 |
| Taxes on capital | 7.6 | 16.9 |
| Taxes on imports | 2.6 | 3.7 |
| Taxes on income | 5.7 | 6.1 |

*Source: Author's calculations*

It was noted that ITR fell more heavily on certain sectors. For example, the ITR on consumption was highest on products produced in the manufacturing food, beverages and tobacco, the manufacturing of textiles and wearing apparel and other manufacturing sectors but non-existent for commodities produced in the agriculture, fishing and mining, electricity, gas and water supply, wholesale and retail trade and transport storage and communication sectors (see A.1.1 in Appendix 1). Similarly, the ITR on imported commodities were higher for products from manufacturing food, beverages and tobacco, manufacturing of textiles and wearing apparel and other manufacturing sectors. These have different implications for the behavioural responses observed when conducting tax policy simulations.

The Maltese government has since the year of the benchmark SAM – recognised that much could be gained from tax reform that improves the structure of the tax system. In light of Malta's standing vis-à-vis the rest of the EU, throughout the last decade, the government has embarked upon a tax reform programme to shift taxation from income to consumption with a number of measures implemented within a couple of years (see Table 4.2). Since at the time Malta was a prospective EU member, the Maltese government also to eliminate all the existing import levies by 2004 (the year Malta joined the EU).

**Table 4.2 - Major tax changes in the Maltese taxation system since 2001**

| *Year* | *Tax Instrument* | *Measure* | *% of GDP* |
|---|---|---|---|
| 2002 | Taxes on income | Revision of personal income tax rates | -0.11 |
| | Taxes on imports | Phasing out of import levies | 0.21 |
| | Taxes on commodities | Revision of excise duty paid on tobacco | 0.10 |
| 2003 | Taxes on income | Revision of personal income tax rates | -0.42 |
| | Taxes on imports | Phasing-out of import levies | -0.19 |
| 2004 | Taxes on commodities | Revision of excise duty paid on tobacco | 0.19 |
| | Taxes on commodities | Removal of VAT on EU imports | -0.78 |
| | Taxes on commodities | Withdrawal of levies | -0.18 |
| | Taxes on commodities | Revision of VAT rate from 15 percent to 18 percent | 1.09 |
| 2005 | Taxes on commodities | Revision of excise duty on kerosene | 0.10 |
| 2006 | Taxes on commodities | Revision of excise duty on petrol and electricity | 0.12 |
| 2007 | Taxes on income | Revision of personal income tax brackets | 0.52 |
| | Taxes on commodities | Realignment on excise duty on petroleum products | 0.52 |

*Source: Authors' calculations*

Table 4.2 shows the estimated increase or decrease in government revenue assuming no behavioural response by the payer. Basing calculations on this assumption, reductions on personal income tax since 2001 would have amounted to more than 1 percent of GDP, while increases in consumption tax have exceeded the 1 percent mark. The government has reduced taxes on income on three occasions and has promised further personal income tax reductions in the near future (see Budget Speech 2008). Meanwhile, changes in taxes on commodities were bi-directional. Reductions were forced by Malta's entry into the EU (such as the removal of levies and VAT on imports), whilst increases reflected the shift from tax on income (and indirectly on labour) to tax on commodities. Assuming no behavioural response, the removal of import levies between 2001 and 2004 should have amounted to a loss in tax revenue of approximately 0.4 percent of GDP. Simulations of tax policy conducted for purposes of this study and discussed in Chapter Seven build upon this background.

# Chapter Five

# A GENERAL EQUILIBRIUM TAX MODEL FOR THE MALTESE ECONOMY

The modelling platform of the Maltese economy is represented by a static computable general equilibrium model based on a SAM for the year 2001 (developed in Chapter Three). It is a representation of the circular flow which exists between industry, institutions and markets in the Maltese economy and has been modelled in this chapter as a system of equations governing these relationships. In its mathematical form, the Malta GETM is a system of simultaneous, non-linear equations. However, when we consider general equilibrium of an economy, the derivation of demand equations alone is not sufficient to guarantee the clearing of all markets. Thus, this chapter also specifies the market clearing conditions for the Malta GETM.

The chapter proceeds by giving a mathematical representation of the GETM for the Maltese economy in Section 5.1 and specifies the general equilibrium conditions in Section 5.2.

## 5.1 THE SPECIFICATION OF THE MALTA GETM

In the GETM of the Maltese economy there are markets for each of the $n$ commodities and consistent optimisation occurs as part of equilibrium. Consumers maximise utility subject to their budget constraint, leading to the demand side specification of the model. Producers maximise profits (or minimise costs) leading to the production side specification of the model. In equilibrium, market prices are such that the required equilibrium conditions hold. Demand equals supply for all commodities, and in the constant return to scale case zero profit conditions are satisfied for each industry.

**Table 5.1 Institutions and markets in the Malta GETM**

| Institutions | Markets |
|---|---|
| Household | Commodity 'i' |
| Firm 'i' | Labour |
| Government | Capital |
| Investment | |
| Rest of the World | |

Like in traditional general equilibrium tax models consumers have initial endowments and demand functions can be derived from the optimising behaviour of all institutions (see Table 5.1).

The other markets relate to capital and labour. Both are assumed to be mobile across sectors, such that in equilibrium each factor receives the same net of tax wage across sectors. Factor services will flow to a sector with higher marginal revenue product from one with a lower marginal revenue product until the net of tax wage is equal across sectors. Demand and supply of goods and factors readjust until all excess demands and excess supplies are eliminated through changes in prices. The forces of perfectly competitive markets guide the allocation of resources in the economy. It is assumed, however, that the economy is distorted by taxes and transfers. The former appear in the model in ad valorem form, that is, they are proportional to their tax bases. All markets are assumed to clear, except for the labour market because of the presence of unemployment in the model.

Government and investors are other agents in the model. The government has been modelled as an agent that optimises its own utility function under a balanced budget. This means that the government is treated as a separate consuming agent. Its income is entirely made up of tax revenues, and spends it either on public consumption or makes transfers to households. Investors use aggregate saving from households to purchase investment goods.

The model operates under the 'small open economy' assumption, whereby the demand for domestically produced commodities is allocated over the domestic market and exports. The domestically produced commodities delivered to the domestic market and imports are combined into a composite commodity acting as a source of supply. The balance of payments is assumed to be in equilibrium.

An important feature relating to the specification of the various agents in the model relates to the choice of functional forms. Bhattarai and Whalley (1998) claim that the major constraint on the choice of demand and production functions is that they be consistent with the theory and are analytically tractable. Thus, functional forms in the Malta GETM have been selected on the basis of which form best allows the key parameter values to be incorporated in the model while retaining tractability. These are the Cobb-Douglas, the CES, the LES and the Leontief functions. In general, a theoretically consistent demand system permits imposition of the general restrictions of classical demand theory, namely, that the value of total demands equals total expenditure, that demands are homogeneous of degree zero in total expenditure and prices, that cross-price derivatives of the Hicksian demands are symmetric, and that direct substitution effects are negative for the Hicksian demands.

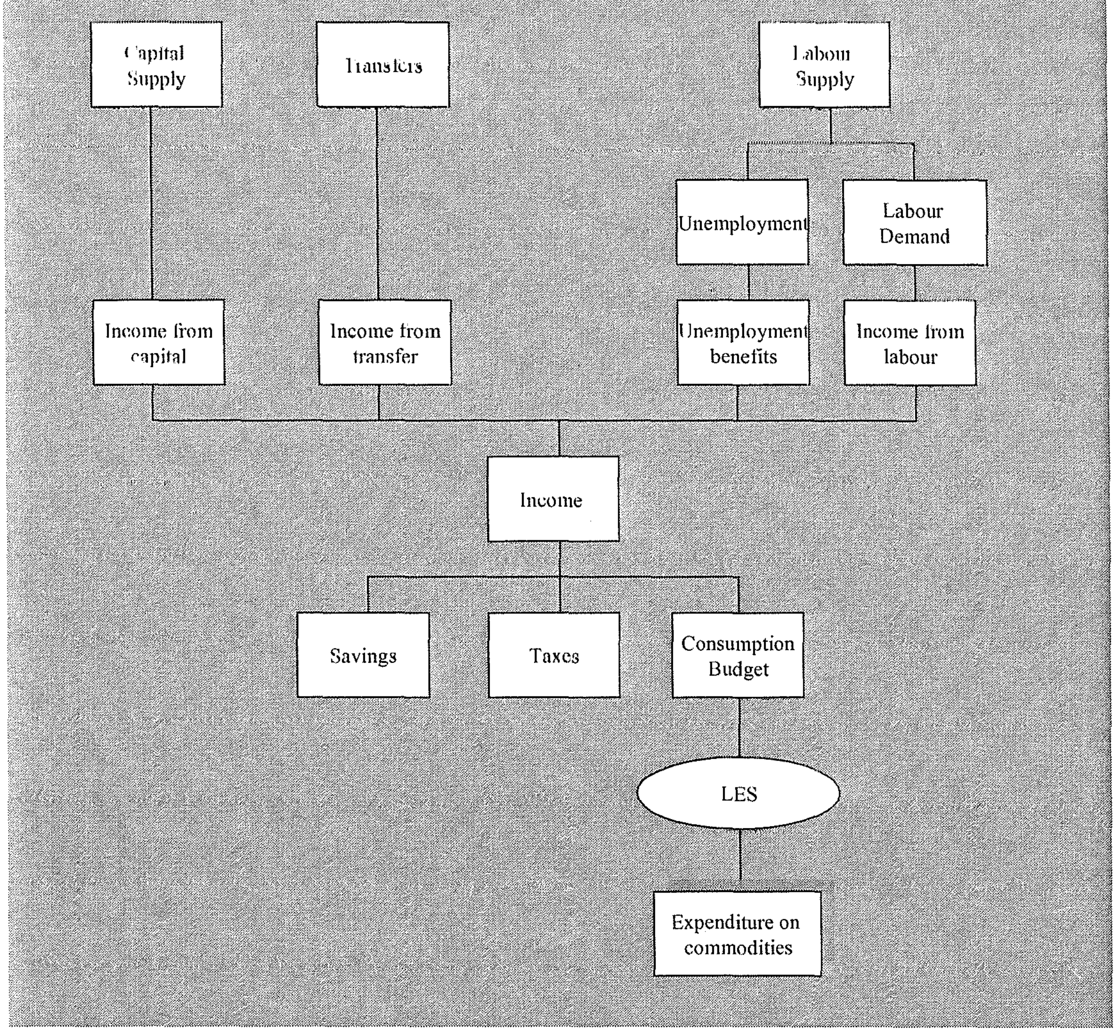
### 5.1.1 The Household Institution

The model assumes that the economy consists of a representative household, receiving a share of capital income, labour income, unemployment benefits and other transfers from government. Taxable income is derived by taking into account the share of income that is subject to personal income tax. Households pay the income tax to the government and save a fixed fraction of net income as given by equation (5.1). The remaining income is used by the household to maximise utility by consuming goods and services. The various income and expenditure flows together with the behavioural functional equations of the household are shown in Figure 5.1.

$$S_H = mps(1 - ty)Y \qquad (5.1)$$

where $S_H$ are household savings, *mps* is the marginal propensity to save, *ty* is the income tax rate and *Y* is the household's total income.

**Figure 5.1 – The Households Decision Structure**




Consumer utility has been incorporated in the Malta GETM by a simple generalisation of the Cobb-Douglas function in the form of a LES. The choice of the LES is, in part, due to convention and because it allows representation of subsistence (that is, minimal) consumption. However, the LES function is also more flexible with respect to the values of elasticities when compared to the Cobb-Douglas function. Whilst Cobb-Douglas utility functions are easy to work with, they have the restrictions of unitary income and uncompensated own-price elasticities, and zero uncompensated cross-price elasticities. Empirical literature shows that these assumptions are not always very realistic.

The optimal allocation between the consumption of commodities is thus given by optimising the Stone-Geary utility function in the context of a LES, which represents a set of consumer demand equations linear in total expenditure (Geary, 1950; Stone, 1954):

$$\text{Max} \quad U_H = \prod_{i=1}^{n} (C_i - \mu H_i)^{\alpha_{H_i}} \tag{5.2}$$

$$\text{Subject to} \quad \text{i. } CB = \sum_{i=1}^{n} (1 + tc_i) P_{C_i} C_i \tag{5.3}$$

$$\text{ii. } C_i > \mu H_i > 0, \; \alpha_{H_i} > 0 \tag{5.4}$$

where $U_H$ is the utility level of the household, $C_i$ is the demand of consumer commodity $i$ by the household, $\mu H_i$ is the subsistence level, $\alpha_{Hi}$ is the marginal budget share of the household's LES utility function (where $\sum \alpha_{Hi} = 1$), CB is the consumption budget, $tc_i$ is the tax rate on consumer commodities and $P_{Ci}$ is the price of commodities.

Writing the constrained optimisation problem in the form of a Lagrange function and differentiating with respect to its arguments yields the first order conditions with respect to the various commodities[4]. This makes it easy to derive demand functions shown by equation (5.5) for the various commodities included in the model.

$$C_i = \mu H_i + \alpha_{H_i} \left( (1 + tc_i) P_i \right)^{-1} \left( CB - \sum_{j=1}^{n} (1 + tc_j) P_j \mu H_j \right) \tag{5.5}$$

showing that expenditure on commodity $i$ consists of two parts: $\mu H_i$ is the minimum expenditure on commodity $i$ to which the consumer commits himself in order to obtain a minimum subsistence level, so that $\mu H_i$ can be interpreted as the minimum required quantity which the consumer purchases first. Then, there is also a minimum expenditure on the remaining commodities $\sum \mu Hi$, so that $(CB - \sum (1 + tc_j) P_j \mu H_j)$ is the income that remains after the consumer has purchased the minimum required quantities of all commodities. This income is called the "supernumerary income" and

[4]A mathematical representation of the derivation of the demand for commodities is given in Section A.2.1 in Appendix 2.

is allocated across the various commodities according to fixed fractions as given by the marginal budgetary shares ($\alpha_{Hi}$).

### 5.1.2 The Industries Institution

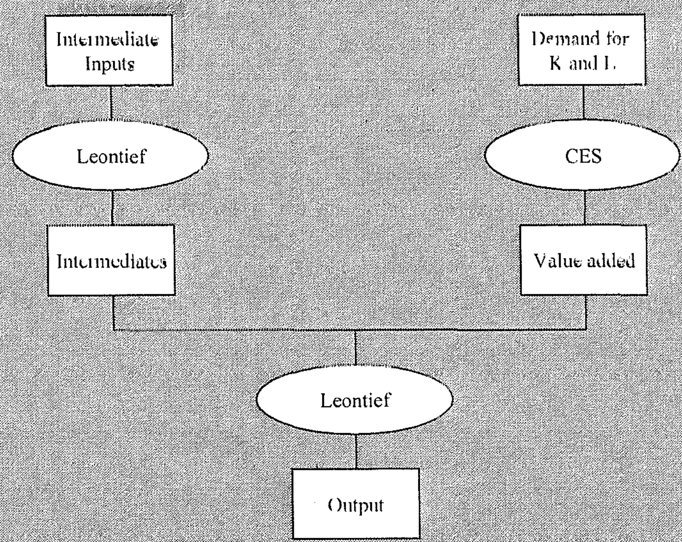
The model distinguishes nine perfectly competitive production sectors consisting of both private and public enterprises. For domestically produced output, each industry must use inputs of factor services and intermediate goods. What distinguishes the Malta GETM production structure from a simple input-output model, is that value added factor usage is responsive to factor costs and intermediate goods are price responsive. In order to allow different treatment for intermediate consumption and factor cost, gross output for each sector is assumed to be determined from a nested structure as shown by Figure 5.2. At the first level, output for each sector is represented by a Leontief input-output production function that represents the non-substitutability between intermediate goods and value added.

$$XD_i = f(VA_i, IO_i) \tag{5.6}$$

where $VA_i = g_{ii}(K_i, L_i)$ and $IO_i = g_{ji}\left(\sum_{j=1}^{n} XD_{ji}\right)$

where $XD_i$ is gross sectoral output of commodity $i$, $VA_i$ is value added, $IO_i$ is the intermediate consumption, $K_i$ is capital demand by firms, $L_i$ is labour demand by firms, $XD_{ii}$ is the quantity of its own commodity that firm $i$ uses in its production process (intermediaries) and $XD_{ij}$ is the quantity used of firm $j$'s commodity.

**Figure 5.2 – The Firms' Production Structure**




At the second level producers are assumed to choose intermediate inputs according to a Leontief production function as given by equation (5.7), while the optimal level of labour and capital is chosen according to a CES function representing substitution possibilities amongst the primary factors as defined by equation (5.8).

$$XD_{ij} = io_{ji} XD_i \qquad (5.7)$$

$$XD_i = F\left(\gamma_{F_i} K_i^{-\rho_{F_i}} + (1-\gamma_{F_i}) L_i^{-\rho_{F_i}}\right)^{-1/\rho_{F_i}} \qquad (5.8)$$

where $XD_i$ is gross output, $io_{ji}$ is the technical coefficient of the inter-industry flows, $F$ is the efficiency parameter, $\gamma_{F_i}$ is the distribution parameter of capital and $\rho$ is the elasticity parameter in the CES production function, which is in turn affecting the elasticity of substitution, $\sigma_{Fi} = 1/(1+\rho_{Fi})$ (Varian, 1992).

Capital and labour are the only value-added factors included in the model. Shoven and Whalley (1992) state three reasons that seem to account for the popularity of this representation. First, if the major contribution of the study is to move from qualitative to quantitative analysis it is natural to retain the same basic theoretical structure. Second, the data are based in a form consistent with two factor models, such as national accounts data which identifies wages and salaries and operating surplus as major cost components. Third, it allows simplified computation and significantly reduces the costs of repeated equilibrium solution.

The firms are then assumed to maximise their profits by minimising their total cost subject to a given level of output:

Minimise $$TC_i = (1+tk)P_K K_i + (1+tl)P_l L_i \qquad (5.9)$$

Subject to

$$\text{i. } XD_i = F\left(\gamma_{F_i} K_i^{\rho_{F_i}} + (1-\gamma_{F_i}) L_i^{\rho_{F_i}}\right)^{-1/\rho_{F_i}} \qquad (5.10)$$

$$\text{ii } 1 > \gamma_{F_i} > 0; \ \infty > \rho_{F_i} > -1 \qquad (5.11)$$

where $TC_i$ is the total cost for each sector, $tk$ is the tax rate of capital use and the $tl$ is the tax rate on labour use.

Utilising the same procedure as in the household's case, the constrained optimisation problem is expressed in the form of a Lagrange function and differentiating with respect to its arguments yields the first order conditions with respect to capital and labour[5]. This facilitates the derivation of the demand functions with respect to K as given by equation (5.12) and L as given by equation (5.13).

$$K_i = \gamma_{F_i}^{\sigma_{F_i}} \left((1+tk_i)P_K\right)^{-\sigma_{F_i}} v^{\sigma_{F_i}/(1-\sigma_{F_i})} \left(XD_i / F_i\right) \qquad (5.12)$$

where $v = \gamma_{F_i}^{\sigma_{F_i}} \left((1+tk_i)P_K\right)^{1-\sigma_{F_i}} + (1-\gamma_{F_i})^{\sigma_{F_i}} \left((1+tl_i)P_L\right)^{-\sigma_{F_i}}$

$$L_i = (1-\gamma_{F_i})^{\sigma_{F_i}} \left((1+tl_i)P_L\right)^{-\sigma_{F_i}} (\delta)^{\sigma_{F_i}/(1-\sigma_{F_i})} \left(XD_i / F_i\right) \qquad (5.13)$$

where $\delta = \gamma_{F_i}^{\sigma_{F_i}} \left((1+tk_i)P_K\right)^{1-\sigma_{F_i}} + (1-\gamma_{F_i})^{\sigma_{F_i}} \left((1+tl_i)P_L\right)^{-\sigma_{F_i}}$

[5] A mathematical representation of the derivation of the demand for capital and labour is given in Section A.2.2 in Appendix 2.

### 5.1.3 The Investment Institution

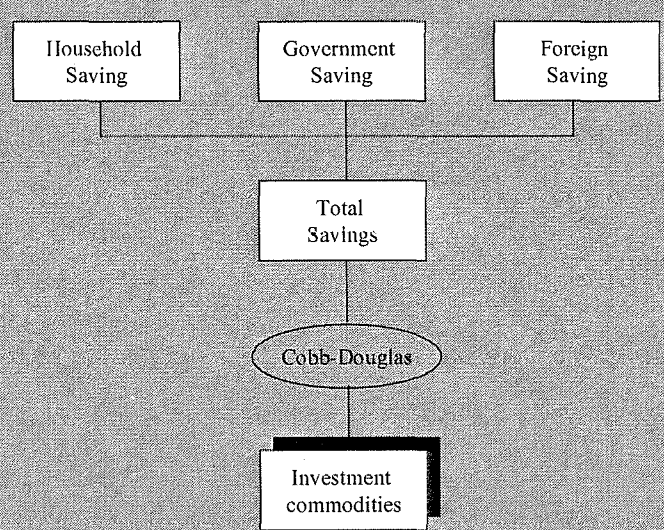
Figure 5.3 shows the invertors' decision structure within the Malta GETM. The household savings ($S_H$), the government savings ($S_G$) and the foreign savings ($S_F$) are allocated over the investment demand for the various commodities. Total savings are thus given by equation (5.14):

$$S = S_H + (CPI)S_G + (ER)S_F \qquad (5.14)$$

$$\text{where} \quad CPI^t = \frac{\sum_{i=1}^{n}\left(1 + tc_i^t\right)P_i^t C_i^0}{\sum_{i=1}^{n}\left(1 + tc_i^0\right)P_i^0 C_i^0} \qquad \text{where } t = 0,1$$

where $S$ is total savings, $S_G$ are government's savings, $S_F$ are foreign savings, CPI is the Consumer Price Index (CPI) of the Laspeyers type and ER is the exchange rate.

**Figure 5.3 – The Investors' Decision Structure**




To this end, the investment institution is assumed to maximise a Cobb Douglas utility function with respect to investment demand for every commodity subject to the constraint that savings are equal to total investments. This is represented mathematically by:

$$\text{Max} \quad U_I = \prod_{i=1}^{n} I_i^{\alpha_{I_i}} \tag{5.15}$$

Subject to

$$\text{i. } S = \sum_{i=1}^{n} P_{D_i} I_i \tag{5.16}$$

$$\text{ii. } 1 > \alpha_{I_i} > 0 \tag{5.17}$$

where $U_I$ is the utility from investment, $I_i$ is the demand for investment commodities and $\alpha_{Ii}$ is the share parameter of the bank's utility function.

Using the same approach as that used for the consumer and producers, the constrained optimisation problem for the investment institution is represented by a Lagrange function and differentiating with respect to its arguments yields the first order conditions[6]. This makes possible the derivation of the demand functions for the various investment commodities included in the model:

$$I_i = \alpha_{I_i} P_i^{-1} S \tag{5.18}$$

### 5.1.4 The Government Institution

The government levies taxes on the consumption of every commodity in the form of taxes on consumption, capital, labour, imports and household income. On the other hand, the government pays unemployment benefits to the household at the going replacement rate and also transfers money for other purposes. Transfers are made nominal by using a CPI. These decisions are shown in Figure 5.4 and represented mathematically by equations (5.19) and (5.20), respectively.

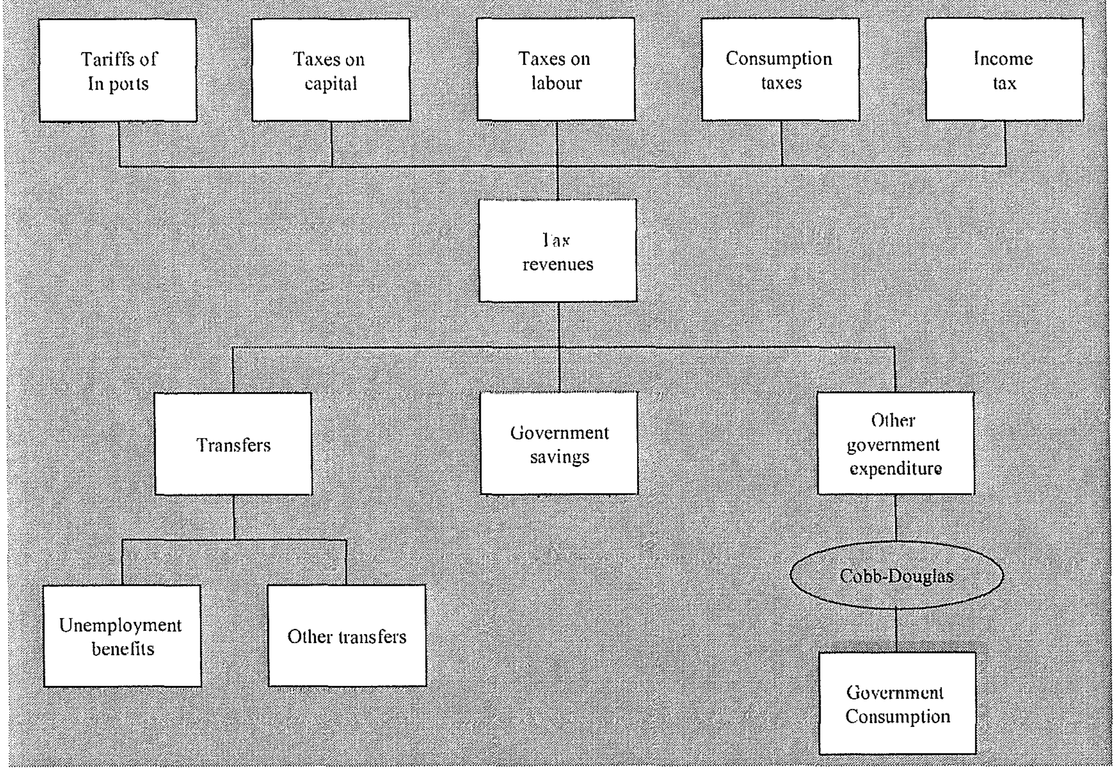
$$TAXR = \sum_{i=1}^{n} \left( tc_i C_i P_{C_i} + tk_i K_i P_K + tl_i L_i P_L \right) + tyY \tag{5.19}$$

$$TRANSF = (replc) P_L UN + (CPI) OTR \tag{5.20}$$

[6] A mathematical representation of the derivation of the demand for investment commodities is given in Section A.2.3 in Appendix 2.

where *TAXR* are total tax revenues, *TRANSF* are total transfers, *replc* is the replacement rate and *OTR* are other transfers to the household.

**Figure 5.4 – The Government's Decision Structure**




It is assumed that the government maximises a Cobb-Douglas utility function with government consumption of the various commodities, under a balanced budget. The problem can thus be written as:

$$\text{Max} \quad U_G = \prod_{i=1}^{n} \left( CG_i^{\alpha_{CG_i}} \right) KG^{\alpha_{KG}} LG^{\alpha_{LG}} \qquad (5.21)$$

Subject to i. $TAXR = TRANSF - (CPI)S_G$ (5.22)

ii. $1 > \alpha_{CG_i} > 0 \,;\, 1 > \alpha_{KG_i} > 0 \,;\, 1 > \alpha_{LG_i} > 0$ (5.23)

where $U_G$ is the government's utility, $CG_i$ is the demand of consumer commodities by government and $\alpha_{CGi}$ is the Cobb-Douglas power of commodities bought by government.

Writing the government's constrained optimisation problem in the form of a Lagrange function and differentiating with respect to its arguments yields the first order conditions with respect to the various commodities[7]. The derivation of demand functions for the various commodities demanded by the government is then given by equation (5.24):

$$CGi = \alpha_{CG_i} P_i^{-1}(TAXR \quad TANSF \quad (CPI)S_{G_i}) \qquad (5.24)$$

### 5.1.5 The Rest of the World Institution

The rest of the world in the Malta GETM is modelled in three steps. First, the relationship between imports and domestic supply is modelled by means of a CES function based on the Armington assumption. Second, the export and domestic markets are incorporated into the model by means of a constant elasticity of transformation (CET) function. And third, the rest of the foreign sector is modelled on the assumption of a small open economy, that is, the country has no influence on world market prices. The production structure of the firms incorporating the rest of the world is shown in Figure 5.5.

According to the Armington assumption[8] the firm produces a composite commodity using the domestic commodity supplied to the domestic market and imports of this commodity. The firm is assumed to minimise its total cost subject to the CES production function:

$$\text{Min} \quad P_{M_i} M_i + P_{DD_i} XDD_i \qquad (5.25)$$

$$\text{Subject to} \quad \text{i. } X_i = A_i\left(\gamma_{A_i} M_i^{-\rho_{A_i}} + (1-\gamma_{A_i}) XDD_i^{-\rho_{A_i}}\right)^{-1/\rho_{A_i}} \qquad (5.26)$$

$$\text{ii. } 1 > \gamma_{A_i} > 0; \; 1 > \rho_{A_i} > 0 \qquad (5.27)$$

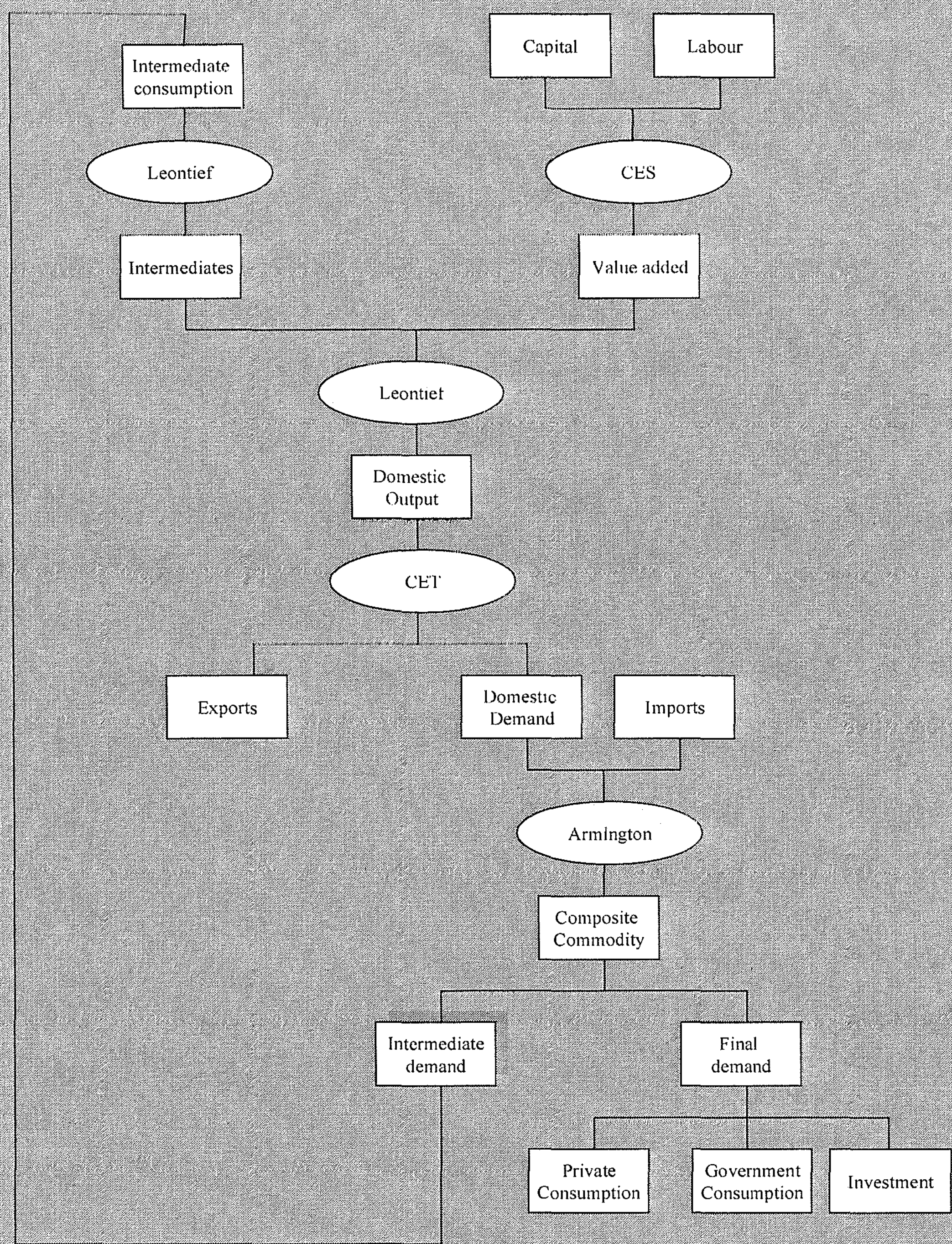
where $PM_i$ is the price of imports, $M_i$ are imports of commodities, $P_{DDi}$ is the price of domestic commodity supplied to the domestic market, $XDD_i$ is the domestic

7 A mathematical representation of the derivation of government demand for commodities is given in Section A.2.4 in Appendix 2.

8 The assumption that products traded internationally are differentiated by country of origin.

commodity supplied to the domestic market, $X_i$ is the composite commodity, $A_i$ is the efficiency parameter of the Armington function, $\gamma_{Ai}$ is the distribution parameter of imports, and $\rho_{Ai}$ is the parameter affecting the elasticity of substitution.

**Figure 5.5 – Production of domestic commodity, supply and demand and production of composite commodity**



Writing the constrained optimisation problem in the form of a Lagrange function, optimising and obtaining the demand equations for imports and domestic commodity supply in similar fashion as with all other institutions[9], we get:

$$M_i = \gamma_{A_i}^{\sigma_{A_i}} P_{M_i}^{-\sigma_{A_i}} (\kappa)^{\sigma_{A_i}/(1-\sigma_{A_i})} (X_i / A_i) \tag{5.28}$$

where $\kappa = \gamma_{A_i}^{\sigma_{A_i}} P_{M_i}^{1-\sigma_{A_i}} + (1-\gamma_{A_i})^{\sigma_{A_i}} P_{DD_i}^{1-\sigma_{A_i}}$

$$XDD_i = (1-\gamma_{A_i})^{\sigma_{A_i}} P_{DD_i}^{-\sigma_{A_i}} (\theta)^{\sigma_{A_i}/(1-\sigma_{A_i})} (X_i / A_i) \tag{5.29}$$

where $\theta = \gamma_{A_i}^{\sigma_{A_i}} P_{M_i}^{1-\sigma_{A_i}} + (1-\gamma_{A_i})^{\sigma_{A_i}} P_{DD_i}^{1-\sigma_{A_i}}$

where $\sigma_{Ai}$ ($= 1/(1+\rho_{Ai})$)is the elasticity of substitution parameter of the Armington function.

On the demand side of the foreign sector the firm has the choice between selling its commodity on the domestic market or on the foreign market. It is assumed to maximise its revenues subject to a CET function:

$$\text{Max} \quad P_{E_i} E_i + P_{DDi} XDD_i \tag{5.30}$$

Subject to

$$\text{i. } XD_i = T_i \left( \gamma_{T_i} E_i^{-\rho_{T_i}} + (1-\gamma_{T_i}) XDD_i^{\rho_{T_i}} \right)^{1/\rho_{T_i}} \tag{5.31}$$

$$\text{ii. } 1 > \gamma_{T_i} > 0; \ 1 > \rho_{T_i} > 0 \tag{5.32}$$

where $E_i$ are exports of domestically produced commodities, $P_{Ei}$ is the export price in local currency, $\gamma_{Ti}$ is the distribution parameter of exports, $T_i$ is the efficiency parameter and $\rho_{Ti}$ is the parameter affecting the elasticity of substitution.

[9] A mathematical representation of the derivation of the demand for imported commodities is given in Section A.2.5 in Appendix 2.

Adopting a similar approach to the one used in the Armington specification, the demand equations for exports and domestic commodity supplies to the domestic market are obtained[10]:

$$E_i = \gamma_{T_i}^{\sigma_{T_i}} P_{E_i}^{-\sigma_{T_i}} \left(\gamma_{T_i}^{\sigma_{T_i}} P_{E_i}^{1-\sigma_{T_i}} + (1-\gamma_{T_i})^{\sigma_{T_i}} P_{DD_i}^{1-\sigma_{T_i}}\right)^{\sigma_{T_i}/(1-\sigma_{T_i})} (X_i/T_i) \tag{5.33}$$

$$XDD_i = (1-\gamma_{T_i})^{\sigma_{T_i}} P_{DD_i}^{-\sigma_{T_i}} \left(\gamma_{T_i}^{\sigma_{T_i}} P_{M_i}^{1-\sigma_{T_i}} + (1-\gamma_{T_i})^{\sigma_{T_i}} P_{DD_i}^{1-\sigma_{T_i}}\right)^{\sigma_{T_i}/(1-\sigma_{T_i})} (X_i/T_i) \tag{5.34}$$

where $\sigma_{Ti}$ (= $1/(1+\rho_{Ti})$)is the elasticity of substitution.

Given that the Maltese economy is that of a small country, it is assumed that domestic demand and supply do not influence world prices of exports and imports. Therefore, prices are exogenous. It is also assumed that Malta's balance of payments is in equilibrium. The import and export price in local currency and the balance of payments are represented mathematically in equation (5.35), (5.36) and (5.37) respectively:

$$P_{M_i} = (1 + tm_i)(ER)P_{WM_i} \tag{5.35}$$

$$P_{E_i} = (ER)P_{WE_i} \tag{5.36}$$

$$\sum_{i=1}^{n} P_{WM_i} M_i = \sum_{i=1}^{n} P_{WE_i} E_i + S_F \tag{5.37}$$

where $ER$ is the exchange rate, $P_{WMi}$ are the world prices of imports and $P_{WEi}$ are the world prices of exports.

## 5.2 GENERAL EQUILIBRIUM

The demand equations derived in the previous section are the building block from which a computable general equilibrium model is constructed. However, the

[10]A mathematical representation of the derivation of the demand for exports is given in Section A.2.5 in Appendix 2.

institutions' optimal behaviour does not guarantee that supply is equal to demand in quantity and price. What binds these elements together are the general equilibrium conditions outlined in Chapter 3, namely, market clearing, income balance and the zero profit condition.

### 5.2.1 Market Clearance

Market clearance implies that the quantity of each composite commodity produced must equal the sum of the quantities of that commodity demanded by the producers in the economy as intermediate input to production, by the representative household, by government and by the investment institution. This is represented mathematically by:

$$X_i = \sum_{i=1}^{n} \left( io_{ji} XD_i \right) + CG_i + C_i + I_i \qquad (5.38)$$

Market clearance is also assumed in the case of the capital market, where the capital used by all producers must sum up to the representative agent's endowment of capital:

$$\sum_{i=1}^{n} (K_i) = KS \qquad (5.39)$$

where $KS$ is the capital supply.

The market clearance in the case of the labour market is less straight forward because of the presence of unemployment. It is incorporated into the model with a Phillips curve relationship between real wages and unemployment. This means that on the labour market there is a negative relationship between the rate of change in real wages and the rate of change in the unemployment rate. The Phillips curve relationship reads:

$$\left( \frac{P_L^1 / CPI^1}{P_L^0 / CPI^0} - 1 \right) = phillips \left( \frac{UN^1 / LS^1}{UN^0 / LS^0} - 1 \right) \qquad (5.40)$$

where $P_L^0/CPI^0$ is the benchmark real gross wage rate, $P_L^1/CPI^1$ is the post-simulation real gross wage rate, $UN^0/LS^0$ is the benchmark unemployment rate, $UN^1/LS^1$ is the post-simulation unemployment rate and *phillips* is the value of the Phillips parameter.

Thus, the market clearance condition for the labour market can be written as:

$$\sum_{i=1}^{n}(L_i) = LS - UN \qquad (5.41)$$

where $LS$ is the supply of labour.

### 5.2.2 Zero Profit Condition

At the optimal level of output, firm's *i* profits are equal to zero. As a consequence the supply equation cannot be derived. However, given that under perfect competition there are no supernormal profits, this problem is overcome by utilising the zero profit condition rather than explicit supply functions.

$$PD_i XD_i = (1+tk_i)P_K K_i + (1+tl_i)P_L L_i + \left( P_i io_{ii} + \sum_{j=1}^{n} P_j io_{ji} \right) XD_i \qquad (5.42)$$

As in the domestic sector, in the foreign sector industries are also assumed to maximise their profits by choosing the optimal level of output. Given that no firm can make any supernormal profits under perfect competition, this level of output can be expressed in terms of the zero profit conditions:

$$P_i X_i = P_{M_i} M_i + P_{DD_i} XDD_i \qquad (5.43)$$

$$P_{D_i} XD_i = P_{E_i} E_i + P_{DD_i} XDD_i \qquad (5.44)$$

### 5.2.3 Income Balance

Income balance implies that the income of the representative household must equal the value of producers' payments to the household itself for the use of the primary factors that the household owns and hires out plus any transfers from the government. The consumption budget is then expressed as total income less income tax paid by the household to the government, less household savings. These are represented mathematically by:

$$Y = P_K KS + P_L (LS - UN) + TRF \qquad (5.45)$$

$$CB = Y - (ty)Y - S_H \qquad (5.46)$$

where $CB$ is the consumption budget of the household

The general equilibrium conditions together with the demand equations derived in the previous section allow for the specification of the supply side of the economy. The ability to incorporate the supply side reactions in the model is in fact one of the major advantages of computable general equilibrium models.

# Chapter Six

# CALIBRATION AND CLOSURE OF THE MALTA GETM

The implementation of the Malta GETM relies on the principle of calibration. It consists in determining the numerical values of the various parameters of functions compatible with the equilibrium of the initial SAM. In the cases of the representative household, industries and the rest of the world institutions, information contained in the SAM was inadequate for calibration of all parameters. Indeed, in cases where functional forms such as CES and LES were selected, estimates of parameters other than those presented in the SAM were necessary.

Additionally, it is required that the model has an equal number of equations and unknowns for it to produce a numerical solution. The principle of fixing a number of variables to ensure that this condition is met is known as 'closure'. Once this condition is satisfied and the model has been calibrated, the benchmark SAM can be replicated.

The chapter proceeds by explaining the numerical calibration of the model parameters in Section 6.1. Issues relating to model closure are discussed in Section 6.2 and the model solution using the Generalised Algebraic Modelling System (GAMS) is discussed in Section 6.3.

## 6.1 CALIBRATION OF MODEL PARAMETERS

Parameter values for the functions used in the model are crucial in determining the results of simulations for the various tax policies. As in traditional GETM, the procedure used in the Malta GETM is 'calibration' as defined by Mansur and Whalley (1984). Under this approach the economy is assumed to be in equilibrium in the presence of the existing input-output transactions, value added, final demand and tax policies. Calibration is then understood as the requirement that the entire model specification be capable of generating the base year equilibrium observation as a model solution.

The required parameter values were calculated using the model equilibrium conditions, assuming that the benchmark data represent equilibrium for the Maltese economy. It should thus be noted that the procedure used for calibrating the parameter values from the constructed equilibrium observation is non-stochastic. In contrast to econometric work which often simplifies the structure of the economic model to allow for substantial richness in statistical specification, here the procedure is the opposite. The richness of the economic structure allows only for a much cruder statistical model that, in the case of calibration to a single year's data, becomes deterministic (Shoven and Whalley, 1992).

Because the data in the Malta SAM is produced in value terms, units had to be chosen for goods and factors so that separate price and quantity observations were obtained. A commonly used convention, originally adopted by Harberger (1962), is to assume units for both goods and factors such that they have a price of unity in the benchmark equilibrium. Therefore, the nominal values of the elements are equal to the real one.

*Calibration of the household institution parameters*

Since the representative household institution is specified by a LES, exogenously specified elasticity values were required. The benchmark SAM provided only price and quantity observations associated with a single equilibrium observation. Consequently, the system had more parameters that needed to be estimated than equations, making the calibration problem of the household institution under-determined. Thus, the use of the LES meant that data for the income elasticities of demand were obtained from sources outside the model (see Section 6.1.1).

A closely related concept is the Frisch parameter, measuring the sensitivity of the marginal utility of income to income/total expenditure. It establishes a relationship between own-price and income elasticities. Its importance in the calibration process of the Malta GETM stems from the lack of price data to provide good estimates of own-price elasticities. In fact, price elasticities of demand are determined simply by the income elasticity in conjunction with the Frisch parameter.

As is common in most general equilibrium models, the estimates for income elasticities and the Frisch parameter were obtained from literature estimates (see Section 6.1.1). Using the income elasticity of demand for commodity $i$ and the budget constraint as given by the values in the benchmark dataset, $\alpha_{Hi}$ could be calibrated as shown by equation (6.1).

$$\alpha_{H_i} = \left( \frac{(1+tc_i)P_{C_i}C_i}{CB} \right) E(C_i, CB) \tag{6.1}$$

$$\text{where } E(C_i, CB) = \frac{\alpha_{H_i} \left( (1+tc_i)P_{C_i} \right)^{-1} CB}{C_i}$$

where $E(C_i,CB)$ is the elasticity of demand for commodity $i$.

Algebraically, the Frisch parameter $\varphi$ was obtained by substituting equation (5.5) of the Malta GETM into the first order condition[11] with respect to consumption of good $i$ of the household's Lagrange function, and then solving for $\lambda$.

$$\varphi = -\frac{CB}{CB - \sum_{i=1}^{n} (1+tc_i)P_{C_i}\mu H_i} \tag{6.2}$$

The formula used to derive the Frisch parameter is simply the negative ratio between the household's total expenditure and the supernumerary income. The subsistence level of commodity $i$ could thus be calibrated by rearranging equation (6.2) in terms of $\mu H_i$ as shown below:

$$\mu H_i = C_i + \alpha_{H_i} \left( (1+tc_i)P_{C_i} \right)^{-1} \varphi^{-1} CB \tag{6.3}$$

[11] See Section A.2.1 in Appendix 2 for the first order conditions of the household's utility function.

*Calibration of the industry institution parameters*

The industry institution is represented by a nested production function, whereby at the first level, the choice between value added and intermediate output is given by a Leontief input-output production function. At the second level intermediate consumption is also governed by a Leontief production function and the demand for factors of production is defined over a CES function. For Leontief functions, the benchmark dataset uniquely identifies a set of parameter values. This is not the case with CES functions.

The elasticity values in the Malta GETM specify the curvature of the isoquants and indifference curves, with their position given by the equilibrium benchmark dataset. Because the curvature of the CES indifference curves and isoquants cannot be inferred from the benchmark data, extraneous values of substitution elasticities were required (see Section 6.1.1). The capital-labour substitution elasticities were obtained from literature estimates (see Section 6.2.1), so that the values of $\gamma_{Fi}$ could be calibrated:

$$\gamma_{F_i} = \left( 1 + \frac{(1+tl_i)P_L}{(1+tk_i)P_K} \left( \frac{K_i}{L_i} \right)^{-1/\sigma_{F_i}} \right)^{-1} \qquad (6.4)$$

Having obtained the values of $\gamma_{Fi}$ and using equation (5.8) in the Malta GETM, the value of $F_i$ was calibrated:

$$F_i = \frac{XD_i}{\left( \gamma_{F_i} K_i^{-(1-\sigma_{F_i})/\sigma_{F_i}} + (1-\gamma_{F_i}) L_i^{-(1-\sigma_{F_i})/\sigma_{F_i}} \right)^{\sigma_{F_i}/(1-\sigma_{F_i})}} \qquad (6.5)$$

*Calibration of the investment institution parameters*

The investment institution is specified by a Cobb-Douglas function. Thus the only unknown parameter was the share parameter of investment in each commodity of overall investment. Given that the level of investment and savings were provided by the SAM and assuming prices are equal to one in the base year, then the computation of the share of each commodity in overall investment is a simple inversion of the demand equation as given by equation (6.6).

$$\alpha_{I_i} = I_i P_{C_i} S^{-1} \qquad (6.6)$$

*Calibration of the government institution parameters*

A Cobb-Douglas function is also used to represent the government institution. The share parameters of the government's Cobb-Douglas function were thus determined in a similar manner to those obtained by the investment institution. This is done by rearranging the equation for government's demand for commodity $i$ in terms of $\alpha_{CGi}$.

$$\alpha_{CG_i} = \frac{P_i CG_i}{TAXR \quad TRANSF \quad (CPI)SG} \qquad (6\ 7)$$

*Calibration of the rest of the world institution parameters*

The rest of the world institution has been modelled by means of the Armington assumption, defining the relationship between imports and domestic supply, and a CET function, incorporating the export and domestic markets.

Given the Armington assumption (specified in the form of a CES function) and assuming price normalisation, the volumes of demand for both domestic and imported products are provided directly by the SAM. The only parameters that required calibration were therefore the share and scale parameters, whilst the elasticity of substitution was obtained from literature estimates (see Section 6.1.1). The share parameter was easily computed by inverting the import demand equation as shown by equation (6.8). The scale parameter was then obtained by a simple inversion of the Armington function as given by equation (6.9).

$$\gamma_{A_i} = \frac{1}{1 + \left(P_{DD_i} / P_{M_i}\right)\left(M_i / XDD_i\right)^{-1/\sigma_{A_i}}} \qquad (6.8)$$

$$A_i = \frac{X_i}{\left(\gamma_{A_i} M_i^{(\sigma_{A_i} - 1/\sigma_{A_i})} + (1 - \gamma_{A_i}) XDD_i^{(\sigma_{A_i} - 1/\sigma_{A_i})}\right)^{\sigma_{A_i}/\sigma_{A_i} - 1}} \qquad (6.9)$$

The same process was applied for the calibration of the CET function. By letting prices equal one in the benchmark year and obtaining the estimate for the elasticity of substitution from literature estimates (see Section 6.1.1), the distributive parameters of the export offer function were derived as shown in equations (6.10) and (6.11).

$$\gamma_{T_i} = \frac{1}{1+\left(P_{DD_i}/P_{E_i}\right)\left(E_i/XDD_i\right)^{-1/\sigma_{T_i}}} \qquad (6.10)$$

$$T_i = \frac{XD_i}{\left(\gamma_{T_i} E_i^{\left(\sigma_{T_i}-1/\sigma_{T_i}\right)} + \left(1-\gamma_{T_i}\right) XDD_i^{\left(\sigma_{T_i}-1/\sigma_{T_i}\right)}\right)^{\sigma_{T_i}/\sigma_{T_i}-1}} \qquad (6.11)$$

Whilst data from the benchmark SAM has been discussed in Chapter Four, the exogenously obtained estimates are the topic of the next subsection.

### 6.1.1 Estimates for Exogenous Parameters

Exogenously determined parameters relate to those estimates – mainly elasticities of substitution – which were obtained from literature searches rather than being determined within the Malta GETM from information provided by the benchmark SAM. Other parameters that required exogenous estimates included the Frisch parameter and the Phillips parameter.

*Elasticities of Substitution*

The elasticity of substitution specifies how easily technological processes can be changed in order to use more of one input and less of another in response to a change in wages or prices. For example, the elasticity of substitution between labour and capital specifies how industries' demands for labour and capital will change following a change in the wage rate of either factor. A high elasticity means that an increase in the wage rate of labour will have a greater effect on capital, such that firms will use more capital and less labour. A lower elasticity, on the other hand, dampens the ability of industries to respond in this way to price changes. At the extreme, an elasticity of zero means that industries will not respond to changes in prices. In this case, an increase in the wage rate of labour would not change the industry's demand for capital.

In line with reference made to elasticities of substitution in Section 6.1, the elasticity parameters of the Cobb-Douglas function could be calibrated using data from the benchmark SAM. However, when LES and CES functions were used to define the behaviour of particular agents in the economy the equilibrium conditions were not sufficient to identify the model. In such circumstances, additional parameter values were exogenously specified until the Malta GETM was identified. As in traditional general equilibrium tax models, heavy reliance was placed on literature searches for elasticity estimates. The econometric approach to calibration (as in Jorgenson, 1984) could have been an alternative. However, such processes tend to be data intensive and would have required a time series of social accounting matrices which are not available for Malta.

Exogenous estimates were mainly obtained from Piggott and Whalley (1985) for the basic calculation. These elasticities are given in Table 6.1, showing the degree of price elasticity of household demand functions, the elasticity between labour and capital in the CES production function, between domestic supplies and imports in the Armington function and the elasticity of transformation between domestic supplies and exports. These elasticity values are commonly used in CGE models and are based on econometric estimates. The influence of the choice of these variables on the results obtained from the Malta GETM has been tested in Chapter Seven by means of sensitivity analysis.

Albeit not treated in this chapter, it should be noted that the elasticity of substitution between intermediate inputs and value added as well as between intermediate consumption, are set to zero. These are common values in computable general equilibrium models reflecting the fact that it is difficult to implement technological change that uses different intermediate inputs.

**Table 6.1 Elasticity parameters used in Malta GETM**

| Industry/Commodity | E(C<sub>i</sub>,CB) | $\sigma_{Fi}$ | $\sigma_{Ai}$ | $\sigma_{Ti}$ |
|---|---|---|---|---|
| 1. Agriculture, fishing and mining | 0.475 | 0.9 | 2.12 | 1.46 |
| 2. Manufacturing of food, beverages and tobacco | 0.795 | 0.74 | 1.75 | 1.20 |
| 3. Manufacturing of textiles and wearing apparel | 0.530 | 1.18 | 2.80 | 1.92 |
| 4. Other manufacturing | 0.530 | 1.18 | 2.80 | 1.92 |
| 5. Electricity, gas and water supply | 0.001 | 1.11 | 2.63 | 1.80 |
| 6. Wholesale and retail trade; Hotels and restaurants | 0.489 | 1.18 | 2.80 | 1.92 |
| 7. Transport, storage and communication | 0.321 | 1.18 | 2.80 | 1.92 |
| 8. Financial intermediation; Real estate services | 0.001 | 1.22 | 2.89 | 1.98 |
| 9. Education, health and social work | 0.253 | 1.18 | 2.80 | 1.92 |

*E($C_i$,CB)*: price elasticity of household demand
$\sigma_{Fi}$: elasticity of substitution between labour and capital
$\sigma_{Ai}$: elasticity of substitution between domestic supplies and imports
$\sigma_{Ti}$: elasticity of transformation between domestic supplies and exports

*Source: Piggott and Whalley (1985)*

It should also be noted that when using exogenous elasticity values it is seldom guaranteed that the budgetary share parameters in the LES function used for the specification of the representative household institution add up to unity. Thus, the calibrated values of the share parameters were scaled such that their sum is equal to one.

*Other parameter estimates obtained from literature*

The estimation of the subsistence consumption level required exogenous estimates of the Frisch parameter. Frisch (1959) himself argued that the parameter would vary with income, that is, one would expect that a higher Frisch parameter exists in poorer countries given the presumption of a declining marginal utility of money. He went so far as to state the following values as being applicable: -10.0 for the very poor, -2.0 for the median part of the population; -0.7 for the better off, -0.1 for the rich. However, it is not clear how Frisch determined these values, and in the case of the LES function, the minimum absolute value must be unity if the subsistence level of consumption were to be positive. Tulpule and Powell (1978) used a value of -1.82 based on Williams (1978), a value also used by Dixon et al. (1982) in calibrating their own general equilibrium model. Based on this information and the unavailability of Frisch parameter estimates for the Maltese economy, the Frisch parameter in the Malta GETM was assumed to stand at -1.80.

The value of the Phillips parameter was also determined exogenously. Estimates for the parameter for the Maltese economy showed a lack of evidence in favour of wage flexibility (author's calculations). However, it is not excluded that a relationship exists between wage growth and unemployment when a single equation based on annual data is used. In line with these calculations, the Phillips' parameter is assumed to be -0.06.

### 6.1.2 Estimates for Endogenously Calibrated Parameters

Data presented in the benchmark SAM together with estimates for exogenously obtained parameters as specified in the previous subsection were used to calibrate parameters for production and consumption sides of the economy. The calibrated share parameters presented in Table 6.2 are consistent with the replication of the benchmark data by the model equilibrium solutions. The estimated parameters seem reasonable. Share parameters of all commodities of Cobb-Douglas and LES functions add up to one and estimates for efficiency parameters also seem reasonable.

The calibrated parameters reveal a lot about the behaviour of the various agents in the Maltese economy. The marginal budgetary share of the household's LES function shows that households spend more than half of their income on commodities of 'food, beverages, tobacco' and 'other manufacturing'. Likewise, the government spends more than half of its income of commodities of 'education, health and social work'. The share parameters with respect to the investment Cobb-Douglas utility function reveal that most of investment demand is directed towards other manufacturing commodities, with a significant part due to investment in construction.

In line with a priori expectations, the subsistence level of consumption is lower than the actual level of consumption, also suggesting that the Frisch parameter estimate is also making economic sense. Most notably, for commodities with an elasticity of substitution close to zero, the subsistence level of consumption accounts for the entire consumption level.

**Table 6.2 - Calibrated parameters**

| | | αHi | μHi | γFi | Fi | αIi | αCGi | γAi | Ai | γTi | Ti |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Commodities/Industries | 1 | 0.104 | 50.432 | 0.756 | 5.323 | 0.000 | 0.012 | 0.368 | 1.944 | 0.885 | 3.685 |
| | 2 | 0.391 | 15.044 | 0.566 | 7.978 | 0.000 | 0.000 | 0.481 | 2.096 | 0.789 | 2.542 |
| | 3 | 0.083 | 26.636 | 0.452 | 7.620 | 0.000 | 0.000 | 0.588 | 2.061 | 0.375 | 2.126 |
| | 4 | 0.212 | 53.197 | 0.529 | 6.110 | 0.955 | 0.073 | 0.572 | 1.971 | 0.432 | 2.036 |
| | 5 | 0.000 | 14.154 | 0.501 | 6.406 | 0.000 | 0.002 | 0.070 | 1.124 | 0.829 | 3.177 |
| | 6 | 0.097 | 44.081 | 0.599 | 3.285 | 0.000 | 0.028 | 0.324 | 1.721 | 0.547 | 2.017 |
| | 7 | 0.062 | 63.159 | 0.559 | 4.689 | 0.000 | 0.016 | 0.414 | 1.922 | 0.515 | 2.002 |
| | 8 | 0.000 | 110.209 | 0.676 | 2.864 | 0.043 | 0.063 | 0.409 | 1.910 | 0.672 | 2.255 |
| | 9 | 0.051 | 71.533 | 0.337 | 2.847 | 0.051 | 0.541 | 0.286 | 1.628 | 0.740 | 2.531 |
| | αKG | | | | | | 0.043 | | | | |
| | αLG | | | | | | 0.221 | | | | |

αHi : marginal budget share of household's LES utility function
μHi : subsistence level of consumption
γFi : distribution parameter of capital in the industries' CES production function
Fi : efficiency parameter in the industries' CES production function
αIi : share parameter in the investment utility function
αCGi : consumption share of government's Cobb-Douglas function
αKGi : capital share of government's Cobb-Douglas function
αLGi : labour share of government's Cobb-Douglas function
γAi : distribution parameter of imports in the Armington function
Ai : efficiency parameter in the Armington function
γTi : distribution parameter of exports in the CET function
Ti : efficiency parameter of the CET function

*Source: Authors' calculations*

The distribution parameters of capital and labour in the industries production function are also in line with data provided in the Malta SAM. For example, the 'agriculture, fishing and mining' industry is capital intensive, whilst the 'education, health and social work' industry is labour intensive. The intensity ratio between labour and capital in the other industries tends to be smaller as outlined in Chapter Four.

The distribution parameters of imports and domestic consumption also reveal much about the industries' input structure. The 'other manufacturing' industry and the 'food, beverages and tobacco' industry have a higher marginal propensity to import in their production process than other industries do. Similarly, the distribution parameter of exports and domestic sales reveal that the share of exports is higher in the 'manufacture of textiles and wearing apparel' and 'other manufacturing' than in other industries.

## 6.2 MODEL CLOSURE

Once the model has been calibrated and the benchmark SAM replicated, the last requirement for the attainment of a solution to the model is the 'closure' condition. This requirement to a large extent affects the policy simulation results obtained by the computable general equilibrium model (Sen, 1973; Taylor and Lysy, 1979). The problem can be mainly interpreted in two ways. In mathematical terms, the problem boils down to the simple notion that the model must consist of an equal number of equations and endogenous variables (unknowns). Alternatively, if the model is built in Walrasian tradition and all decisions are based on optimising behaviour, the closure rule problem could be addressed by introducing macroeconomic constraints that impinge upon the microeconomic behaviour of the individual agents. In that case one would have to introduce additional balancing equations.

The number of variables and equations in the Malta GETM amount to one hundred fifty-two (152) and one hundred forty-eight (148) respectively. For the sake of simplicity, the macro closure problem in the Malta GETM was solved by making some variables exogenous (that is, fixed), until the number of endogenous variables and equations was equal. Closure was obtained by fixing the variables for capital supply (KS), labour supply (LS), other transfers to households (OTR), government savings ($S_G$) and foreign savings ($S_F$)

Model closure assured that the number of equations and endogenous variables in the system were equal. However, when Walras' law applies, the number of independent equations is reduced to one hundred forty-seven (147), once again making the system underdetermined The law states that when there are *n* markets, and *n-1* of them are cleared, then the $n^{th}$ market automatically clears. This result follows the fact that the various demand equations which were used to obtain the model solution have been determined such that the respective budget constraints are met with. Alternatively, if all markets are in equilibrium and all, but one, budget constraints are binding, then the last budget constraint is binding as well (Dinwiddie and Teal, 1988). Hence, even after dropping one equilibrium condition all markets would clear. In order to get a square system the market clearing of the labour market equation was removed from the model.

Consequently, the number of equations and endogenous variables in the Malta GETM was unequal. One last adjustment to equate the number of equations and unknowns was the choice of one variable to act as a numeraire. In the Malta GETM, the price of labour was chosen as the numeraire such that the analysis assumes that prices are normalised by the wage's price. This assumption is possible because in the spirit of Walrasian equilibrium only the determination of relative prices matter.

## 6.3 IMPLMENTING AND SOLVING THE MODEL IN GAMS

Since the set of simultaneous equations now consists of an equal number of equations and endogenous variables a model solution could be obtained. But the resulting equations are highly nonlinear, so they must be solved using an iterative numerical procedure. A demonstration that the iterative process leads or converges to a steady state from an arbitrary starting point can be regarded as a proof of existence of equilibrium in the model (Creedy, 1997).

This iterative process can be understood as follows. Starting with an arbitrary total amount of labour (the market clearing equation which was assumed to clear automatically as the $n^{th}$ market), numerical values for all the market clearing conditions specified in the Malta GETM are obtained. If there is excess supply in any market, a lower input of labour is used and the process is repeated. This process will converge to equilibrium in the various markets. At this point, the assumed total amount of labour may be compared with the total supply generated as a result of the factor and goods prices associated with equilibrium. If there is an excess supply of labour, the total amount of labour assumed in the first stage is increased slightly and the process is repeated. Convergence is reached when there is simultaneous equilibrium in the labour market and all other markets in the model.

The early general equilibrium tax models typically used Scarf's algorithm for the solution of the iterative procedure (Scarf, 1967; Scarf and Hansen, 1973) and were solved with codes written in FORTRAN. In recent years, however, large scale general equilibrium modelling has become easier with the development of the GAMS optimisation software (Bhattarai and Whalley, 1998). The Malta GETM was thus solved using the GAMS software (Brook, Kendrick and Meeraus, 1992;

Rutherford, 1995). All equilibrium conditions were written as constraints for the optimisation problem, with an arbitrary objective function called the 'hypothetical objective function'. Any solution to the optimisation problem which lies in the constraint set is, by definition, an equilibrium.

The Malta GETM written in GAMS syntax (see Appendix 3) is essentially a set of statements which declare sets, data, parameters, variables, equations and assign model relationships. Optimisation solvers, MINOS5 and CONOPT, are the most popular for solving non-linear and linear programming problems in GAMS, while PATH is a more powerful solver for mixed complementarity problems (Dirkse and Ferris, 1995). The PATH solver has been used to solve the Malta GETM.

A series of tests to ensure that the calibrated model replicated the benchmark SAM were carried out. First, the single equation solution was checked in order to enable the isolation of offending equations. Second, the simultaneous solution was checked to ensure coherence amongst equations, that is, to make sure that the implemented model is reproducing the baseline data. Third, it was checked that Walras' law was satisfied, that is, the clearance of the $n^{th}$ market is equal to zero or very close to zero. Fourth, the homogeneity test was carried out. Since the assumptions of optimisation and interaction within competitive markets imply that the model is homogenous of degree zero, multiplying the numeraire price by a constant *k* should have produced a solution where real values remained unchanged but all nominal values were multiplied by *k*. Once the implemented model met all the necessary conditions, it was ready to be used for simulation purposes.

# Chapter Seven

# EFFICIENCY AND REALLOCATION IMPACTS OF TAX POLICY

The Malta GETM developed in this study is used to measure the economic impact of tax policy changes. It uses comparative static analysis by calculating differences between the baseline solution (equilibrium prior to policy change) and the counterfactual solution (post-reform equilibrium). This is done using two main indicators: the percentage changes of endogenous variables from the baseline solution and welfare measures using equivalent and compensating variations.

In line with developments outlined in Chapter Four, the policy simulations conducted address only reforms that have taken place since 2001 (the year of the benchmark SAM). To facilitate understanding of the impact created by each of these taxes in terms of efficiency, Section 7.1 estimates the overall distortionary costs created by each of these tax instruments in the benchmark economy. It does so by completely removing, in turn, only taxes on consumption (simulation 2), only taxes on income (simulation 3), only taxes on imports (simulation 4) and finally all three tax instruments together (simulation 1). Analysis of these simulations is mainly focused on observing changes in welfare, GDP, tax revenues and household consumption rather than tracing the ripple affects of the resulting changes on the various markets and institutions.

This is followed by tax simulations intended to mimic the actual measures implemented by the Maltese government since 2001. These include an increase in consumption taxes by approximately 1 percent of GDP (simulation 5), a decrease in income taxes by approximately 1 percent of GDP (simulation 6) and the removal of import levies (simulation 7). After simulations 5, 6 and 7, the study proceeds to analyse the impact of the resulting tax mix (simulation 8). Analysis of results is conducted by first focusing on the direct impact of the policy change and then the ripple effects on the various markets and institutions are traced. This enables the identification of those agents who gain and those who lose following a policy change

The study proceeds by focusing on tax efficiency in Section 7.1, thereby addressing simulations 1 to 4, and then estimates the impact of tax measures implemented by the Maltese Government since 2001 in Section 7.2. It is important to emphasise that the results generated by the Malta GETM will not go beyond what has been built into the model in terms of both structure and assumptions. Thus the interpretation of results has to be framed within this context. In the third part of the chapter, the key results will be analysed as regards to how sensitive they are to elasticity parameters, thereby revealing the robustness of impact results outlined in Sections 7.1 and 7.2.

## 7.1 TAX EFFICIENCY ANALYSIS

This section is mainly intended to measure the overall distortionary costs created by the presence of consumption, income and import taxes in the benchmark economy. As outlined in Chapter Four, the ITR on consumption stood at 12.3 percent, that on income at 6.1 percent and that on imports at 3.7 percent. A comparison between benchmark and counterfactual equilibria was undertaken following a number of tax policy experiments, such that the respective ITR of the instrument under consideration was reduced to zero.

Simulation 1: Elimination of taxes on income, consumption and imports
Simulation 2: Elimination of taxes on income only
Simulation 3: Elimination of taxes on consumption only
Simulation 4: Elimination of taxes on imports only

The ultimate goal of any policy measure should be the improvement or optimisation of welfare in the economy. Thus it is consistent that utility measures are used to evaluate macro impacts of policies. However, because the utility level is expressed in an absolute number, it does not provide concrete ideas about the welfare status from a viewpoint of actual economic activities. In order to overcome this shortcoming of utility as a welfare indicator, monetary measures of welfare effects were used to obtain quantitative evaluations of how much better off or worse off households actually are. The most common measures are equivalent and compensating variations, a detailed explanation of which is given in Section A.2.6 and A.2.7 in Appendix 2. The equivalent variation shows what would be the income change, at initial prices, that is welfare equivalent to the observed change in prices, while the compensating variation shows the amount of money required to bring the household back to the same level of utility as in the benchmark equilibrium following a policy change. Thus, in essence there is no difference between the two measures.

The overall welfare cost of taxes, as presented in Table 7.1, shows that the cost of using consumption, income and import taxes is obviously higher than using either tax on its own. Indeed, the overall distortionary impact in simulation 1 amounts to 20.6 percent of benchmark GDP when measured using the equivalent variation and 18.8 percent when using the compensating variation. The elimination of either the consumption or income tax (simulation 2 or 3) leads to a decline in tax revenue collected by government of 14 percent, such that welfare comparisons presented in Table 7.1 show the *relative* distortionary impact created by the two types of taxes. The elimination of only taxes on income has a positive effect on the household's utility which could amount up to 5.3 percent of GDP when using equivalent variation and 5.4 percent when using compensating variation. In comparison, taxes on consumption have significantly higher distortions. Calculations suggest that the gains in money metric utility resulting from the elimination of consumption taxes could amount up to 11.4 percent of benchmark GDP when using equivalent variation and to 10.5 percent when using compensating variation. Households ultimately bear the burden of all taxes

**Table 7.1 - Money Metric Utility**

| | *Equivalent Variation (EV)* | *Compensating Variation (CV)* |
|---|---|---|
| **Simulation 1** | 20.6% | 18.60% |
| **Simulation 2** | 5.3% | 5.4% |
| **Simulation 3** | 11.4% | 10.5% |
| **Simulation 4** | 3.6% | 3.5% |

*Source: Author's calculations using the Malta GETM* *% of GDP*

The macroeconomic effects of these tax policies on overall GDP, consumption, investment, government revenue and expenditure are shown in Table 7.2 below.

Clearly, in terms of GDP and household consumption the adverse macroeconomic impacts of taxes on consumption are higher than those imposed by taxes on income. The relatively greater impact on the two variables resulting from the elimination of only the consumption tax in comparison to the elimination of only the income tax stems from lower gross of tax prices faced by the consumers. If the prices are high because of taxes they can increase their utility by consuming less of the heavily taxed commodity. As prices gross of tax fall following the elimination of the consumption tax, both domestic and foreign demand for commodities increases. It should however be noted, that this reaction initiates a series of second round effects resulting from the interrelation between the various markets and agents in the Malta GETM which ultimately impacts upon the overall macroeconomic variables. However, this will be the topic of the next section.

**Table 7.2 - Macroeconomic Impacts**

| | *Sim1* | *Sim2* | *Sim3* | *Sim4* |
|---|---|---|---|---|
| ***GDP*** | 7.9% | 1.0% | 4.8% | 2.2% |
| ***Household consumption*** | 21.8% | 5.9% | 11.6% | 3.8% |
| ***Investment*** | 8.6% | 6.0% | 0.4% | 2.8% |
| ***Government consumption*** | -43.6% | -22.6% | 14.8% | -4.0% |
| ***Tax revenue*** | -35.5% | -14.4% | -14.1% | -5.0% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

Results also suggest that the level of investment is more sensitive to the imposition of a tax on income rather than on consumption. Under the income tax system, the tax liability is incurred before the individual decides what to do with his money This is not true in the case of the consumption tax. Here the tax liability is created only when the income is spent. Therefore, the elimination of only taxes on income results in higher net of tax income. Assuming the same marginal propensity to save, both investment and demand for commodities increases as savings and the consumption budget increase. As in the case where taxes on consumption are increased, the effect of an increase in taxes on income on consumption and savings will initiate second round effects, but their discussion is also postponed to the next section.

The assumption of a balanced rest of the world account (together with the non-existence of foreign savings) necessarily entails an equal impact on imports and exports. Should this not have been the case, consumption led growth would not be the best news for a small open economy like Malta whose marginal propensity to import is higher than in most developed countries. Indeed, the increase in demand for composite commodities resulting from the elimination of the commodity taxes consists of a 4.8 percent increase in domestic output delivered to the home market and a 9.6 percent increase in imports. In this sense, it is preferable for growth to be driven by increasing investment, generating more production and ultimately exports. Under such circumstances, taxes on consumption are deemed to have a more desirable impact on the economy. However, this is not reflected in the model results, given the simplistic assumptions made on the foreign sector, investment and endogenous growth.

Meanwhile, the removal of import taxes brings about an improvement in welfare of 3.6 percent of GDP when measured using equivalent variation and 3.5 percent when using compensating variation. Clearly, the overall distortion created by import taxes in the Maltese economy in 2001 is lower than the distortion created by either the consumption or income taxes. From a viewpoint of its effect on macroeconomic variables, the removal of import taxes would increase GDP by 2.2 percent when compared to the benchmark level. This is mainly driven by the resulting increase in household consumption and investment, the effect of which is mitigated by the drop in government expenditure as a result of lower tax revenues.

## 7.2 IMPACTS OF MALTA'S TAX REFORM POST-2001

In line with measures implemented by the Maltese government in recent years (see Chapter Four), this section simulates the changes in ITRs on consumption, income and imports. Whilst the previous section addressed mainly the issue of tax efficiency, this section is mainly intended to identify the winners and losers of tax reform. It does so by tracing the reallocation of resources and readjustment between the markets and agents in the Maltese economy. Each simulation is explained by its direct impact and by the second round (indirect) effects it generates thereafter, where impacts are mainly a reflection of elasticities governing the respective choices made by either firms or households. The simulations conducted include:

Simulation 5. Increase in taxes on consumption by 1 percent of benchmark GDP
Simulation 6: Reduction in income tax by 1 percent of GDP
Simulation 7: Removal of import levies
Simulation 8: The resulting tax mix from incorporating simulations 5, 6 and 7

The results obtained for each simulation are presented in two tables showing percentage changes from the baseline for aggregate variables and variables at a micro level respectively. The variables included are GDP, tax revenue, consumption budget and household income in case of the former, and variables such as composite commodity prices (made up of imports and domestic production delivered to the home markets), household consumption, government consumption, imports, gross domestic output, and capital and labour demand in case of the latter. A complete overview of results is given in Appendix 1. It is important to note that a potential problem with the use of percentage changes is that if a parameter is small, percentage changes may be large relative to those of other variables. In fact, if the initial parameter value is zero, percentage changes to the parameter are not defined. For these parameters, absolute changes were observed.

### 7.2.1 Increase in taxes on consumption by 1 percent of GDP (simulation 5)

Following an increase in taxes on consumption, the GDP of the Maltese economy is likely to decline by 0.8 percent and consequently so would the welfare of the Maltese households. The main driver of this decline is the significantly lower level of household consumption, albeit this being mitigated by increases in government consumption expenditure. Following the policy implementation, government revenue would also be expected to increase significantly (1.6 percent). A reallocation of resources between the various sectors constituting the supply side of the Maltese economy is the likely result, with gains being recorded by the 'education, health and social work' (Sec9) sector and the 'financial services (including real estate services)' (Sec8) sector while loses would be expected to be recorded in the 'manufacturing of food, beverages and tobacco' (Sec2) and in the 'manufacturing of textiles and wearing apparel' (Sec3) sectors. The impact of these policy changes is shown in Table 7.3 and 7.4.

**Table 7.3 - Simulation 5: Impacts on variables at an aggregate level**

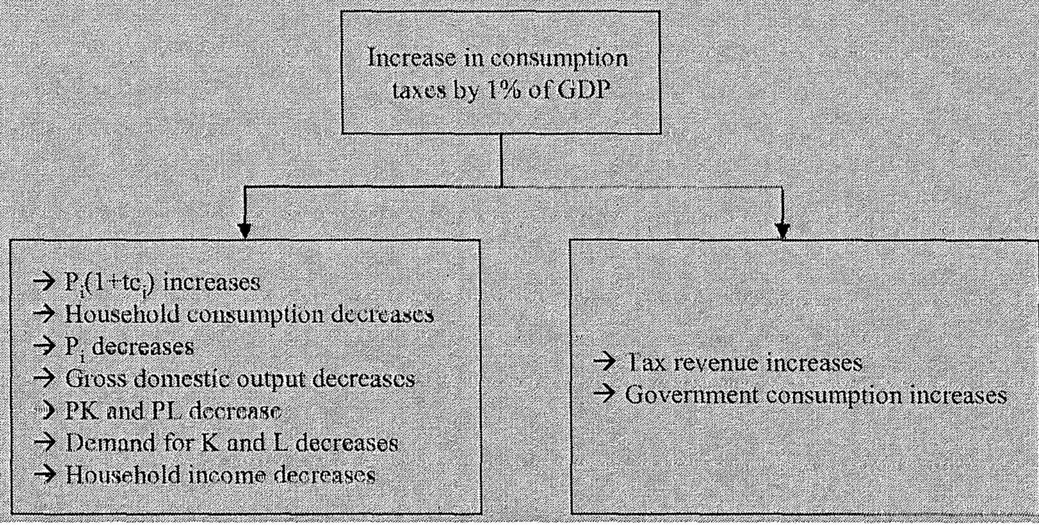
| | |
|---|---|
| **GDP** | -0.8 % |
| **Household Income** | -0.8 % |
| **Household Consumption Budget** | -0.8 % |
| **Tax Revenue** | 1.6 % |
| **Transfers to household** | 3.3 % |

*Source: Authors' calculation using the Malta GETM* *% change from baseline*

An overview of the major responses generated by the policy change is represented in Figure 7.1, showing developments at an aggregate level. As the consumption tax increases, the tax-inclusive price of the taxed composite commodity faced by the consumer increases causing overall consumption to fall by 1.5 percent. Whilst the reaction of overall consumption is intuitive, the change in demand for the respective commodities is the result of the decisions made by the representative household upon the information conveyed to it by commodity prices. Two forces are at play. First, the household's ability to react to the increase in the tax-inclusive price depends on the price elasticity of household demand. When this is high, the household's reaction to price changes is greater because the demand for the good is relatively elastic. Second, the reaction of the household demand is obviously dependent on the relative price movements for the various commodities. The tax increases the relative price of the commodity on which the tax is levied, which results in a reduction in the demand for its use by the representative household for consumption and by non-taxed industries for intermediate inputs. It is noticeable, that the reaction to the increase in the consumption tax is greater for those commodities in which both the relative increase in price and the price elasticity of demand are relatively higher when compared to other commodities.

For example, the change in consumption is greater for 'other manufacturing' (Com4) commodities than for 'education, health and social work' (Com9) because both the price elasticity of demand and the change in relative price are greater in the case of the former. On the other hand, the reaction of household consumption of 'financial intermediation' (Com8) is equal to zero simply because the price elasticity of demand for that particular commodity is zero. The greatest changes in consumption are observed in the demand for 'other manufacturing' (Com4), 'textiles and wearing apparel' (Com3) and 'food, beverages and tobacco' (Com2) products. On the other hand, no change in consumption levels of 'electricity, gas and water supply' (Com5) and 'financial services (including real estate services)' (Com8) occurred.

**Figure 7.1 – Tracing the impact of an increase in consumption taxes**




Meanwhile, government's revenue increased by 1.6 percent such that overall government consumption also increased by 1.5 percent. This increase was reflected in consumption for all commodities except for 'food, beverages and tobacco' (Com2) and 'textiles and wearing apparel' (Com3). This is explained by the fact that their respective shares in the government's consumption budget amounted to zero

**Table 7.4 Simulation 5: Impact of variables at a micro level**

| Commodity/Sector | Price of composite goods | Capital demand | Labour demand | Gross domestic output | Consumption | Investment | Imports | Government Consumption |
|---|---|---|---|---|---|---|---|---|
| 1 | -0.80 | -0.60 | -1.70 | -0.90 | -0.60 | 0.00 | -1.10 | 1.40 |
| 2 | -0.70 | -1.80 | -2.70 | -2.20 | -2.40 | 0.00 | -1.50 | 0.00 |
| 3 | -0.60 | -3.40 | -4.80 | -4.20 | -2.90 | 0.00 | -2.60 | 0.00 |
| 4 | -0.70 | -0.50 | -2.00 | -1.20 | -3.60 | -0.10 | -1.10 | 1.70 |
| 5 | -0.70 | -0.30 | -1.70 | -1.00 | 0.00 | 0.00 | -1.60 | 1.60 |
| 6 | -0.80 | -0.10 | -1.60 | -0.70 | -0.60 | 0.00 | -1.00 | 1.80 |
| 7 | -0.80 | 0.10 | -1.30 | -0.50 | -0.40 | 0.00 | -0.60 | 1.70 |
| 8 | -0.90 | 0.40 | -1.10 | 0.00 | 0.00 | 0.10 | -0.70 | 1.80 |
| 9 | -0.50 | 1.50 | 0.00 | 0.50 | -0.50 | -0.30 | 1.40 | 1.40 |
| T | | | -1.30 | -0.90 | -1.50 | 0.00 | -1.10 | 1.50 |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

At the second level (indirect effects), the tax exclusive prices and output (and import) levels must fall for the markets to clear, leading to a reduction in demand for intermediate consumption and primary factors by industry. Indeed, tax-exclusive prices fell for all products, reflecting the drop in the consumption level of the various commodities as well as developments in government consumption expenditure and investment. It is interesting to note that the price of taxed commodities increased relative to the benchmark level, but not by the full amount of the tax. This highlights the importance of general equilibrium interactions.

The overall gross domestic output and import levels fell by 0.9 percent and 1.1 percent respectively, with the largest declines recorded in the 'manufacturing of food, beverages and tobacco' (Sec2) and the 'manufacturing of textiles and wearing apparel' (Sec3) sectors. The varying magnitudes of variation between the output and household consumption levels stem from the increase in government demand for most commodities following the increase in tax revenue generated by the increase in consumption tax. In particular, it is noticeable that whilst the largest drop in household consumption was recorded in the 'other manufacturing' (Sec4) sector, the decline in gross domestic output was greater in 'manufacturing of food, beverages and tobacco' (Sec2) and 'manufacturing of textiles and wearing apparel' (Sec3) reflecting the fact that sectors 2 and 3 had a zero budgetary share in government consumption expenditure. Albeit the drop recorded in household consumption and investment demand, gross domestic output and imports recorded by the 'education, health and social work' (Sec9) sector increased reflecting the increase in government consumption of commodities produced by that industry. Whilst the government's increase in demand for commodities is also true for other sectors, the share in government consumption with respect to commodities produced by sector 9 (and 8) is significantly greater than that of other commodities. This explains the increase (and non-decrease) in the gross domestic output of the two sectors.

As the levels of gross domestic output declined, the demand for factors of production followed suit. In line with the decline in gross domestic production, labour and capital demand decreased in most sectors. The decline in the demand for both factors was mitigated by the increase in government demand for the respective factor. Whilst it is assumed that there is full employment of resources in the capital market, the labour market allows for unemployment. Part of the decline in labour demand was in fact reflected in an increase of 1.0 percentage point in unemployment to stand at 7.5 percent. These developments were reflected in falling household income level as the increase in transfers from government (3.3 percent) following the increase in unemployment was not enough to compensate for the decline in demand for capital and labour and their respective prices.

### 7.2.2 Decrease in taxes on income by 1 percent of GDP (simulation 6)

Table 7.5 shows that such a policy change is estimated to bring about an increase in GDP of around 0.1 percent with an improvement in money metric utility amounting to almost 1 percent of GDP. It is noticeable that the change in GDP generated by an increase in the consumption tax is greater (albeit in the opposite direction) than the change brought about by reducing the income tax. Government's income from tax revenue declined by 2.5 percent and is reflected in a significantly lower share in GDP. The drivers of growth are in this case attributed to consumption and investment. Consequently, there is a reallocation of resources away from the 'education, health and social work' (Sec9) and 'financial services' sectors towards all other sectors, most notably the 'manufacturing of food, beverages and tobacco' (Sec2), 'manufacturing of textiles and wearing apparel' (Sec3) and 'other manufacturing' (Sec4) sectors. The impact of this policy change is shown in Tables 7.5 and 7.6.

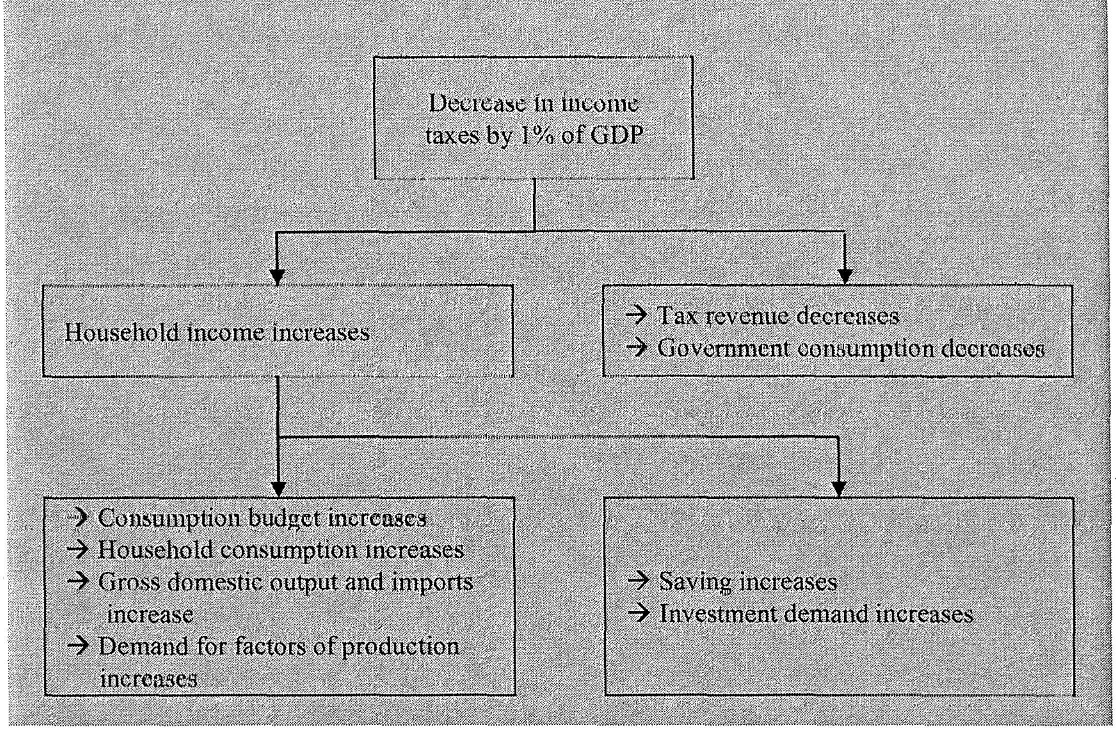
**Table 7.5 - Simulation 6: Impacts on variables at an aggregate level**

| | |
|---|---|
| **GDP** | 0.1 % |
| **Household income** | 0.2 % |
| **Household Consumption Budget** | 1.3 % |
| **Tax Revenue** | -2.5 % |
| **Transfers to household** | 1.0 % |

*Source: Authors' calculation using the Malta GETM* *% change from baseline*

A graphical representation tracing the institution's responses throughout the economy is given by Figure 7.2. The direct impact of a decrease in the ITR on income entails an increase in household income (0.2 percent) and consequently a larger consumption budget (1.3 percent) and household savings (1.1 percent). Since the marginal propensity to save is constant, investment took up approximately 21 percent of the net of tax increase in income. The increases recorded in investment reflected increases in the demand for commodities produced by the 'other manufacturing' (Sec4), 'financial services' (Sec8) and 'education, health and social work' (Sec9) sectors. Meanwhile, government's revenue from taxation fell by 2.5 percent leading to lower government consumption levels (4.0 percent).

**Figure 7.2 – Tracing the impact of a decrease in income taxes**




The increase in the consumption budget brought about an increase in the consumption of all products whose marginal budgetary share in the household's LES utility function is greater than zero. The greatest increases were recorded in 'manufacturing of food, beverages and tobacco' (Sec2) and 'other manufacturing' (Sec4) sectors simply because the marginal budgetary share of 'food, beverages and tobacco' (Com2) and 'other manufacturing' (Com4) products is relatively higher than that of other commodities. Meanwhile, no increase in consumption was recorded in the consumption of 'electricity, gas and water supply' (Com5) and 'financial services' (Com8) because their marginal budgetary share was equal to zero. It is important to note that in case of commodities for which the price elasticity of demand is perfectly inelastic, the subsistence consumption constitutes the entire expenditure on that commodity (see equation 5.5). Consequently, the marginal budgetary share would be zero.

**Table 7.6 – Simulation 6: Impact on variables at a micro level**

| Commodity/Sector | Price of composite goods | Capital demand | Labour demand | Sales of composite commodity | Gross domestic output | Domestic output delivered to home market | Consumption | Investment | Imports | Government Consumption |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.30 | 0.90 | 1.40 | 1.10 | 1.00 | 1.00 | 1.10 | 0.00 | 1.10 | -4.50 |
| 2 | 0.30 | 1.50 | 1.90 | 1.70 | 1.70 | 1.70 | 1.80 | 0.00 | 2.60 | 0.00 |
| 3 | 0.20 | 1.90 | 2.40 | 1.60 | 2.20 | 1.90 | 0.60 | 0.00 | 1.40 | 0.00 |
| 4 | 0.30 | 0.70 | 1.20 | 0.80 | 0.90 | 0.90 | 1.20 | 1.10 | 0.80 | 4.10 |
| 5 | 0.30 | 0.20 | 0.70 | 0.50 | 0.50 | 0.50 | 0.00 | 0.00 | 0.00 | -4.10 |
| 6 | 0.30 | 0.40 | 0.30 | 0.60 | 0.60 | 0.60 | 1.10 | 0.00 | 0.60 | -4.10 |
| 7 | 0.30 | 0.20 | 0.80 | 0.40 | 0.50 | 0.40 | 0.70 | 0.00 | 0.40 | -4.10 |
| 8 | 0.30 | -0.20 | 0.30 | 0.00 | -0.10 | 0.00 | 0.00 | 1.00 | 0.10 | -4.20 |
| 9 | 0.20 | -2.60 | 2.10 | 2.30 | -2.20 | -2.30 | 0.60 | 1.20 | -2.60 | -4.00 |
| T | | 0.10 | 0.10 | 0.40 | 0.40 | 0.20 | 1.00 | 1.10 | 0.90 | -4.00 |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

Following the increase in consumption of most products, the prices of composite commodities rose across all sectors, including sectors 5 and 8 The increase in the price of these two composite commodities can be explained by the increase recorded in final demand expenditure, most notably investment.

At the same time, the increase in household consumption generated an overall increase in domestic output delivered to the domestic market of 0.2 percent. From a sectoral perspective, domestic output registered increases in line with developments in final expenditure. The decline in output recorded by the 'financial services' (Sec9) sector is due to the sector's share in government's decline in consumption expenditure. It is also interesting to note that the decline in the sales of 'education, health and social work' (Com9) commodities was accompanied by a 0.2 percent increase in the price of the commodity produced by the very same sector. This is explained by the fact that government's expenditure on particular composite commodities is not directly dependent on price developments, but rather on the amount of tax revenues generated.

The increase in household consumption expenditure also increased the demand for imported commodities (except sector 9). Indeed, overall imports increased by 0.9

percent when compared to the benchmark level. As imports together with gross domestic output constitute the supply of composite commodities, the developments in terms of import by the various sectors were in line with the changes observed in gross domestic output, and hence also with household consumption expenditure.

Developments in industries' capital and labour demand were in line with the changes recorded in gross domestic production. A reallocation of resources is noticeable towards those sectors in which gross domestic production increased, mainly away from 'financial services' (Com8) and 'education, health and social work' (Com9) towards 'manufacturing of food, beverages and tobacco' (Com2) and 'manufacturing of textiles and wearing apparel' (Com3) sectors. The sectoral increases in capital and labour demand were dependent upon the distribution parameters of capital and labour in the industries' CES production functions[12]. For example, an increase in gross domestic production in sector 1 led to an increase in capital which was larger in share than the increase in labour. On the contrary, the larger share of the decline in sector 9's gross domestic output was accounted for by labour demand.

### 7.2.3 Removal of import levies (simulation 7)

Estimates show that such a policy change should bring about an increase in GDP of around 0.3 percent and an improvement in household welfare of 0.7 percent of benchmark GDP. Tax revenue declined by 0.9 percent and consequently so did government consumption. Meanwhile, a reallocation of resources towards the 'manufacturing of textiles and wearing apparel' (Sec3) is also noted. The impact of removing import levies is shown in Tables 7.7 and 7.8 and reflected graphically in Figure 7.3.

**Table 7.7 - Simulation 7: Impacts on variables at an aggregate level**

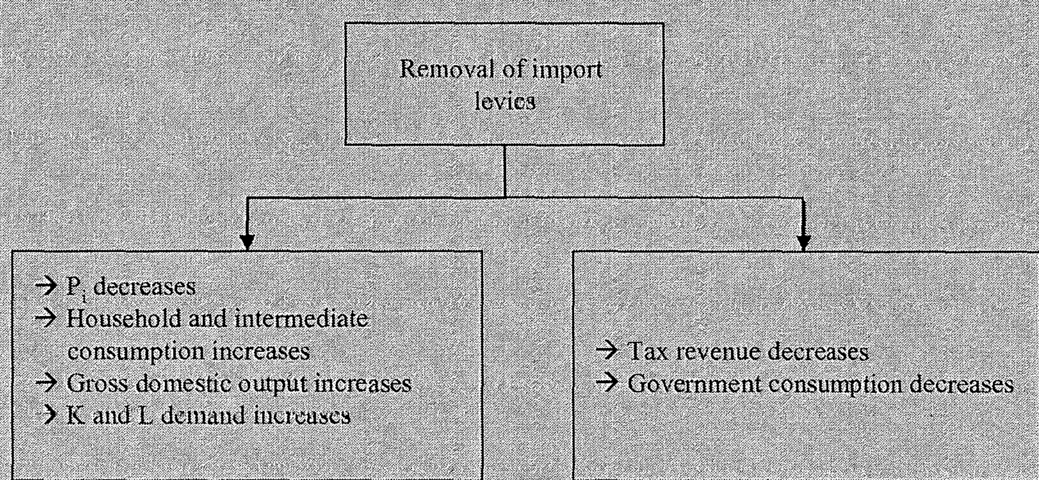
| | |
|---|---|
| GDP | 0.3 % |
| Household income | 0.3 % |
| Household Consumption Budget | 0.3 % |
| Tax Revenue | -0.9 % |
| Transfers to household | -1.4 % |

*Source: Authors' calculation using the Malta GETM* — *% change from baseline*

[12] Since percentage changes from the base could be misleading, absolute change were observed.

The elimination of taxes on imports results in a decline in the price of composite commodities that the households face, causing overall consumption of the composite commodity to increase by 0.6 percent (see Table 7.8). The increase in the purchases of composite commodities is higher in those sectors which are taxed relative to non-taxed sectors as reflected in the 'agriculture, fishing and quarrying' (Sec1), 'manufacturing of food, beverages and tobacco' (Sec2) and 'other manufacturing' (Sec3) sectors. It is only those commodities which account for large shares in government consumption expenditure that experience a fall in demand due to lower tax revenues. Mainly this reflects two changes. First, it reflects the increase in household consumption for those commodities whose price elasticity of demand is greater than zero (that is, not perfectly elastic). Second, the lower price of imports – which is ultimately reflected in a lower price for composite commodities – has an effect on the cost of intermediate consumption used by the various industries, particularly those with a high marginal propensity to import. This is particularly reflected by the domestic output delivered to the home market in sector 3 as it increases by 5 percent compared to a 3.6 percent increase in the imports of the same commodity.

**Figure 7.3 – Tracing the impact of the removal of import levies**




The relative price of imports of commodities which are subject to tax is now lower than that of domestic commodities. For the given elasticities of substitution (ranging from 1.75 to 2.89) and the decline in import prices, the increase in import demand is substantially higher relative to the change in demand for domestically produced commodities. This is most evident for those sectors whose imported commodities were subject to high import levies.

**Table 7.8 - Simulation 7: Impacts on variables at a micro level**

| Commodity/Sector | Price of composite goods | Prices of imports | Capital demand | Labour demand | Sales of composite commodity | Gross domestic output | Domestic output delivered to home market | Consumption | Investment | Imports | Government Consumption |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -0.70 | -3.40 | -1.10 | -0.60 | 0.60 | -0.90 | -0.90 | 0.70 | 0.00 | 6.50 | -0.40 |
| 2 | -1.00 | -1.90 | -0.30 | 0.10 | 1.10 | -0.10 | -0.20 | 1.50 | 0.00 | 3.70 | 0.00 |
| 3 | -1.90 | -1.80 | 8.30 | 9.00 | 4.10 | 8.70 | 5.00 | 1.00 | 0.00 | 3.60 | 0.00 |
| 4 | 0.20 | -0.30 | 0.60 | 1.20 | 0.70 | 0.90 | 0.50 | 0.60 | 0.50 | 0.80 | -0.50 |
| 5 | 0.30 | 0.10 | 0.60 | 1.20 | 0.90 | 0.90 | 0.90 | 0.00 | 0.00 | 0.00 | -1.10 |
| 6 | 0.30 | 0.10 | 0.10 | 0.70 | 0.50 | 0.30 | 0.40 | 0.20 | 0.00 | 0.90 | -1.00 |
| 7 | 0.20 | 0.10 | -0.30 | 0.30 | 0.10 | 0.00 | 0.00 | 0.20 | 0.00 | 0.30 | -0.90 |
| 8 | 0.30 | 0.10 | -0.50 | 0.10 | 0.00 | -0.30 | -0.20 | 0.00 | 0.00 | 0.50 | -1.00 |
| 9 | 0.10 | -1.00 | -0.90 | -0.40 | -0.30 | -0.50 | -0.50 | 0.20 | 0.30 | 2.80 | -0.80 |
| T | 0.00 | | 0.00 | 0.60 | 0.60 | 0.50 | 0.10 | 0.60 | 0.50 | 1.40 | 0.80 |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

It is also noticeable that as gross domestic output rises, overall labour demand also rises (0.6 percent), particularly in those sectors which benefit the most from lower prices for their intermediate consumption, that is, the 'manufacturing of textiles and wearing apparel' (Sec3), the 'other manufacturing' (Sec4) sector and the 'electricity, gas and water supply' (Sec5) sector. Meanwhile, overall capital demand remains unchanged, but with a reallocation of resources away from those sectors that produce products for which demand has fallen and towards those sector for which gross domestic output has increased, most notably the 'manufacture of textiles and wearing apparel' (Sec3) sector.

As a result of increasing household and industry demand, on aggregate, imports increased by 1.4 percent, with the largest changes experienced by those sectors in which the ITR on imports was highest. In particular instances, the lower priced imports acted as a substitute to gross domestic output as evidenced mainly in 'agriculture, fishing and mining' (Sec1), 'manufacturing of food, beverages and tobacco' (Sec2) and 'education, health and social work' (Sec9) sectors.

### 7.2.4 The "new" tax policy mix (simulation 8)

Simulation 8 brings together measures implemented by the Maltese government since 2001 in an attempt to identify the winners and losers of the "new" tax policy mix and the resulting impact on welfare and GDP. These include an increase in consumptions taxes of approximately 1 percent of GDP, a decrease in consumption taxes of approximately 1 percent of GDP and the removal of import levies. The impact of these policy changes is shown in Table 7.9 and Table 7.10.

**Table 7.9 - Simulation 8: Impacts on variables at an aggregate level**

| | |
|---|---|
| **GDP** | -0.2% |
| **Household Income** | -0.3% |
| **Household Consumption Budget** | 0.9% |
| **Tax Revenue** | -1.8% |
| **Transfers to household** | 2.8% |

*Source: Authors' calculation using the Malta CGETM* — *% change from baseline*

When compared to the benchmark level, the GDP resulting from the "new" tax policy mix fell by 0.2 percent. However, it is suggested that the Maltese households are actually better off in terms of welfare by approximately 0.1 percent of GDP. This reflects the resulting increase in overall consumption (0.2 percent) which is, in turn, the result of decline in both consumption and import taxes. The other driver of economic growth was the increase in investment. The seemingly contrasting outcome of an increase in welfare while GDP declined is explained by the fall in overall government consumption (3.3 percent) as its revenue from taxes fell by 1.8 percent.

**Table 7.10 - Simulation 8: Impact on variables at a micro level**

| Commodity/Sector | Price of composite goods | Capital demand | Labour demand | Gross domestic output | Consumption | Investment | Imports | Government Consumption |
|---|---|---|---|---|---|---|---|---|
| 1 | -1.20 | -0.70 | -0.99 | -0.78 | 1.22 | 0.00 | 6.51 | -2.76 |
| 2 | -1.40 | -0.58 | -0.81 | -0.69 | 0.83 | 0.00 | 3.02 | 0.00 |
| 3 | -2.30 | 6.54 | 6.14 | 6.31 | -0.14 | 0.00 | 2.29 | 0.00 |
| 4 | -0.70 | 0.78 | 0.40 | 0.60 | -1.92 | 1.58 | 0.46 | -2.88 |
| 5 | -0.20 | 0.53 | 0.18 | 0.36 | 0.00 | 0.00 | 0.00 | -3.40 |
| 6 | -0.20 | 0.35 | -0.03 | 0.20 | 0.69 | 0.00 | 0.56 | -3.31 |
| 7 | 0.30 | 0.10 | 0.27 | 0.06 | 0.47 | 0.00 | 0.11 | -3.26 |
| 8 | -0.20 | -0.29 | -0.67 | -0.40 | 0.00 | 1.12 | -0.03 | -3.31 |
| 9 | -0.20 | -1.99 | -2.35 | -2.24 | 0.23 | 1.18 | 1.56 | -3.33 |
| T | | 0.07 | -0.51 | 0.08 | 0.20 | 1.56 | 0.94 | 3.27 |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

Most of the increase in final demand was catered for by an increase in imports (0.9 percent), as a result of both the removal of import taxes and Malta's high marginal propensity to import. However, gross domestic output also increased by 0.1 percent, thereby increasing the demand for capital (0.1 percent). However, a drop in overall employment was recorded such that the unemployment rate stood at 7.3 percent. Consequently, transfers to household increased, further depressing the government's consumption budget.

Overall, the new tax policy mix also resulted in a reallocation of resources mainly towards the 'manufacturing of textiles and wearing apparel' (Sec3) and the 'other manufacturing' (Sec4) sectors from 'education, health and social work' (Sec9).

### 7.2.5 A note on the generation of tax revenue and behavioural responses

Table 7.11 shows that following the reduction of tax rates on income (simulation 6) and imports (simulation 7), the behavioural response of the various institutions raised taxable income. Indeed, when no behavioural response is considered, the reductions in tax rates on income and imports would have resulted in declines of Lm17.1 million and Lm6.5 million respectively. However, the tax revenue declined by only Lm12.7 million and Lm4.6 million when the institutions' behavioural responses were incorporated into the analysis. Therefore, while any tax rate cut that could completely pay for itself would be unusual, this study showed that taxpayer behaviour can offset a substantial portion of estimated revenue loss. The same affect is observable in the opposite direction in simulation 5 as consumption tax increases by 1% of GDP.

**Table 7.11 - Impact on tax revenue**

| | Tax revenue change in no behavioural response case | Tax revenue change in case of behavioural response |
|---|---|---|
| **Simulation 5** | 18.8 | 7.8 |
| **Simulation 6** | 17.1 | 12.7 |
| **Simulation 7** | -6.5 | -4.6 |

*Source: Author's calculations* *Lm million*

## 7.3 SENSITIVITY ANALYSIS

This section gives an overview of the results of a number of sensitivity analysis tests obtained with the aim of testing the underpinnings of the Malta GETM. The elasticity parameter values used in the Malta GETM (see Section 6.1) are subject to error and change. In order to understand the implications of these potential changes or errors on conclusions drawn from the model in Sections 7.1 and 7.2, the robustness of the model is tested by means of sensitivity analysis of the results to eight sets of substitution elasticities between labour and capital, between domestic supplies and imports and between domestic supplies and exports. Thus, this section helps to gauge the correctness of the assumed elasticity values.

The procedure used for conducting sensitivity analysis was to construct a range around the central estimate of the parameters used in the main model and conduct eight simulations, in each of which every elasticity value is varied by either plus of minus a particular range, keeping all other elasticities fixed. For simplicity, the results of the conducted experiments are compared to levels and changes in gross domestic output in the baseline scenario.

Chart 7.1 shows the sensitivity of gross domestic output to assumptions made on the elasticity between capital and labour. The model appears to be quite robust to changes in the elasticity values between capital and labour. However, it is observed that the costs of an increase in consumption taxes (simulation 5) are higher in an economy which has a high elasticity of substitution between capital and labour. At the same time, the gains from decreasing income (simulation 6) and import (simulation 7) taxes are higher for an economy with a relatively high elasticity of substitution between the two variables. It is also noted, that gross domestic output level is more sensitive to the reduction in consumption taxes than it is in the case of changes in income and import taxes (see Chart 7.2).

Chart 7.1 - Sensitivity Analysis w.r.t. elasticity of substitution between capital and labour (absolute)

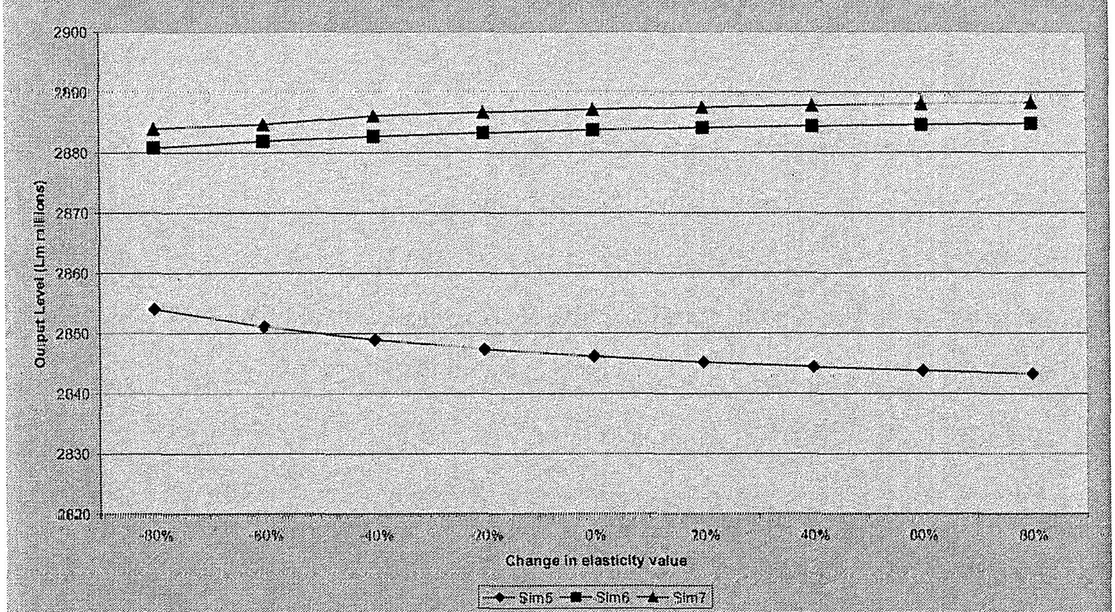
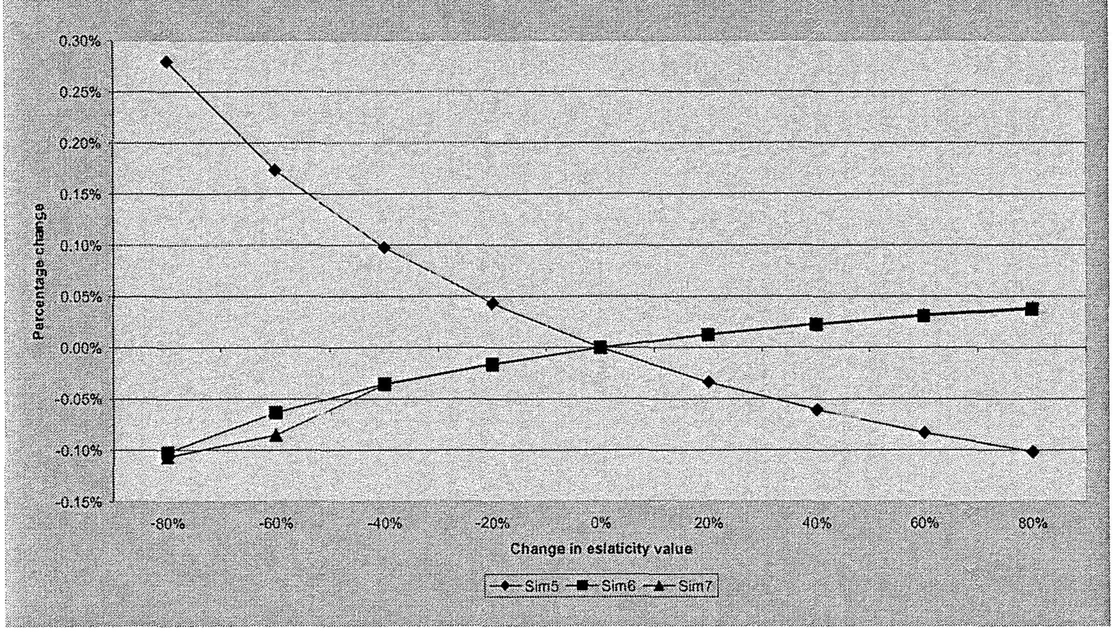



Chart 7.2 - Sensitivity Analysis w.r.t. elasticity of substitution between capital and labour (percentage)



Sensitivity analysis results with respect to elasticities of substitution between domestic supplies and imports are shown in Chart 7.3 and 7.4. As the elasticity between the two parameters is varied by -80 percent to +80 percent, the changes in the gross domestic output level does not exceed 0.03 percent, suggesting that the results generated by the Malta GETM are robust. However as the elasticity of substitution increases, the costs of increasing consumption taxes and the gains of

Chart 7.3 - Sensitivity Analysis w.r.t. elasticity of substitution between domestic supply and imports (absolute)

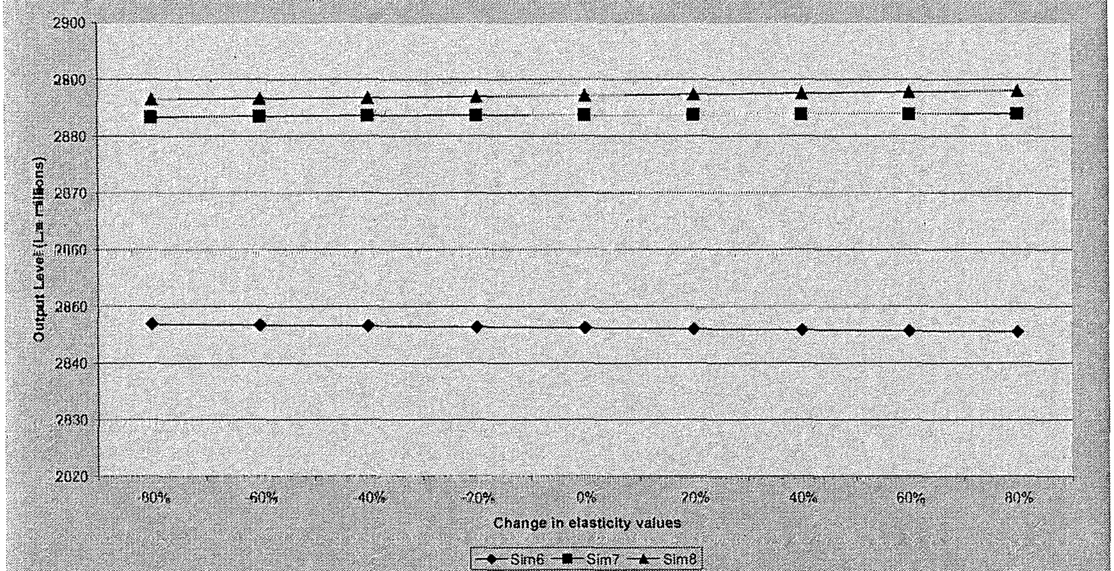
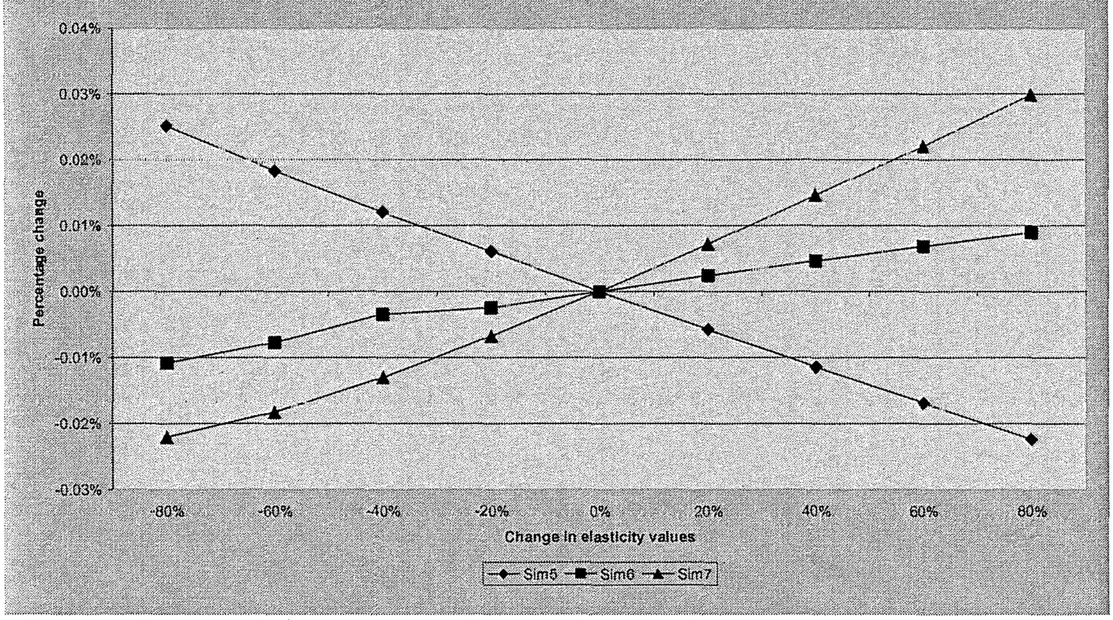


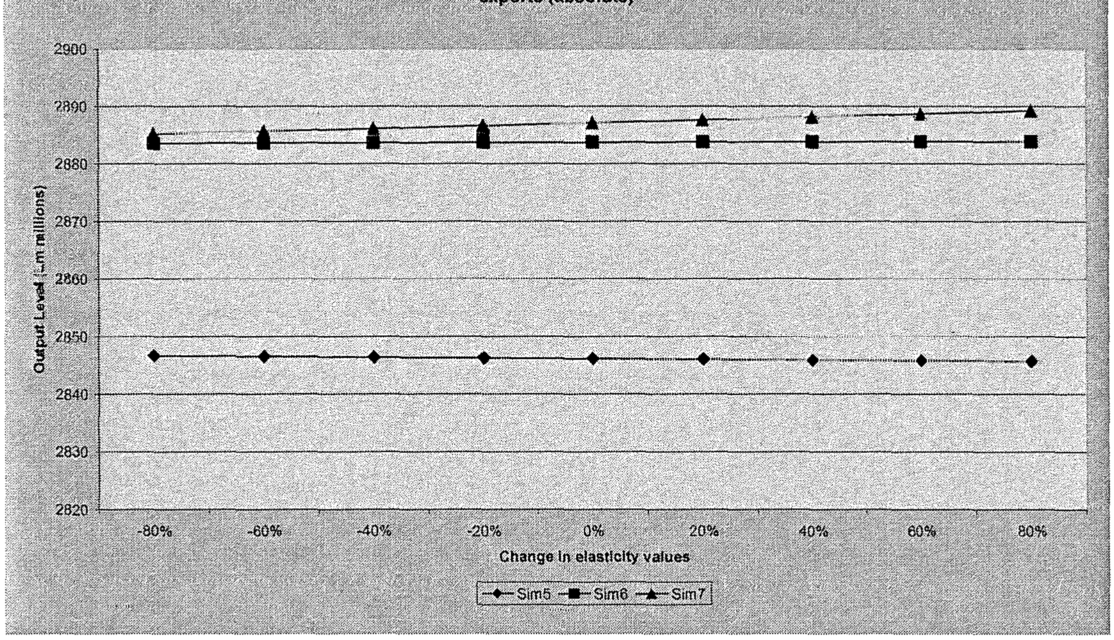

Chart 7.4 - Sensitivity Analysis w.r.t. elasticity of substitution between domestic supply and imports (percentage)

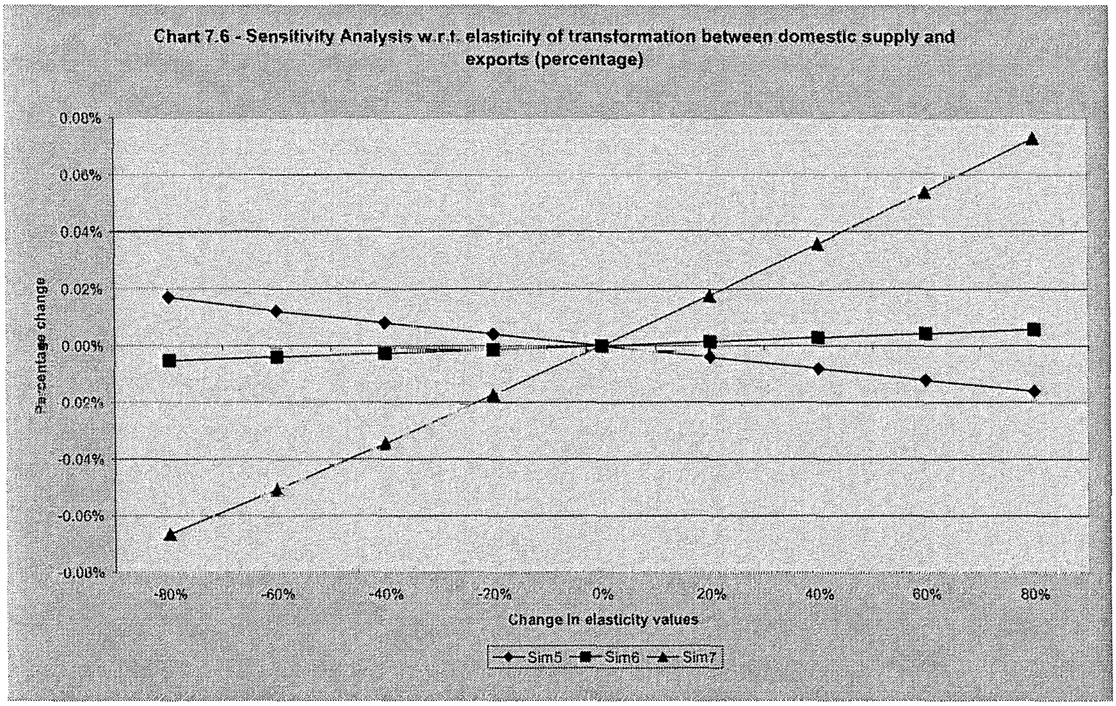


reducing income and import taxes increase. In line with a priori expectations, Chart 7.4 reveals that taxes on consumption and imports tend to be more sensitive to changes in elasticity values assigned to the Armington CES function simply because both taxes have a direct impact on prices of composite commodities while taxes on income do not.

The robustness of the results obtained in Sections 7.1 and 7.2 have also been tested with respect to variations in the elasticity of transformation between domestic supply and exports. Once again the results obtained appear to be robust (see Chart 7.5). Furthermore, it is observed that the cost of increasing taxes on consumption tends to be greater for higher elasticity values. The positive effects on output for lower income and import taxes are also higher for higher elasticity values between domestic supply and exports. It is also noted that the sensitivity to these elasticity values is greater for changes in import taxes than for taxes on income and consumption (see Chart 7.6).

Chart 7.5 Sensitivity Analysis w.r.t. elasticity of transformation between domestic supply and exports (absolute)






Overall, it can be concluded that the results generated by the Malta GETM in Section 7.1 and Section 7.2 are robust and almost linear as commonly found in literature[13]. This information is extremely valuable in policy analysis as it allows for a significant degree of confidence in recommending policy changes.

[13] See Bhattarai and Okyere (2005)

# Chapter Eight

# CONCLUSIONS AND POLICY RECOMMENDATIONS

This study sought to provide an overview of the fundamentals of CGE modelling by addressing issues related to the construction and logic of a SAM for the Maltese economy, followed by a description of the formulation, numerical calibration and solution of the Malta GETM. It has been put into practice in an attempt to quantitatively analyse the distortionary impacts created by the presence of taxes in the Maltese economy and the affects of major tax policy measures implemented by the Maltese government since 2001. These include an increase in consumption taxes by 1 percent of GDP, a decrease in income taxes by 1 percent of GDP and the removal of import levies. The approach adopted uses comparative static analysis by calculating differences between the baseline solution and the counterfactual solution.

At this point a cautionary note is warranted. Models such as this one often have lurking within them several key driving forces that originate in their SAM database, algebraic structure and parameter assumptions, but whose influence on the model's results remain hidden and open to misattribution. On this line of thought, an attempt was made to challenge the results until they were in accordance with economic logic and intuition. Furthermore, it should be noted that the model's usefulness in policy analyses owes less to its predictive accuracy, and more to its ability to shed light on the economic mechanisms through which price and quantity adjustments are transmitted amongst markets. This generates a great amount of information which has been summarised in the following sections.

## 8.1 EFFICIENCY AND IMPACT ANALYSIS OF MALTA'S TAX POLICY

In line with studies based on past experience (see Feldstein, 2006), the study concludes that cutting taxes stimulates economic activity. The behavioural changes raise taxable incomes, and that in turn reduces the revenue cost of lowering tax rates. While any tax rate cut that could completely pay for itself would be unusual, this study showed that taxpayer behaviour can offset a substantial portion of estimated revenue loss.

From a tax efficiency perspective, the presence of either consumption or income taxes had an impact of similar size on government's tax revenue collections, but the distortionary costs created by the former by far outweighed those created by the latter. This result is a reflection of the direct impact on prices brought about by changes in consumption tax. However, it should be noted that the relatively lower distortionary impact created by income taxes is probably a consequence of the inability of the model to cater for the choice between work and leisure.

Results also suggest that the distortionary impact of consumption taxes tends to fall more heavily on GDP and consumption levels. However, the level of investment seems to be more sensitive to the imposition of a tax on income rather than on consumption. This result stems from the fact that under the income tax system, the tax liability is incurred before the individual decides what to do with his money. This is not true in the case of consumption taxes. Here the tax liability is created only when the income is spent.

Meanwhile, the overall distortion (in terms of welfare) created by import taxes in the Maltese economy in 2001 is lower than the distortion created by either the consumption or income taxes, reflecting the fact that its share in government revenue is relatively smaller. From a viewpoint of its effect on macroeconomic variables, the removal of import taxes would increase GDP more than the removal of income taxes would, but less than consumption taxes.

Thus, the results derived from the Malta GETM reveal that generating a given amount of tax revenue is more distortionary in the form of consumption and import taxes than in the form of income taxes because of their direct effect on commodity prices. On the other hand, investment appears to be more sensitive to changes in income tax. Indeed, the conclusion reached from a tax efficiency perspective would have to be reversed if the model was reformulated to incorporate endogenous growth as reductions in income tax increase investment and in turn generate higher GDP growth.

Provided with insight with respect to the relative merits and demerits of the various tax instruments analysed, the impacts of the actual measures implemented by the Maltese government since 2001 were estimated. A change in the rate of any tax instrument – subject to experiment in this study – has a direct impact on government revenue and household consumption. The effect on these variables initiates a series of second round effects bringing change in output per industry, resulting in a reallocation of resources (in terms of capital and labour) from those industries whose output decreases towards those industries whose output increases. The final effect will then determine the welfare of households, the improvement of which should be the ultimate goal of any policy measure. The four experiments conducted in this regard yielded the following conclusions.

First, it is suggested that increasing the tax rate on consumption by 1 percent of GDP would have reduced the GDP by 0.8 percent. As prices increase, household consumption falls, resulting in a reallocation of resources from the 'manufacturing of food, beverages and tobacco' and 'manufacturing of textiles and wearing apparel' sectors towards the 'education, health and social work' and the 'financial services' sectors. In this case, government revenue increased by 1.6 percent.

Second, according to the results derived from the Malta GETM, the lower tax rates on income in the Maltese economy relative to the 2001 ITR could have increased GDP by around 0.1 percent while tax revenue declined by 2.5 percent. Whilst in the previous experiment negative growth was driven by a decline in consumption levels following an increase in the tax rate on consumption, contributions to economic growth are in this case attributed to improvements in both consumption and investment levels. These developments should have led to a reallocation of resources away from 'education, health and social work' and the 'financial services' sectors towards 'manufacturing of food, beverages and tobacco', 'manufacturing of textiles and wearing apparel' and 'other manufacturing' sectors. It can thus be concluded that the developments observed by simulating an increase in consumption taxation and a reduction in income taxation resulted in similar reallocation effects in the opposite direction.

The third major experiment was aimed to estimate the impact brought about by the removal of import levies. The results generated by the Malta GETM suggest that GDP could have increased by around 0.3 percent and consequently so would the welfare of the Maltese households. While the increase in GDP exceeds that generated by a reduction in the income tax rate, the welfare improvements are significantly lower. This is explained by a relatively small increase in household consumption (0.6 percent) and a relatively small decline in government consumption (0.8 percent). The latter contributes to Malta's GDP, but has no direct effect on household welfare. As a result reallocation of resources towards the 'manufacturing of textiles and wearing apparel' sector is also noted.

The impacts of the "new" tax policy mix resulting from the implementation of all three measures together were estimated to reduce GDP by 0.2 percent. However, it is suggested that Maltese households are actually better off in terms of welfare by approximately 0.1 percent of GDP reflecting the overall increase in household consumption. The other driver of economic growth was investment. The seemingly contrasting outcome of an increase in welfare while GDP declined is explained by the fall in overall government consumption (3.3 percent) as its revenue from taxes fell by 1.8 percent. Overall, it is also suggested that the new tax policy mix resulted in a reallocation of resources mainly towards the 'manufacturing of textiles and wearing apparel' (Sec3) and the 'other manufacturing' (Sec4) sectors from 'education, health and social work' (Sec9).

The reallocation towards 'manufacturing of textiles and wearing apparel' seems to contrast the actual developments experienced by the Maltese economy in recent years. However, comparisons of this type are not considered to be appropriate, particularly because a number of other exogenous effects have influenced the performance of the Maltese economy during this period. The emergence of the Chinese and Indian economies as major competitors to Malta's manufacturing industry is just one of many. Therefore, as pointed out earlier, this type of modelling is not intended as a forecasting tool, but rather to shed light on the direction and extent of change recorded by endogenous variables within the Malta GETM following the implementation of a *particular* policy change.

From a theoretical perspective, a number of points stand out from these experiments:

- First, it is interesting to note that the reaction to the increase in the consumption tax rate is greater for those commodities in which both the relative increase in price and the price elasticity of demand are relatively higher when compared to other commodities.

- Second, the (tax-inclusive) price of taxed commodities increased relative to the benchmark level, but not by the full amount This highlights the importance of general equilibrium interactions.

- Third, following a reduction in income tax rates, the increase in the consumption budget brought about an increase in consumption of all products whose marginal budgetary share in the household's LES utility function is greater than zero. These happen to be those products whose price elasticity of demand is not perfectly inelastic and consequently subsistence consumption does not constitute the entire expenditure on that commodity.

- And lastly, the increase in consumption for commodities following the removal of import levies is higher for those products to which an import levy applied relative to non-taxed sectors. The sectors that benefit most from this reform are those sectors with a high marginal propensity to import.

## 8.2 SENSITIVITY ANALYSIS

The robustness of the results outlined above was checked by means of a sensitivity analysis. The impacts for varying values of elasticities of substitution between capital and labour, domestic supply and imports, and domestic supply and exports reveal that the results generated by the Malta GETM are quite robust.

The analysis has also provided further insight into the possible effects of varying elasticities of substitution. First, it is observed that the distortionary costs and benefits of changes in taxation are higher in an economy with high elasticities of substitution, be it between labour and capital or between domestic supplies and imports or between domestic supplies and exports. Second, it is noticeable that the gross domestic output level is more sensitive to changes in consumption taxes than for income and import taxes for varying levels of elasticity of substitution between capital and labour. Third, taxes on consumption and imports tend to be more sensitive to changes in elasticity values between domestic supplies and imports than income taxes. Fourth, the sensitivity to varying values of the elasticity of substitution between domestic supplies and exports is greater for changes in import taxes than for income and consumption taxes.

## 8.3 POLICY RECOMMENDATIONS

The conclusions reached from the conducted experiments constitute the basis for providing advice to policy makers as how to best use tax policy as a tool to meet the government's goals outlined in Chapter One, that is, to generate sufficient tax revenue and to promote economic growth. However, the improved performance of the economy as a whole must not undermine the well-being of specific sectors or households in the economy. This section highlights how the conclusions reached in the discussion above can be used to meet these goals Recommendations are based on results derived from this study alone, ignoring the possibility of alternative assumptions. The robustness of the results outlined in the previous section allows for a significant degree of confidence in recommendations. The possibility of changes in taxes on imports is not considered here because EU rules do not allow the imposition of such levies.

It can be said that reductions in tax rates of any tax instrument are likely to boost Malta's *economic activity* The conclusions reached above suggest that the gains are likely to be higher when the measures implemented are in the form of a reduction in consumption tax. However, consumption led growth is not the best of news for a small, open economy like Malta's that depends heavily on foreign trade. In these circumstances, a reduction on income taxes may be more ideal if the policy maker is aiming for investment led growth.

From the perspective of generating *tax revenue*, income and consumption taxes appear to be equally effective. However, it should be noted that the imposition of any tax will bring about a change in behaviour of the various agents in the economy. With this in mind, the results outlined above suggest that a tax on consumption of commodities for which demand is highly inelastic is likely to generate relatively higher tax revenues for the government simply because household consumption of that commodity will respond relatively less to changes in the tax-inclusive price. However, the targeting of such commodities with the aim of reducing "harmful" consumption may prove unsuccessful.

Whilst the two goals of boosting economic activity and generating sufficient tax revenue – were up to now addressed individually in this section, reality calls for the achievement of both goals simultaneously. Whilst striking a balance between the two is merely the policy makers' job, it should be pointed out that lower tax rates are likely to induce behavioural changes that raise taxable income, and this in turn reduces that cost of lowering tax rates. While the results showed that tax payer behaviour can offset substantial portions of estimated revenue loss, any tax rate cut that could completely pay for itself would be unusual. Thus, contrary to suggestions that such reforms may be self-financing, the results obtained in this study suggest the economy does benefit from such stimulus but at a much smaller pace than expected.

The conclusion outlined in Section 8.2 also reveals that higher elasticity values, for capital and labour in particular, are likely to amplify the effect of changes in taxation. This has important implications from a policy making perspective because elasticities of substitution tend to be higher in the long run. This means that a tax rate cut is likely to increase GDP relatively more in the long run when compared to the short run.

And finally, the conclusions outlined in Section 8.3 above highlight the usefulness of general equilibrium analysis for obtaining information on who gains and who looses following a policy change. Such information is revealed both in terms of agents (that is, industries and households) and in terms of aggregate macroeconomic variables. Therefore, it is recommended that general rather than partial equilibrium analysis is undertaken to evaluate the impact of major reforms in the Maltese economy to fully understand ultimate impact of the implemented measures.

## 8.4 LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH

The recommendations were based on the results generated by the Malta GETM presented in this study, which are in turn subject to a number of limitations that stem from the design and implementation of both the model and the experimental conditions under which it is simulated. For example, it is observable that most of the reallocation within the Maltese economy reflects changes in government's consumption. This deficiency results from the way in which the government institution has been incorporated into the Malta GETM. The use of a Cobb-Douglas utility function for its specification has the short-coming of not being able to account for government's "subsistence" consumption. This is particularly problematic in cases of public administration expenditure – mostly directed towards the 'education, health and social work' sector – which tends to be highly inelastic.

A second important limitation is the constancy of the net export position of the economy. A more realistic model would permit the trade balance to adjust in response to changes in aggregate income and domestic commodity prices relative to world prices. Such modification is likely to reveal important information given the dependence of the Maltese economy on external trade.

Another shortcoming is the treatment of both capital and labour as being in inelastic supply. Furthermore, both factors are modelled as homogenous, mobile factors whose input may be reallocated among industries in a frictionless manner as relative prices change. In reality, reductions in an activity are likely to entail substantial capital "scrap" and associated short sun costs.

Notwithstanding these limitations this study contributes by providing a detailed coverage of the multi-stage process of constructing a computable general equilibrium model, by providing further insight into the economic processes triggered by tax reform, and by setting the stage for further research. For example, if the policy maker requires better identification of the winners and losers of a policy change, the model could be extended to a multiple household model by incorporating data from a family expenditure. As for the recent suggestions made by the Maltese government that a reduction in labour income tax rates can actually increase tax revenue because people choose to work more and declare more income, the labour-leisure choice may be incorporated into the household's utility function.

Furthermore, this is a static model and useful only for comparative static analysis between two equilibria. It cannot say anything about the inter-temporal adjustment from one equilibrium to the next. In spite of this shortcoming the steady solutions of dynamic models are often close to comparative static results of static models.

## 8.5 CONCLUSION

Despite the limitations, this study produced interesting results in line with economic theory and intuition. In particular, it has shown how quantitative estimates of welfare and resource reallocation impacts can be obtained by an applied GETM, making possible the analysis of distortionary impacts created by the various tax instruments and identifying the winners and losers following a policy change. This study thus sets out a framework to aid tax policy formulation in the Maltese economy by providing insight into how this economic tool can be used to recognise the extent to which taxes change behaviours.

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# Appendix 1 - Simulation Results Using the Malta GETM

## A.1.1 - Social Accounting Matrix (SAM) for the Maltese Economy 2001

Lm 000s

| | | Agriculture, fishing and mining | Manufacturing of food, beverages and tobacco | Manufacturing of textiles and wearing apparel | Other manufacturing | Electricity, gas and water supply | Wholesale and retail trade; Hotels and restaurants | Transport, storage and communication | Financial intermediation; Real Estate Services | Education, health and social work | Agriculture, fishing and mining | Manufacturing of food, beverages and tobacco | Manufacturing of textiles and wearing apparel | Other manufacturing | Electricity, gas and water supply | Wholesale and retail trade; Hotels and restaurants | Transport, storage and communication | Financial intermediation; Real Estate Services | Education, health and social work | Capital | Labour | Household | Government | Tax on Commodities (VAT) | Tax on labour | Tax on capital | Import duties and levies | Tax on income | Investment | Rest of the World | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sectors | | | | | | | | | Commodities | | | | | | | | | Value Added | | | | Taxes | | | | | | | |
| | | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 | A24 | A25 | A26 | A27 | A28 | A29 | A30 |
| **Sectors** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Agriculture, fishing and mining | A1 | | | | | | | | | | 4247 | 34224 | 1184 | 7249 | | | | | | | | 114265 | 4546 | | | | | | | | 165716 |
| Manufacturing of food, beverages and tobacco | A2 | | | | | | | | | | 17084 | 35211 | | | | 11909 | | | | | | 257416 | | | | | | | | | 321620 |
| Manufacturing of textiles and wearing apparel | A3 | | | | | | | | | | 2515 | | 38254 | | | | | | | | | 81649 | | | | | | | | | 122418 |
| Other manufacturing | A4 | | | | | | | | | | 12786 | 14922 | 13478 | 428815 | | 14690 | 69570 | 1331 | 21162 | | | 209562 | 26512 | | | | | | 300871 | | 1113700 |
| Electricity, gas and water supply | A5 | | | | | | | | | | 3681 | 5359 | 4857 | 9765 | 4445 | 7890 | 778 | | 4373 | | | 14170 | 736 | | | | | | | | 56005 |
| Wholesale and retail trade, Hotels and restaurants | A6 | | | | | | | | | | 13651 | 13696 | 12451 | 25096 | 17332 | 12357 | 38919 | 6940 | 14217 | | | 103745 | 10027 | | | | | | | | 268432 |
| Transport, storage and communication | A7 | | | | | | | | | | 6740 | 11842 | | 32132 | | 41684 | 40373 | 18631 | 12585 | | | 101464 | 5889 | | | | | | | | 271339 |
| Financial intermediation; Real Estate Services | A8 | | | | | | | | | | 10383 | 15508 | | 38090 | 8177 | 46422 | 36144 | 66918 | 13673 | | | 120586 | 23063 | | | | | | 13524 | | 392489 |
| Education, health and social work | A9 | | | | | | | | | | 4619 | | 4719 | | | | 2087 | | 8862 | | | 104713 | 196791 | | | | | | 591 | | 322381 |
| **Commodities** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Agriculture, fishing and mining | A10 | 131780 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6691 | 138471 |
| Manufacturing of food, beverages and tobacco | A11 | | 163664 | | | | | | | | | | | | | | | | | | | | | | | | | | | 33717 | 197381 |
| Manufacturing of textiles and wearing apparel | A12 | | | 33295 | | | | | | | | | | | | | | | | | | | | | | | | | | 89010 | 122305 |
| Other manufacturing | A13 | | | | 329893 | | | | | | | | | | | | | | | | | | | | | | | | | 556939 | 886833 |
| Electricity, gas and water supply | A14 | | | | | 55942 | | | | | | | | | | | | | | | | | | | | | | | | 3261 | 59203 |
| Wholesale and retail trade; Hotels and restaurants | A15 | | | | | | 237960 | | | | | | | | | | | | | | | | | | | | | | | 165598 | 403558 |
| Transport, storage and communication | A16 | | | | | | | 196970 | | | | | | | | | | | | | | | | | | | | | | 174878 | 371848 |
| Financial intermediation; Real Estate Services | A17 | | | | | | | | 284270 | | | | | | | | | | | | | | | | | | | | | 68678 | 352948 |
| Education, health and social work | A18 | | | | | | | | | 298717 | | | | | | | | | | | | | | | | | | | | 40145 | 338862 |
| **Value Added** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Capital | A19 | | | | | | | | | | 35673 | 27547 | 13799 | 157381 | 10132 | 148143 | 90415 | 162591 | 70039 | | | | 15804 | | | | | | | | 731525 |
| Labour | A20 | | | | | | | | | | 10445 | 21627 | 18135 | 132384 | 8420 | 91977 | 66877 | 65828 | 153352 | | | | 80588 | | | | | | | | 649633 |
| **Household** | A21 | | | | | | | | | | | | | | | | | | | 731525 | 649633 | | 134518 | | | | | | | | 1515677 |
| **Government** | A22 | | | | | | | | | | | | | | | | | | | | | | | 121064 | 118971 | 123696 | 41623 | 93121 | | | 498475 |
| **Taxes** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tax on Commodities (VAT) | A23 | | 26017 | 13590 | 68334 | | | | 10346 | 2878 | | | | | | | | | | | | | | | | | | | | | 171065 |
| Tax on labour | A24 | | | | | | | | | | 6521 | 8650 | 8304 | 28329 | 6055 | 11140 | 12134 | 9154 | 28683 | | | | | | | | | | | | 118970 |
| Tax on capital | A25 | | | | | | | | | | 10126 | 8793 | 7125 | 27591 | 4641 | 17345 | 14602 | 21557 | 11916 | | | | | | | | | | | | 123696 |
| Import duties and levies | A26 | 5888 | 13225 | 7249 | 14061 | | | | | 1198 | | | | | | | | | | | | | | | | | | | | | 41623 |
| Tax on income | A27 | | | | | | | | | | | | | | | | | | | | | 93121 | | | | | | | | | 93121 |
| **Investment** | A28 | | | | | | | | | | | | | | | | | | | | | 314986 | | | | | | | | | 314986 |
| **Rest of the World** | A29 | 28044 | 118714 | 68284 | 701411 | 63 | 30472 | 74369 | 97972 | 19588 | | | | | | | | | | | | | | | | | | | | | 1138917 |
| **Total** | A30 | 165713 | 321620 | 122418 | 1113700 | 56005 | 268432 | 271339 | 392489 | 322381 | 138471 | 197381 | 122305 | 886833 | 59203 | 403558 | 371848 | 352951 | 338862 | 731525 | 649633 | 1515677 | 498475 | 121064 | 118971 | 123696 | 41623 | 93121 | 314986 | 1138917 | |

*Source: Author's Calculations*

## Table A.1.2 - Price of Composite Commodities

| | Commodity | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 4.6% | 1.7% | 5.8% | -4.0% | -0.8% | 0.3% | -0.7% | -1.2% |
| 2 | Manufacturing of food, beverages and tobacco | 3.0% | 1.6% | 5.3% | -5.2% | -0.7% | 0.3% | -1.0% | -1.4% |
| 3 | Manufacturing of textiles and wearing apparel | -2.3% | 1.2% | 4.3% | -10.2% | -0.6% | 0.2% | -1.9% | -2.3% |
| 4 | Other manufacturing | 5.6% | 1.5% | 5.1% | -1.3% | -0.7% | 0.3% | -0.2% | -0.7% |
| 5 | Electricity, gas and water supply | 7.8% | 1.5% | 5.2% | 1.4% | -0.7% | 0.3% | 0.3% | -0.2% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 8.7% | 1.7% | 5.8% | 1.5% | -0.8% | 0.3% | 0.3% | -0.2% |
| 7 | Transport, storage and communication | 7.7% | 1.5% | 5.4% | 1.0% | -0.8% | 0.3% | 0.2% | -0.3% |
| 8 | Financial intermediation; Real Estate Services | 9.2% | 1.8% | 6.2% | 1.5% | -0.9% | 0.3% | 0.3% | -0.2% |
| 9 | Education, health and social work | 4.3% | 0.9% | 3.2% | 0.3% | -0.5% | 0.2% | 0.1% | -0.2% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.3 - Price of Domestic Production

| | Commodity | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 7.8% | 1.7% | 5.9% | 0.1% | -0.8% | 0.3% | 0.0% | -0.5% |
| 2 | Manufacturing of food, beverages and tobacco | 6.3% | 1.6% | 5.4% | -1.0% | -0.7% | 0.3% | -0.2% | -0.6% |
| 3 | Manufacturing of textiles and wearing apparel | 3.6% | 1.3% | 4.4% | -2.8% | -0.6% | 0.2% | -0.5% | -0.9% |
| 4 | Other manufacturing | 6.5% | 1.5% | 5.1% | 0.0% | -0.7% | 0.3% | 0.0% | -0.4% |
| 5 | Electricity, gas and water supply | 7.7% | 1.5% | 5.2% | 1.3% | -0.7% | 0.3% | 0.3% | -0.2% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 8.1% | 1.6% | 5.6% | 1.1% | -0.8% | 0.3% | 0.2% | -0.3% |
| 7 | Transport, storage and communication | 7.5% | 1.5% | 5.3% | 0.8% | -0.7% | 0.3% | 0.2% | -0.3% |
| 8 | Financial intermediation; Real Estate Services | 9.4% | 1.8% | 6.3% | 1.6% | -0.9% | 0.3% | 0.3% | -0.2% |
| 9 | Education, health and social work | 4.3% | 1.0% | 3.3% | 0.7% | -0.5% | 0.2% | 0.1% | -0.2% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.4 - Price of Imports

| | Commodity | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | -6.1% | 1.6% | 5.1% | -17.0% | -0.7% | 0.2% | -3.4% | -5.3% |
| 2 | Manufacturing of food, beverages and tobacco | -0.6% | 1.6% | 5.2% | -9.6% | -0.7% | 0.3% | -1.9% | -2.3% |
| 3 | Manufacturing of textiles and wearing apparel | -0.4% | 1.5% | 5.2% | -9.2% | -0.7% | 0.3% | -1.8% | -2.3% |
| 4 | Other manufacturing | 5.4% | 1.6% | 5.2% | -1.6% | -0.7% | 0.3% | -0.3% | -0.7% |
| 5 | Electricity, gas and water supply | 6.8% | 1.6% | 5.2% | 0.4% | -0.7% | 0.3% | 0.1% | -0.3% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 6.8% | 1.6% | 5.2% | 0.4% | -0.7% | 0.3% | 0.1% | -0.3% |
| 7 | Transport, storage and communication | 6.8% | 1.6% | 5.2% | 0.4% | -0.7% | 0.3% | 0.1% | -0.3% |
| 8 | Financial intermediation; Real Estate Services | 6.8% | 1.6% | 5.2% | 0.4% | -0.7% | 0.3% | 0.1% | -0.3% |
| 9 | Education, health and social work | 2.5% | 1.6% | 5.2% | -5.4% | -0.8% | 0.3% | -1.0% | -1.4% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.5 - Capital Demand

| | Sector | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 4.3% | 5.1% | 3.6% | -5.9% | -0.6% | 0.9% | -1.1% | -0.7% |
| 2 | Manufacturing of food, beverages and tobacco | 20.0% | 8.5% | 12.3% | -1.4% | -1.8% | 1.5% | -0.3% | -0.6% |
| 3 | Manufacturing of textiles and wearing apparel | 108.9% | 10.8% | 28.3% | 67.0% | -3.4% | 1.9% | 8.3% | 6.5% |
| 4 | Other manufacturing | 8.5% | 3.8% | 5.3% | 1.2% | -0.5% | 0.7% | 0.6% | 0.8% |
| 5 | Electricity, gas and water supply | 9.2% | 1.3% | 2.3% | 5.1% | -0.3% | 0.2% | 0.6% | 0.5% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 3.8% | 2.1% | 0.6% | 1.1% | -0.1% | 0.4% | 0.1% | 0.4% |
| 7 | Transport, storage and communication | -2.7% | 1.6% | -1.3% | -2.3% | 0.1% | 0.2% | -0.3% | 0.1% |
| 8 | Financial intermediation; Real Estate Services | -6.6% | -1.2% | -3.0% | -2.8% | 0.4% | -0.2% | -0.5% | -0.3% |
| 9 | Education, health and social work | -30.3% | -14.4% | -12.8% | -4.4% | 1.5% | -2.6% | -0.9% | -2.0% |
| | Total | 1.1% | 0.6% | 0.4% | 0.1% | 0.0% | 0.1% | 0.0% | 0.1% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.6 - Labour Demand

| | Sector | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 17.2% | 7.6% | 12.2% | -3.9% | -1.7% | 1.4% | -0.6% | -1.0% |
| 2 | Manufacturing of food, beverages and tobacco | 32.1% | 10.7% | 19.9% | 0.3% | -2.7% | 1.9% | 0.1% | -0.8% |
| 3 | Manufacturing of textiles and wearing apparel | 143.5% | 14.2% | 42.3% | 71.7% | -4.8% | 2.4% | 9.0% | 6.1% |
| 4 | Other manufacturing | 26.4% | 7.0% | 16.9% | 4.1% | -2.0% | 1.2% | 1.2% | 0.4% |
| 5 | Electricity, gas and water supply | 20.8% | 4.3% | 12.9% | 7.9% | -1.7% | 0.7% | 1.2% | 0.2% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 21.0% | 5.2% | 11.6% | 3.9% | -1.6% | 0.3% | 0.7% | 0.0% |
| 7 | Transport, storage and communication | 13.4% | 4.3% | 9.5% | 0.5% | -1.3% | 0.8% | 0.3% | -0.3% |
| 8 | Financial intermediation; Real Estate Services | 9.4% | 2.0% | 8.0% | 0.0% | -1.1% | 0.3% | 0.1% | -0.7% |
| 9 | Education, health and social work | -18.7% | -11.7% | -3.3% | -1.8% | 0.0% | -2.1% | -0.4% | -2.4% |
| | Total | 13.6% | 1.1% | 9.5% | 3.5% | -1.3% | 0.1% | 0.6% | -0.5% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.7 - Sales of Composite Commodity

| | Commodity | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 14.8% | 5.9% | 6.3% | 3.3% | -0.9% | 1.1% | 0.6% | 0.7% |
| 2 | Manufacturing of food, beverages and tobacco | 31.9% | 9.5% | 15.9% | 6.3% | -2.3% | 1.7% | 1.1% | 0.5% |
| 3 | Manufacturing of textiles and wearing apparel | 67.0% | 8.9% | 23.8% | 30.2% | -2.9% | 1.6% | 4.1% | 2.5% |
| 4 | Other manufacturing | 16.6% | 4.6% | 9.6% | 2.9% | -1.1% | 0.8% | 0.7% | 0.4% |
| 5 | Electricity, gas and water supply | 17.4% | 2.7% | 7.4% | 6.6% | -1.0% | 0.5% | 0.9% | 0.4% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 12.5% | 3.4% | 5.5% | 3.5% | -0.8% | 0.6% | 0.5% | 0.3% |
| 7 | Transport, storage and communication | 6.0% | 2.5% | 3.7% | 0.3% | -0.5% | 0.4% | 0.1% | 0.0% |
| 8 | Financial intermediation; Real Estate Services | 1.1% | 0.1% | 1.6% | -0.4% | -0.3% | 0.0% | 0.0% | -0.3% |
| 9 | Education, health and social work | -22.3% | -12.8% | -7.1% | -1.3% | 0.6% | -2.3% | -0.3% | 1.2% |
| | Total | 12.3% | 2.5% | 6.7% | 3.3% | -0.9% | 0.4% | 0.6% | 0.5% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.8 - Gross Domestic Output

| | Sector | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 7.6% | 5.8% | 5.8% | -5.4% | -0.9% | 1.0% | -0.9% | -0.8% |
| 2 | Manufacturing of food, beverages and tobacco | 25.3% | 9.5% | 15.7% | -0.7% | -2.2% | 1.7% | -0.1% | -0.7% |
| 3 | Manufacturing of textiles and wearing apparel | 127.6% | 12.7% | 36.0% | 59.6% | -4.2% | 2.2% | 8.7% | 6.3% |
| 4 | Other manufacturing | 16.5% | 5.2% | 10.6% | 2.5% | -1.2% | 0.9% | 0.9% | 0.6% |
| 5 | Electricity, gas and water supply | 17.3% | 2.7% | 7.4% | 6.5% | -1.0% | 0.5% | 0.9% | 0.4% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 10.1% | 3.3% | 4.7% | 2.2% | -0.7% | 0.6% | 0.3% | 0.2% |
| 7 | Transport, storage and communication | 4.0% | 2.5% | 3.2% | -1.1% | -0.5% | 0.5% | 0.0% | -0.1% |
| 8 | Financial intermediation; Real Estate Services | -2.2% | -0.3% | 0.1% | -2.0% | 0.0% | -0.1% | -0.3% | -0.4% |
| 9 | Education, health and social work | -22.5% | -12.6% | -6.3% | -2.6% | 0.5% | -2.2% | -0.5% | -2.2% |
| | Total | 12.0% | 2.4% | 6.6% | 3.2% | -0.9% | 0.4% | 0.5% | 0.1% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.9 - Domestic Output Delivered to the Home Market

| | Sector | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 7.7% | 5.8% | 5.9% | -5.4% | -0.9% | 1.0% | -0.9% | -0.8% |
| 2 | Manufacturing of food, beverages and tobacco | 25.2% | 9.5% | 15.7% | -1.0% | -2.2% | 1.7% | -0.2% | -0.8% |
| 3 | Manufacturing of textiles and wearing apparel | 87.8% | 11.1% | 30.7% | 39.1% | -3.6% | 1.9% | 5.0% | 3.1% |
| 4 | Other manufacturing | 15.4% | 5.0% | 10.2% | 1.2% | -1.2% | 0.9% | 0.5% | 0.2% |
| 5 | Electricity, gas and water supply | 17.4% | 2.7% | 7.4% | 6.6% | -1.0% | 0.5% | 0.9% | 0.4% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 11.8% | 3.4% | 5.2% | 3.1% | -0.7% | 0.6% | 0.4% | 0.3% |
| 7 | Transport, storage and communication | 5.1% | 2.5% | 3.4% | -0.4% | -0.5% | 0.4% | 0.0% | 0.0% |
| 8 | Financial intermediation; Real Estate Services | -1.1% | -0.2% | 0.6% | -1.5% | -0.1% | 0.0% | -0.2% | -0.4% |
| 9 | Education, health and social work | -22.9% | -12.7% | -6.8% | -2.5% | 0.6% | -2.3% | -0.5% | -2.2% |
| | Total | 6.2% | 1.1% | 4.8% | 0.4% | -0.7% | 0.2% | 0.1% | -0.4% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.10 - Household Consumption

| | Commodity | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 13.0% | 5.9% | 3.8% | 4.3% | -0.6% | 1.1% | 0.7% | 1.2% |
| 2 | Manufacturing of food, beverages and tobacco | 35.8% | 10.1% | 17.3% | 8.4% | -2.4% | 1.3% | 1.5% | 0.8% |
| 3 | Manufacturing of textiles and wearing apparel | 34.2% | 6.2% | 16.9% | 8.7% | -2.9% | 0.5% | 1.0% | -0.1% |
| 4 | Other manufacturing | 47.4% | 6.8% | 34.3% | 2.9% | -3.6% | 1.2% | 0.6% | -1.9% |
| 5 | Electricity, gas and water supply | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 12.7% | 6.1% | 3.9% | 1.1% | -0.6% | 1.1% | 0.2% | 0.7% |
| 7 | Transport, storage and communication | 7.4% | 4.1% | 2.7% | 0.9% | -0.4% | 0.7% | 0.2% | 0.5% |
| 8 | Financial intermediation; Real Estate Services | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 9 | Education, health and social work | 8.0% | 3.4% | 3.7% | 0.9% | -0.5% | 0.5% | 0.2% | 0.2% |
| | Total | 21.8% | 5.9% | 11.6% | 3.8% | -1.5% | 1.0% | 0.6% | 0.2% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.11 - Investment

| | Commodity | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2 | Manufacturing of food, beverages and tobacco | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 3 | Manufacturing of textiles and wearing apparel | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 4 | Other manufacturing | 8.3% | 6.0% | 0.4% | 2.9% | -0.1% | 1.1% | 0.5% | 1.6% |
| 5 | Electricity, gas and water supply | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 7 | Transport, storage and communication | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 8 | Financial intermediation; Real Estate Services | 5.2% | 5.7% | -0.7% | 0.0% | 0.1% | 1.0% | 0.0% | 1.1% |
| 9 | Education, health and social work | 10.0% | 6.6% | 2.2% | 1.4% | -0.3% | 1.2% | 0.3% | 1.2% |
| | Total | 8.5% | 6.0% | 0.4% | 2.8% | 0.0% | 1.1% | 0.5% | 1.6% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.12 - Exports

| | Sector | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 6.3% | 5.6% | 4.7% | -5.0% | -0.7% | [illegible] | -0.8% | -0.5% |
| 2 | Manufacturing of food, beverages and tobacco | 26.2% | 9.5% | 15.4% | 1.0% | -2.2% | [illegible] | 0.2% | -0.3% |
| 3 | Manufacturing of textiles and wearing apparel | 141.6% | 15.3% | 37.9% | 30.3% | -4.4% | 2.3% | 10.0% | 7.5% |
| 4 | Other manufacturing | 17.2% | 5.4% | 10.8% | 3.3% | -1.3% | [illegible] | 1.1% | 0.8% |
| 5 | Electricity, gas and water supply | 15.5% | 2.8% | 7.4% | 4.7% | -1.0% | 0.5% | 0.6% | 0.1% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 7.7% | 3.1% | 3.9% | 0.8% | -0.6% | 0.6% | 0.1% | -0.5% |
| 7 | Transport, storage and communication | 2.9% | 2.7% | 3.0% | -1.8% | -0.3% | 0.6% | 0.0% | 0.0% |
| 8 | Financial intermediation; Real Estate Services | -6.6% | -0.8% | -2.0% | -4.3% | 0.3% | -0.1% | -0.7% | -0.6% |
| 9 | Education, health and social work | -19.5% | -11.6% | [illegible] | -3.1% | 0.0% | -2.0% | -0.6% | -2.6% |
| | Total | 20.8% | 4.4% | 9.5% | 7.4% | -1.2% | 0.8% | 1.3% | 0.8% |

*Source: Author's calculations using the Malta GETM* — *% change from baseline*

## Table A.1.13 - Imports

| | Commodity | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | 44.5% | 6.2% | 7.6% | 40.6% | -1.1% | 1.1% | 6.5% | 6.5% |
| 2 | Manufacturing of food, beverages and tobacco | 41.7% | 10.4% | 17.2% | 16.7% | -1.5% | 2.5% | 3.7% | 3.0% |
| 3 | Manufacturing of textiles and wearing apparel | 58.1% | 8.0% | 20.9% | 26.4% | -2.6% | 1.4% | 3.6% | 2.3% |
| 4 | Other manufacturing | 17.2% | 4.4% | 9.3% | 3.7% | -1.1% | 0.3% | 0.8% | 0.5% |
| 5 | Electricity, gas and water supply | 19.0% | 1.6% | 6.3% | 7.9% | -1.6% | 0.0% | 0.0% | 0.0% |
| 6 | Wholesale and retail trade; Hotels and restaurants | 18.0% | 3.7% | 7.3% | 6.7% | -1.0% | 0.6% | 0.9% | 0.6% |
| 7 | Transport, storage and communication | 8.5% | 2.4% | 4.2% | 2.0% | -0.6% | 0.4% | 0.3% | 0.1% |
| 8 | Financial intermediation; Real Estate Services | 7.6% | 0.8% | 4.6% | 2.8% | -0.7% | 0.1% | 0.5% | 0.0% |
| 9 | Education, health and social work | -18.7% | -14.3% | -11.9% | 16.1% | 1.4% | -2.6% | 2.3% | 1.6% |
| | Total | 20.9% | 4.5% | 9.6% | 7.4% | -1.1% | 0.9% | 1.4% | 0.9% |

*Source: Author's calculations using the Malta GETM* — *% change from baseline*

## Table A.1.14 - Government Consumption

| | Commodity | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Agriculture, fishing and mining | -43.5% | -23.3% | -16.7% | -0.2% | 1.4% | -4.5% | -0.4% | -2.8% |
| 2 | Manufacturing of food, beverages and tobacco | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 3 | Manufacturing of textiles and wearing apparel | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 4 | Other manufacturing | -43.8% | -22.9% | -15.8% | -2.5% | 1.7% | -4.1% | -0.5% | -2.9% |
| 5 | Electricity, gas and water supply | -45.0% | -23.0% | -15.9% | -5.2% | 1.6% | -4.1% | -1.1% | -3.4% |
| 6 | Wholesale and retail trade; Hotels and restaurants | -45.4% | -23.0% | -16.3% | -5.2% | 1.8% | -4.1% | -1.0% | -3.3% |
| 7 | Transport, storage and communication | -44.9% | -22.9% | -16.0% | -4.8% | 1.7% | -4.1% | -0.9% | -3.3% |
| 8 | Financial intermediation; Real Estate Services | -45.7% | -23.1% | -16.7% | -5.2% | 1.8% | -4.2% | -1.0% | -3.3% |
| 9 | Education, health and social work | -43.1% | -22.5% | -14.2% | -4.1% | 1.4% | -4.0% | -0.8% | -3.3% |
| | Total | -43.6% | -22.6% | -14.8% | -4.0% | 1.5% | -4.0% | -0.8% | -3.3% |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

## Table A.1.15 - Other Variable

| Variable | Sim1 | Sim2 | Sim3 | Sim4 | Sim5 | Sim6 | Sim7 | Sim8 |
|---|---|---|---|---|---|---|---|---|
| Consumption budget | 14.3% | 7.6% | 5.5% | 1.5% | -0.8% | 1.3% | 0.3% | 0.9% |
| Household income | 7.8% | 1.0% | 5.5% | 1.5% | -0.8% | 0.2% | 0.3% | -0.3% |
| Government capital demand | -47.9% | -23.7% | -19.0% | -6.0% | 2.2% | -4.3% | -1.2% | -3.2% |
| Government labour demand | -40.7% | -21.7% | -11.5% | -3.8% | 0.9% | -3.8% | -0.7% | -3.5% |
| Tax revenue | -35.5% | -14.4% | -14.1% | -5.0% | 1.6% | -2.5% | -0.9% | -1.8% |
| Transfers to households | -21.4% | 5.4% | -21.3% | -8.1% | 3.3% | 1.0% | -1.4% | 2.8% |
| Gross Domestic Product | 7.9% | 1.0% | 4.8% | 2.2% | -0.8% | 0.1% | 0.3% | -0.2% |
| Equivalent variation* | 20.5% | 5.3% | 11.4% | 3.6% | -1.5% | 0.9% | 0.7% | 0.1% |
| Compensating variation* | 18.3% | 5.4% | 10.5% | 3.5% | -1.5% | 0.9% | 0.7% | 0.1% |
| *Percent of GDP* | | | | | | | | |

*Source: Author's calculations using the Malta GETM* *% change from baseline*

# Appendix 2 – Mathematical Workings

## A.2.1 – The Household Institution

The household's constrained optimisation problem is to maximise its utility subject to its budget constraint. This is given by:

Max $$U_H = \prod_{i=1}^{n} (C_i - \mu H_i)^{\alpha_{H_i}}$$

Subject to

i. $$CB = \sum_{j=1}^{n} (1 + tc_j) P_j C_j$$

ii. $$C_i > \mu H_i \geq 0;\ \alpha_{H_i} > 0$$

The Lagrange function for the constrained optimisation problem is given by:

$$L(C_i, \lambda) = \prod_{i=1}^{n} (C_i - \mu H_i)^{\alpha_{H_i}} + \lambda \left( CB - \sum_{j=1}^{n} (1 + tc_j) P_j C_j \right)$$

The first order conditions for utility maximisation are:

$$\frac{dL(C_i, \lambda)}{dC_i} = \alpha_i (C_i - \mu H_i)^{-1} U - \lambda (1 + tc_i) P_i$$

$$\frac{dL(C_i, \lambda)}{d\lambda} = CB - \sum_{i=1}^{n} (1 + tc_i) P_i C_i$$

Using these equations, the demand equations for consumption were derived:

$$C_i = \mu H_i + \alpha_i \left( (1 + tc_i) P_i \right)^{-1} \left( CB - \sum_{j=1}^{n} (1 + tc_j) P_j \mu H_j \right)$$

## A.2.2 – The Industries Institution

The firm's constrained optimisation problem is to minimise its total cost subject to its production function. This is given by:

Minimise $$TC_i = (1+tk)P_K K + (1+tl)P_L L$$

Subject to i. $XD_i = F\left(\gamma K^{-\rho} + (1-\gamma)L^{-\rho}\right)^{-1/\rho}$

ii. $1 > \gamma_{F_i} > 0;\ \infty > \rho_{F_i} > 1$

The Lagrange function for the constrained optimisation problem is given by:

$$L(K,L,\lambda) = (1+tk)P_K K + (1+tl)P_L L + \lambda\left(XD_i - F\left(\gamma K^{-\rho} + (1-\gamma)L^{-\rho}\right)^{-1/\rho}\right)$$

The first order conditions for cost minimisation are:

$$\frac{dL(K,L,\lambda)}{dK} = (1+tk)P_K - \lambda\gamma K^{-(1+\rho)} F\left(\gamma K^{-\rho} + (1-\gamma)L^{-\rho}\right)^{-(1+\rho)/\rho}$$

$$\frac{dL(K,L,\lambda)}{dL} = (1+tl)P_L - \lambda(1-\gamma)L^{-(1+\rho)} F\left(\gamma K^{-\rho} + (1-\gamma)L^{-\rho}\right)^{(1+\rho)/\rho}$$

$$\frac{dL(K,L,\lambda)}{d\lambda} = XD_i - F\left(\gamma K^{-\rho} + (1-\gamma)L^{-\rho}\right)^{-1/\rho}$$

Using these equations, the demand equation for capital and labour were derived:

$$K_i = \gamma_i^{\sigma_i}\left((1+tk_i)P_K\right)^{-\sigma_i}\left(\gamma_i^{\sigma_i}\left((1+tk_i)P_K\right)^{1-\sigma_i} + (1-\gamma_i)^{\sigma_i}\left((1+tl_i)P_L\right)^{-\sigma_i}\right)^{\sigma_i/(1-\sigma_i)}\left(XD_i/F_i\right)$$

$$L_i = (1-\gamma_i)^{\sigma_i}\left((1+tl_i)P_L\right)^{-\sigma_i}\left(\gamma_i^{\sigma_i}\left((1+tk_i)P_K\right)^{1-\sigma_i} + (1-\gamma_i)^{\sigma_i}\left((1+tl_i)P_L\right)^{-\sigma_i}\right)^{\sigma_i/(1-\sigma_i)}\left(XD_i/F_i\right)$$

### A.2.3 The Investment Institution

The investment institution's constrained optimisation problem is to maximise its utility subject to its budget constraint. This is given by.

Max $U_I = \prod_{i=1}^{n} I_i^{\alpha_i}$

Subject to i. $S = \sum_{i=1}^{n} P_{D_i} I_i$

ii. $1 > \alpha_{I_i} > 0$

The Lagrange function for the constrained optimisation problem is given by:

$$L(I,\lambda) = \prod_{i=1}^{n} I_i^{\alpha_i} + \lambda\left(S - \sum_{i=1}^{n} P_{D_i} I_i\right)$$

The first order conditions (FOC) for utility maximisation are:

$$\frac{dL(I,\lambda)}{dI_i} = \alpha_i I_i{}^{1} U_I - \lambda P_{D_i}$$

$$\frac{dL(I,\lambda)}{d\lambda} = S \quad \sum_{i=1}^{n} P_{D_i} I_i$$

Using these equations, the demand equations for consumption were derived:

$$I_i = \alpha_{I_i} P_i^{-1} S$$

## A.2.4 – The Government Institution

The government's constrained optimisation problem is to maximise its utility subject to its budget constraint. This is given by:

Max $$U = \prod_{i=1}^{n} \left( CG_i^{\alpha_{CG_i}} \right) KG^{\alpha_{KG}} LG^{\alpha_{LG}}$$

Subject to i. $TAXR = TRANSF - (CPINDEX) S_G$

ii. $1 > \alpha_{CG_i} > 0$, $1 > \alpha_{KG_i} > 0$, $1 > \alpha_{LG_i} > 0$

The Lagrange function for the constrained optimisation problem is given by:

$$L(CG, KG, LG) = \prod_{i=1}^{n} \left( CG_i^{\alpha_{CG_i}} \right) KG^{\alpha_{KG}} LG^{\alpha_{LG}} + \lambda \left( TAXR - TRANSF - (CPINDEX) S_G \right)$$

The first order conditions for utility maximisation are:

$$\frac{dL(CG, KG, LG)}{dCG_i} = \alpha_{CG_i} \prod_{i=1}^{n} \left( CG_i^{\alpha_{CG_i}} \right) KG^{\alpha_{KG}} LG^{\alpha_{LG}} CG_i^{\alpha_{CG_i} - 1}$$

$$\frac{dL(CG, KG, LG)}{dKG} = \alpha_{KG_i} \prod_{i=1}^{n} \left( CG_i^{\alpha_{CG_i}} \right) KG^{\alpha_{KG} - 1} LG^{\alpha_{LG}}$$

$$\frac{dL(CG, KG, LG)}{dLG} = \alpha_{LG_i} \prod_{i=1}^{n} \left( CG_i^{\alpha_{CG_i}} \right) KG^{\alpha_{KG}} LG^{\alpha_{LG} - 1}$$

Using these equations, the demand equation for commodities, capital and labour were derived:

$$CGi = \alpha_{CG_i} P_i^{-1} \left( TAXR - TANSF - (CPINDEX) S_G \right)$$

$$KG = \alpha_{KG} P_i^{-1} \left( TAXR - TANSF - (CPINDEX) S_G \right)$$

$$IG = \alpha_{IG} P_i^{-1}\left(TAXR - TANSF - (CPINDEX)S_G\right)$$

## A.2.5 – The Rest of the World Institution

From a supply side perspective, the foreign sector's constrained optimisation problem is given by:

Min $\quad P_{M_i} M_i + P_{DD_i} XDD_i$

Subject to $\quad$ i. $X_i = A_i\left(\gamma_{A_i} M_i^{-\rho_{A_i}} + (1-\gamma_{A_i})XDD_i^{-\rho_{A_i}}\right)^{-1/\rho_{A_i}}$

ii. $1 > \gamma_{A_i} > 0;\ 1 > \rho_{A_i} > 0$

The Lagrange function for the constrained optimisation problem is given by:

$$L(M, XDD, \lambda) = P_{M_i} M_i + P_{DD_i} XDD_i + \lambda\left(X_i - A_i\left(\gamma_{A_i} M_i^{-\rho_{A_i}} + (1-\gamma_{A_i})XDD_i^{-\rho_{A_i}}\right)^{-1/\rho_{A_i}}\right)$$

The first order conditions are:

$$\frac{L(M, XDD, \lambda)}{dM} = P_{M_i} - \lambda\gamma M^{-(1+\rho)} A\left(\gamma_{A_i} M_i^{-\rho_{A_i}} + (1-\gamma_{A_i})XDD_i^{-\rho_{A_i}}\right)^{-(1+\rho)/\rho}$$

$$\frac{L(M, XDD, \lambda)}{dXDD} = P_{DD_i} - \lambda(1-\gamma)XDD^{-(1+\rho)} A\left(\gamma_{A_i} M_i^{-\rho_{A_i}} + (1-\gamma_{A_i})XDD_i^{-\rho_{A_i}}\right)^{-(1+\rho)/\rho}$$

$$\frac{L(M, XDD, \lambda)}{d\lambda} = X_i - A_i\left(\gamma_{A_i} M_i^{\rho_{A_i}} + (1-\gamma_{A_i})XDD_i^{\rho_{A_i}}\right)^{-1/\rho_{A_i}}$$

Using these equations, the demand equations for imports and domestic supply delivered to the home market were derived:

$$M_i = \gamma_{A_i}^{\sigma_{A_i}} P_{M_i}^{-\sigma_{A_i}} \left(\gamma_{A_i}^{\sigma_{A_i}} P_{M_i}^{1-\sigma_{A_i}} + (1-\gamma_{A_i})^{\sigma_{A_i}} P_{DD_i}^{1-\sigma_{A_i}}\right)^{\sigma_{A_i}/(1-\sigma_{A_i})} \left(X_i / A_i\right)$$

$$XDD_i = (1-\gamma_{A_i})^{\sigma_{A_i}} P_{DD_i}^{-\sigma_{A_i}} \left(\gamma_{A_i}^{\sigma_{A_i}} P_{M_i}^{1-\sigma_{A_i}} + (1-\gamma_{A_i})^{\sigma_{A_i}} P_{DD_i}^{1-\sigma_{A_i}}\right)^{\sigma_{A_i}/(1-\sigma_{A_i})} (X_i / A_i)$$

From a demand side perspective, the foreign sector's constrained optimisation problem is given by:

Max $\quad P_{E_i} E_i + P_{DD\,i} XDD_i$

Subject to $\quad$ i. $XD_i = T_i \left(\gamma_{T_i} E_i^{-\rho_{T_i}} + (1-\gamma_{T_i}) XDD_i^{-\rho_{T_i}}\right)^{-1/\rho_{T_i}}$

ii. $1 > \gamma_{T_i} > 0; \; 1 > \rho_{T_i} > 0$

The Lagrange function for the constrained optimisation problem is given by:

$$L(E, XDD, \lambda) = P_{E_i} E_i + P_{DD\,i} XDD_i + \lambda \left(XD_i - T_i \left(\gamma_{T_i} E_i^{\ \rho_{T_i}} + (1-\gamma_{T_i}) XDD_i^{\ \rho_{T_i}}\right)^{-1/\rho_{T_i}}\right)$$

The first order conditions are:

$$\frac{L(E, XDD, \lambda)}{dE} = P_{E_i} - \lambda \gamma E^{-(1+\rho)} T \left(\gamma_{T_i} E_i^{-\rho_{T_i}} + (1-\gamma_{T_i}) XDD_i^{-\rho_{T_i}}\right)^{-(1+\rho)/\rho}$$

$$\frac{L(E, XDD, \lambda)}{dXDD} = P_{DD_i} - \lambda (1-\gamma) XDD^{-(1+\rho)} T \left(\gamma_{T_i} E_i^{-\rho_{T_i}} + (1-\gamma_{T_i}) XDD_i^{-\rho_{T_i}}\right)^{-(1+\rho)/\rho}$$

$$\frac{L(E, XDD, \lambda)}{d\lambda} = XD_i - T_i \left(\gamma_{T_i} E_i^{-\rho_{T_i}} + (1-\gamma_{T_i}) XDD_i^{-\rho_{T_i}}\right)^{-1/\rho_{T_i}}$$

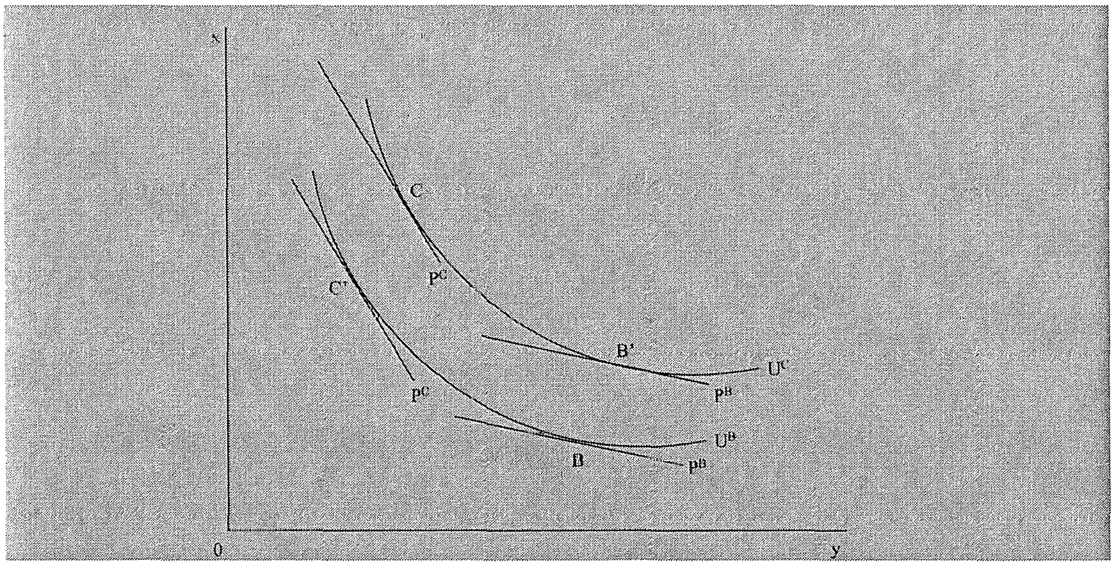
Using these equations, the demand equations for exports and domestic supply delivered to the home market were derived:

$$E_i = \gamma_{T_i}^{\sigma_{T_i}} P_{E_i}^{-\sigma_{T_i}} \left(\gamma_{T_i}^{\sigma_{T_i}} P_{E_i}^{1-\sigma_{T_i}} + (1-\gamma_{T_i})^{\sigma_{T_i}} P_{DD_i}^{1-\sigma_{T_i}}\right)^{\sigma_{T_i}/(1-\sigma_{T_i})} (X_i / T_i)$$

$$XDD_i = (1-\gamma_{T_i})^{\sigma_{T_i}} P_{DD_i}^{-\sigma_{T_i}} \left(\gamma_{T_i}^{\sigma_{T_i}} P_{M_i}^{1-\sigma_{T_i}} + (1-\gamma_{T_i})^{\sigma_{T_i}} P_{DD_i}^{1-\sigma_{T_i}}\right)^{\sigma_{T_i}/(1-\sigma_{T_i})} (X_i / T_i)$$

## A.2.6 – The Theory of Compensating and Equivalent Variations

The theory of compensating and equivalent variations draws upon Hick's (1939) well-known work on welfare comparisons. Assume a two-good economy and suppose that the initial (benchmark) prices were ($P^B$). After some policy change, new (counterfactual) prices ($P^C$) are observed assuming, for simplicity, that nominal income is unchanged. The figure below shows that a higher level of utility is attained after the policy change, since utility $U^C$ is further than $U^B$ from the origin.




A quantitative estimate of the size of the impact of a policy change is given by measuring the distance between the two indifference curves, at constant prices. Those prices could be final or initial ones. In case of the former, the measure is called the compensating variation (CV). It measures the amount of money required to bring a household back to the same level of utility as in the benchmark equilibrium following some policy changes. This can be written mathematically by:

$$CV = E(U^C, P^C) - E(U^B, P^C)$$

where *E(UC,PC)* is the expenditure necessary to achieve the level of utility $U^C$ at prices $P^C$.

The consumer's consumption bundle associated with the benchmark equilibrium is at *B*. The relative prices faced in the original equilibrium are given by the slope of the price line $P^B$. The new equilibrium, as a result of a policy change, moves the consumer to a preferred consumption point *C*. Associated with consumption at point *C* is a different set of equilibrium prices $P^C$. The calculation of CV begins at point *C*. The consumer's budget constraint is shifted from point C until a tangency point *C'* is reached with the original indifference curve. Compensating variation is the distance between the budget constraints tangent to the two points *C* and *C'* using price $P^C$.

The second measure is called the equivalent variation, calculating what would be the income change, at initial prices, that is welfare-equivalent to the observed change in prices. This can be written as:

$$EV - E(U^C, P^B) - E(U^B, P^O)$$

In the figure above, this is given by the distance between the budget constraints tangent to points B and B', each constructed using prices $P^B$. Point *B'* corresponds to the consumption point on the indifference curve achieved by the household in the new equilibrium, and is associated with a price line that is parallel to the budget constraint faced in the original equilibrium. A comparison between point *B* and *B'* illustrates how much the equilibrium change is equivalent to for this consumer. Thus, the difference between compensating and equivalent variation is the initial point of reference.

## A.2.7 – Applying EV and CV to the LES Utility Function

Estimates for different policy scenarios using monetary measures of welfare effects were used to obtain quantitative evaluations of how much better off or worse households are. The most common measures are the compensating (CV) and equivalent variation (CV), a detailed explanation of which is given in section A.2.6.

The compensating variation compares the benchmark utility level to that in the counterfactual scenario. It measures how much the consumer needs to be compensated to bring him/her back to the original utility level after the changes in the tax take place. Obtaining the indirect utility function for equation (5.5) and solving for income, gives the money metric indirect utility function m(P,v) which is a measure of the income needed to attain utility level v at the vector of prices P. Formally, the compensating variation can then be written as

$$CV = m\left(P_i^C, v\left(P_i^C, Y^C\right)\right) - m\left(P_i^B, v\left(P_i^B, Y^B\right)\right) = Y^C - m\left(P_i^C, v\left(P_i^B, Y^B\right)\right)$$

where superscripts $C$ represent the respective variables at the counterfactual equilibrium, superscripts $B$ represent the respective variables at the benchmark equilibrium and $v(P, Y)$ is the indirect utility function.

It follows that since the representative household is specified by an LES function, the CV is given by:

$$CV = SI^C - \prod_{i=1}^{n}\left(\frac{(1+tc^C)P_i^C}{(1+tc^B)P_i^B}\right)^{\alpha_{H_i}} SI^B$$

where $$SI^C = \left(\left(1-ty^C\right)Y^C - \sum_{i=1}^{n}\left(1+tc^C\right)P_i^C \mu H_i\right)$$

and $$SI^B = \left(\left(1-ty^B\right)Y^B - \sum_{i=1}^{n}\left(1+tc^B\right)P_i^B \mu H_i\right)$$

where $SI^C$ is the supernumerary income.

The equivalent variations are measured as a variation in the money metric utility in the counterfactual scenario in comparison to the benchmark scenario. It shows how much are the benefits from the tax change equivalent in terms of the original equilibrium. Formally this can be written as

$$EV = m\left(P_i^B, v\left(P_i^C, Y^C\right)\right) - m\left(P_i^B, v\left(P_i^B, Y^B\right)\right) = m\left(P_i^B, v\left(P_i^C, Y^C\right)\right) - Y^B$$

In the case of a LES, the equivalent variation is given by:

$$EV = \prod_{i=1}^{n}\left(\frac{(1+tc^B)P_i^B}{(1+tc^C)P_i^C}\right)^{\alpha_{H_i}} SI^C - SI^B$$

where $$SI^C = \left( \left(1 - ty^C\right)Y^C - \sum_{i=1}^{n} \left(1 + tc^C\right)P_i^C \mu H_i \right)$$

and $$SI^B = \left( \left(1 - ty^B\right)Y^B - \sum_{i=1}^{n} \left(1 + tc^B\right)P_i^B \mu H_i \right)$$

# Appendix 3 - Implementation of Malta GETM in GAMS

```
Sets      sec   commodities       /sec1*sec9 / ;

Alias     (sec,secc) ;


* Declaration of scalars and assignment of values

Scalars
  PKZ           Initial return to capital                          / 1 /
  PLZ           Initial wage rate                                  / 1 /
  ERZ           Initial exchange rate                              / 1 /
  KSZ           Initial capital endowment
  LSZ           Initial supply of labour
  YZ            Initial income level
  UZ            Initial utility level for the household
  CPIZ          Initial consumer price index (commodities)         / 1.00 /

  frisch        Initial value of Frisch parameter                  / 1.8 /
  phillips      Initial value of Phillips parameter                / -0.06 /

  SZ            Initial total savings
  SHZ           Initial household savings                          / 314.98568/
  SGZ           Initial government savings                         / 0.00 /
  SFZ           Initial foreign savings                            / 0.00 /
  CBZ           Initial household expenditure
  UNZ           Initial involuntary unemployment                   / 45.16167/
  KGZ           Initial government capital demand                  / 15.80384/
  LGZ           Initial government labour demand                   / 80.58809/

  TRYZ          Initial income tax revenues                        / 93.12085/
  TAXRZ         Initial total tax revenues
  tyz           Initial tax rate on income
  ty            Tax rate on income
  replc         Replacement rate                                   / 0.50 /
  TRANSFZ       Initial total transfers                            / 134.51835/
  OTRZ          Initial other transfers                            / 111.93755/  ;


* Declaration of parameters and assignment of values

Parameters
  PDZ(sec)      Initial price of domestic output of firm(sec)          /sec1*sec9  1/
  PZ(sec)       Initial price of domestic sales of composite commodities
                                                                            /sec1*sec9   1 /
  PDDZ(sec)     Initial price of domestic output delivered to home market
                                                                            /sec1*sec9   1 /
  PWEZ(sec)     Initial world price of exports                              /sec1*sec9   1 /
  PWMZ(sec)     Initial world price of imports                              /sec1*sec9   1 /


  sigmaA(sec)   Initial substitution elasticities of Armington function
             /  sec1  2.12
                sec2  1.75
                sec3  2.80
```

sec4 2.80
sec5 2.63
sec6 2.80
sec7 2.80
sec8 2.89
sec9 2.80 /

sigmaT(sec) Initial elasticities of transformation in CET function
/ sec1 -1.46
sec2 -1.20
sec3 -1.92
sec4 -1.92
sec5 -1.80
sec6 -1.92
sec7 -1.92
sec8 -1.98
sec9 -1.92 /

sigmaF(sec) Initial CES capital-labour substitution-elasticities firm(sec)
/ sec1 0.900
sec2 0.740
sec3 1.180
sec4 1.180
sec5 1.110
sec6 1.180
sec7 1.180
sec8 1.220
sec9 1.180 /

elasY(sec) Initial income elasticities of demand for commodity(sec)
/ sec1 0.475
sec2 0.795
sec3 0.530
sec4 0.530
sec5 0.001
sec6 0.489
sec7 0.321
sec8 0.001
sec9 0.253 /

XZ(sec) Initial domestic sales of composite commodity(sec)
XDZ(sec) Initial gross domestic production (output) level firm(sec)
XDDZ(sec) Initial domestic production delivered to home markets
KZ(sec) Initial capital demand
LZ(sec) Initial labour demand

CZ(sec) Initial consumer demand for commodities and leisure
IZ(sec) Initial investment demand
EZ(sec) Initial export demand
MZ(sec) Initial import demand
PMZ(sec) Initial import price EX tariffs in local currency
PEZ(sec) Initial price of exports in local currency
IOZ(sec,secc) Initial intermediate commodity demand
CGZ(sec) Initial government commodity demand

TRCZ(sec) Initial tax revenue on consumer commodities
TRKZ(sec) Initial tax revenue on capital use
TRLZ(sec) Initial tax revenue on labour use
TRMZ(sec) Initial tax revenue on imports

tcz(sec) Initial tax rate on consumer commodities
tc(sec) Tax rate on consumer commodities
tk(sec) Tax rate on capital use
tl(sec) Tax rate on labour use
tm(sec) Tariff rate on imports

io(sec,secc) Technical coefficients

gammaF(sec) CES distribution parameter in the production function
F(sec) Efficiency parameter of CES production function
gammaA(sec) CES distribution parameter of Armington function
A(sec) Efficiency parameter of Armington function
gammaT(sec) CET distribution parameter regarding destination of domestic
T(sec) Shift parameter in the CET function of firm
alphaHLES(sec) Power in nested-ELES houschold utility function
mmH(sec) Subsistence household consumption quantities
mps Household's marginal propensity to save
alphaI(sec) Cobb-Douglas power in the bank's utility function
alphaCG(sec) Cobb-Douglas power in government utility function (C)
alphaKG Cobb-Douglas power in government utility function (K)
alphaLG Cobb-Douglas power in government utility function (L) ;

** Data on inter-industry commodity flows in the economy*

Table
IOZ(sec,secc)

| | sec1 | sec2 | sec3 | sec4 | sec5 | sec6 | sec7 | sec8 | sec9 |
|---|---|---|---|---|---|---|---|---|---|
| sec1 | 4.2469 | 34.2243 | 1.1835 | 7.24949 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| sec2 | 17.0841 | 35.2114 | 0.000 | 0.000 | 0.000 | 11.9093 | 0.000 | 0.000 | 0.000 |
| sec3 | 2.5151 | 0.000 | 38.2537 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| sec4 | 12.7862 | 14.9220 | 13.4784 | 428.815 | 0.000 | 14.6903 | 69.5698 | 1.3313 | 21.1618 |
| sec5 | 3.6805 | 5.3589 | 4.8571 | 9.76490 | 4.4454 | 7.8898 | 0.7283 | 0.000 | 4.3733 |
| sec6 | 13.6511 | 13.6965 | 12.4507 | 25.0961 | 17.3320 | 12.3573 | 38.9189 | 6.9397 | 14.2169 |
| sec7 | 6.7399 | 11.8423 | 0.000 | 32.1316 | 0.000 | 41.6841 | 40.3726 | 18.6314 | 12.5847 |
| sec8 | 10.3827 | 15.5081 | 0.000 | 38.0903 | 8.1766 | 46.4219 | 36.1444 | 66.9182 | 13.6735 |
| sec9 | 4.6190 | 0.000 | 4.7186 | 0.000 | 0.000 | 0.000 | 2.0868 | 0.000 | 8.8618 ; |

**Data on capital, labour, trade and consumer, investment and government demand and tax revenues*

Table
dataz(*,sec)

| | sec1 | sec2 | sec3 | sec4 | sec5 | sec6 | sec7 | sec8 | sec9 |
|---|---|---|---|---|---|---|---|---|---|
| KZ | 35.6735 | 27.5469 | 13.7991 | 157.381 | 10.1324 | 148.143 | 90.4153 | 162.591 | 70.0393 |
| LZ | 10.448 | 21.6271 | 18.1354 | 132.384 | 8.4203 | 91.9769 | 66.8765 | 65.8283 | 153.352 |
| CZ | 114.265 | 231.398 | 68.0593 | 141.228 | 14.1705 | 103.745 | 101.464 | 110.339 | 101.834 |
| IZ | 0.00001 | 0.00001 | 0.00001 | 300.871 | 0.00001 | 0.00001 | 0.00001 | 13.5238 | 0.59110 |
| EZ | 6.6906 | 33.7172 | 89.0101 | 556.939 | 3.2607 | 165.598 | 174.878 | 68.6781 | 40.1448 |
| MZ | 28.0441 | 118.714 | 68.284 | 701.411 | 0.0625 | 30.4719 | 74.3691 | 97.9723 | 19.5880 |
| CGZ | 4.5462 | 0.00001 | 0.00001 | 26.5119 | 0.7358 | 10.0274 | 5.8892 | 23.0630 | 196.791 |
| TRCZ | 0.000 | 26.0170 | 13.5900 | 68.3339 | 0.000 | 0.000 | 0.000 | 10.2464 | 2.8781 |
| TRKZ | 10.1261 | 8.7935 | 7.1247 | 27.5910 | 4.6410 | 17.3453 | 14.6018 | 21.5567 | 11.9159 |
| TRLZ | 6.5211 | 8.6505 | 8.3037 | 28.3290 | 6.0550 | 11.1403 | 12.1339 | 9.1537 | 28.6829 |
| TRMZ | 5.884 | 13.2253 | 7.2493 | 14.0613 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1983 ; |

** Reading data and assigning initial values*

KZ(sec) = dataz("KZ",sec) ;

```
  LZ(sec) = dataz("LZ",sec) ;
  CZ(sec) = dataz("CZ",sec) ;
  IZ(sec) = dataz("IZ",sec) ;
  EZ(sec) = dataz("EZ",sec) ;
  MZ(sec) = dataz("MZ",sec) ;
  CGZ(sec) = dataz("CGZ",sec)  ;
  TRCZ(sec) = dataz("TRCZ",sec) ;
  TRKZ(sec) = dataz("TRKZ",sec) ;
  TRLZ(sec) = dataz("TRLZ",sec) ;
  TRMZ(sec) = dataz("TRMZ", sec) ;


* Calculating tax revenue and tax rates

  TAXRZ    = sum(sec, TRCZ(sec) + TRKZ(sec) + TRLZ(sec) + TRMZ(sec) ) + TRYZ;

  tc(sec)  = TRCZ(sec)/(CZ(sec)*PZ(sec)  ) ;
  tk(sec)  = TRKZ(sec)/(KZ(sec)*PKZ ) ;
  tl(sec)  = TRLZ(sec)/(LZ(sec)*PLZ ) ;
  tcz(sec) = tc(sec) ;
  tm(sec)  = TRMZ(sec)/(MZ(sec)*PWMZ(sec)*ERZ)  ;


* Factor endowments

  KSZ  = sum(sec, KZ(sec)) + KGZ ;
  LSZ  = sum(sec, LZ(sec)) + LGZ + UNZ ;


* Domestic output

  XDZ(sec)  = sum(secc, ioz(secc,sec)) + KZ(sec) + TRKZ(sec) + LZ(sec) + TRLZ(sec) ;


* Domestic output supplied on the domestic markets

  XDDZ(sec)   = XDZ(sec) - EZ(sec) ;


* Supply of composite goods

  XZ(sec)    = XDDZ(sec) + MZ(sec) + TRMZ(sec);

display
    XDZ, XDDZ, XZ ;


* Income, consumer expenditure, savings, income tax

  YZ  = PKZ*KSZ + PLZ*(LSZ - UNZ) + TRANSFZ;
  ty  = TRYZ/YZ ;
  tyz = ty;
  CBZ  = sum(sec, CZ(sec)*PZ(sec)) + sum(sec, TRCZ(sec)) ;
  SHZ  = YZ - CBZ - TRYZ ;
  SZ = SHZ + SGZ*CPIZ + SFZ*ERZ ;
  mps  = SZ/(YZ - TRYZ)  ;

display CZ, YZ, tk, tl, tc, tm, ty  ;
```

```
* Technical coefficients

  io(sec,secc) = IOZ(sec,secc) / XDZ(secc) ;

* Parameters of LES utility function: commodities (6.31)

   alphaHLES(sec)    = elasY(sec)*(1 + tc(sec))*PZ(sec)*CZ(sec)/ CBZ ;

Scalar   aux   rescaling of marginal budget shares ;

   aux = sum(sec, alphaHLES(sec)) ;

   alphaHLES(sec) = alphaHLES(sec)/aux ;


* Calibration of muH

  muH(sec)  = CZ(sec) + alphaHLES(sec)*CBZ/( PZ(sec)*frisch*(1 + tc(sec)) ) ;


* Initial utility level

  UZ  =  prod(sec, (CZ(sec) - muH(sec))**alphaHLES(sec)) ;


*Parameters of CES production function

    gammaF(sec)  = 1/( 1 + ((1 + tl(sec))*PLZ)/((1 + tk(sec))*PKZ)
                      *(KZ(sec)/LZ(sec))**(-1/sigmaF(sec)) ) ;

    F(sec)      = XDZ(sec) /(  gammaF(sec)*KZ(sec)**
                    ( (sigmaF(sec)-1)/sigmaF(sec) ) +
                    (1 - gammaF(sec))*LZ(sec)**
                    ( (sigmaF(sec)-1)/sigmaF(sec) ) )
                     **( sigmaF(sec)/(sigmaF(sec) - 1) ) ;


* Definition of import and export prices

    PMZ(sec)  =  (1 + tm(sec))*PWMZ(sec)*ERZ  ;
    PEZ(sec) = PWEZ(sec)*ERZ ;


* Calibration of the parameters of the ARMINGTON function

    gammaA(sec)  = 1/( 1 + ( PDDZ(sec)/PMZ(sec) )*
                 ( MZ(sec)/XDDZ(sec) )**( -1/sigmaA(sec) ) )  ;

    A(sec)  = XZ(sec)/ ( gammaA(sec)*MZ(sec)**
                  ( (sigmaA(sec) -1)/sigmaA(sec) ) +
                  (1 - gammaA(sec))*XDDZ(sec)**
                  ( (sigmaA(sec)- 1)/sigmaA(sec) ) )
                  **(sigmaA(sec)/(sigmaA(sec) - 1) ) ;


*Calibration the parameters of the CET function

    gammaT(sec)  = 1/( 1 + ( PDDZ(sec)/(PEZ(sec)) )*
                 ( EZ(sec)/XDDZ(sec) )**( -1/sigmaT(sec) ) )  ;
```

```
T(sec) = XDZ(sec)/ ( gammaT(sec)*EZ(sec)**
            ( (sigmaT(sec) -1)/sigmaT(sec) ) +
            (1 - gammaT(sec))*XDDZ(sec)**
            ( (sigmaT(sec)- 1)/sigmaT(sec) ) )
            **(sigmaT(sec)/(sigmaT(sec) - 1) ) ;


* Parameters of the bank's Cobb-Douglas utility function

   alphaI(sec) = IZ(sec)*PZ(sec)/SZ ;


* Parameters of government Cobb-Douglas utility function

  alphaCG(sec) = PZ(sec)*CGZ(sec)/(TAXRZ - TRANSFZ - CPIZ*SGZ) ;
  alphaKG      = PKZ*KGZ/(TAXRZ - TRANSFZ - CPIZ*SGZ) ;
  alphaLG      = PLZ*LGZ/(TAXRZ - TRANSFZ - CPIZ*SGZ) ;

Display
        io
        elasY
        mps
        alphaI
        alphaHLES, muH
        gammaF, F
        alphaCG, alphaKG, alphaLG
        sigmaA, gammaA, A,
        sigmaT, gammaT, T;
```

**Variables**

| | |
|---|---|
| PK | Return to capital |
| PL | Wage rate |
| P(sec) | Prices of composite commodities and price of leisure |
| PD(sec) | Domestic producer prices of commodities |
| PDD(sec) | Price of domestic output delivered to home market |
| PE(sec) | Export prices in national currency |
| PM(sec) | Import prices in national currency |
| ER | Exchange rate |
| CPI | Consumer price index (commodities) |
| KS | Capital endowment (exogenous) |
| LS | Labour supply (endogenous) |
| X(sec) | Domestic sales composite commodity(sec) |
| XD(sec) | Gross domestic output |
| E(sec) | Exports |
| M(sec) | Imports |
| XDD(sec) | Domestic output delivered to home market |
| SF | Foreign savings |
| K(sec) | Capital demand |
| L(sec) | Labour demand |
| C(sec) | Consumer demand for commodities and leisure |
| CB | Consumer expenditure (commodities) |
| UN | Involuntary unemployment |
| Y | Household income |
| SH | Household savings |
| S | Total savings |
| I(sec) | Investment demand for commodities |
| SG | Government savings |
| CG(sec) | Public demand for commodities |

|  |  |
|---|---|
| KG | Government capital demand |
| LG | Government labour demand |
| TAXR | Tax revenues |
| TRANSF | Total transfers |
| OTR | Other transfers |
| HOF | Artificial objective variable ; |

Positive variables
PK, PL, P, PD, PDD, PE, PM, ER, KS, LS, X, XD, XDD, K, L, C, E, M,
CB, Y ,S, I, UN,CPI, CG, KG, LG, TRANSF, OTR ;

** Declaration of the model equations according to specifications in the Malta GETM*

**Equations**

* Household

|  |  |
|---|---|
| EQC(sec) | Consumer demand for commodity(sec) |
| EQSH | Household savings |

* Industries

|  |  |
|---|---|
| EQK(sec) | Capital demand function firm(sec) |
| EQL(sec) | Labour demand function firm(sec) |
| EQPROFIT(sec) | Zero profit condition for the firms |

* Investment

|  |  |
|---|---|
| EQS | Total savings |
| EQI(sec) | Investment demand function for commodities |

* Government

|  |  |
|---|---|
| EQCG(sec) | Government demand for commodities |
| EQKG | Government capital demand function |
| EQLG | Government labour demand function |
| EQTAXREV | Total tax revenues |
| EQTRANSFER | Total transfers |

* Imports and Exports

|  |  |
|---|---|
| EQEXPORT(sec) | Export supply |
| EQXDD (sec) | Domestic supply of domestic good |
| EQPROFITT(sec) | CET zero profit condition |
| EQIMPORT(sec) | Import demand |
| EQARMD(sec) | Demand for domestic goods |
| EQPROFITA(sec) | Armington zero profit condition |

* Market Clearing

|  |  |
|---|---|
| EQMARKETL | Market clearing for labour |
| EQMARKETK | Market clearing for capital |
| EQMARKETC(sec) | Market clearing for commodities |
| EQTRADEBAL | Balance of payments |

* Others

|  |  |
|---|---|
| EQEXPRICE(sec) | Export price equation |
| EQIMPRICE(sec) | Import price equation |

```
          EQCPI                 Laspeyres consumer index
          EQINCOME              Household income
          EQCB                  Household expenditure on commodities
          EQPHILLIPS            Wage curve

* Objective Function

          OBJECTIVE             Objective function ;

* Specification of Model Equations;

* Household

     EQC(sec)..    (1+tc(sec))*P(sec)*C(sec) =E= (1+tc(sec))*P(sec)*muH(sec)
                   + alphaHLES(sec)*(CB-sum(secc, muH(secc)*(1+tc(secc))*P(secc)));


     EQSH..        SH =E= mps*(Y - ty*Y) ;

* Industries

     EQK(sec)..    K(sec) =E= ( XD(sec)/F(sec) )*( gammaF(sec)/((1+tk(sec))*PK) )**sigmaF(sec)*
                   ( gammaF(sec)**sigmaF(sec)*((1+tk(sec))*PK)**(1-sigmaF(sec))
                   + (1-gammaF(sec))**sigmaF(sec)*((1+tl(sec))*PL)**(1-sigmaF(sec))
                   ) **( sigmaF(sec)/(1-sigmaF(sec)) ) ;

     EQL(sec)..    L(sec) =E= ( XD(sec)/F(sec) )*( (1-gammaF(sec))/((1+tl(sec))*PL) )
                   **sigmaF(sec)*( gammaF(sec)**sigmaF(sec)*((1+tk(sec))*PK)**(1-sigmaF(sec))
                   + (1-gammaF(sec))**sigmaF(sec)*((1+tl(sec))*PL)**(1-sigmaF(sec))
                   ) **( sigmaF(sec)/(1-sigmaF(sec)) ) ;


* Zero profit (implicit supply)

     EQPROFIT(sec)..     PD(sec)*XD(sec) =E= (1+tk(sec))*PK*K(sec) +(1+tl(sec))*PL*L(sec)
                         +sum(secc,io(secc,sec)*XD(sec)*P(secc)) ;

* Investment

       EQS..             S    =E= SH + SG*CPI + SF*ER ;
       EQI(sec)..        P(sec)*I(sec) =E= alphaI(sec)*S ;

* Government

       EQCG(sec)..       P(sec)*CG(sec) =E= alphaCG(sec)*(TAXR - TRANSF - SG*CPI) ;
       EQKG..            PK*KG     =E= alphaKG*(TAXR - TRANSF - SG*CPI) ;
       EQLG..            PL*LG     =E= alphaLG*(TAXR - TRANSF - SG*CPI) ;

       EQTAXREV..        TAXR      =E= ty*Y + sum(sec,(P(sec)*tc(sec)*C(sec)+
                         tk(sec)*K(sec)*PK + tl(sec)*L(sec)*PL +
                         tm(sec)*M(sec)*PWMZ(sec)*ER ) ) ;

       EQTRANSFER..      TRANSF =E= replc*PL*UN + OTR*CPI ;

* Foreign Sector

       EQEXPORT(sec)..   E(sec) =E= (XD(sec)/T(sec))*(gammaT(sec)/PE(sec))
```

```
                  **sigmaT(sec)*( (gammaT(sec)**sigmaT(sec))*
                  (PE(sec)**(1 - sigmaT(sec))) +((1 - gammaT(sec))
                  **sigmaT(sec))*(PDD(sec)**(1 - sigmaT(sec)))
                   ) **(sigmaT(sec)/(1 - sigmaT(sec))) ;

   EQXDD(sec)..   XDD(sec) =E= (XD(sec)/T(sec))*((1 - gammaT(sec))/PDD(sec))
                  **sigmaT(sec)*( (gammaT(sec)**sigmaT(sec))*
                  (PE(sec)**(1 - sigmaT(sec))) +((1 - gammaT(sec))**sigmaT(sec))*
                  (PDD(sec)**(1 - sigmaT(sec)))) **(sigmaT(sec)/(1 - sigmaT(sec))) ;

* Zero profit CET

  EQPROFITT(sec)  PD(sec)*XD(sec) =E= PE(sec)*E(sec) + PDD(sec)*XDD(sec) ;

* Import demand and demand of domestic goods (from the Armington function)

   EQIMPORT(sec)..  M(sec)  =E= (X(sec)/A(sec))*(gammaA(sec)/PM(sec))**sigmaA(sec)*
                    ( (gammaA(sec)**sigmaA(sec))* (PM(sec)**(1 - sigmaA(sec))) +
                    ((1 - gammaA(sec))**sigmaA(sec))* (PDD(sec)**(1 - sigmaA(sec)))
                    ) **(sigmaA(sec)/(1 - sigmaA(sec))) ;

   EQARMD(sec)..    XDD(sec)  =E= (X(sec)/A(sec))* ((1 - gammaA(sec))/PDD(sec))
                    **sigmaA(sec)* ( (gammaA(sec)**sigmaA(sec))*
                    (PM(sec)**(1 - sigmaA(sec))) + ((1 - gammaA(sec))**sigmaA(sec))*
                    (PDD(sec)**(1 - sigmaA(sec)))) **(sigmaA(sec)/(1 - sigmaA(sec))) ;

* Zero profit Armington

   EQPROFITA(sec)..   P(sec)*X(sec)  =E= PM(sec)*M(sec) + PDD(sec)*XDD(sec) ;

* Market Clearing

   EQMARKETL..        sum(sec, L(sec)) + LG  =E= LS - UN ;
   EQMARKETK..        sum(sec, K(sec)) + KG  =E= KS       ;
   EQMARKETC(sec)     C(sec)+I(sec)+sum(secc, io(sec,secc)*XD(secc))+CG(sec) =E= X(sec)  ;
   EQTRADEBAL..       sum(sec, M(sec)*PWMZ(sec)) =E= sum(sec, PWEZ(sec)*E(sec)) + SF ;

* Consumer price index

   EQCPI..            CPI  =E=  sum(sec, (1+tc(sec))* P(sec) *CZ(sec) ) /
                      sum(sec, (1+tcz(sec))*PZ(sec)*CZ(sec) ) ;
* Import and export prices

   EQIMPRICE(sec)..   PM(sec)  =E=  (1 + tm(sec))*ER*PWMZ(sec) ;
   EQEXPRICE(sec)..   PE(sec)  =E=  PWEZ(sec)*ER ;

* Income definition

   EQINCOME..         Y =E= PK*KS + PL*(LS - UN) + TRANSF ;

* Consumer expenditure

   EQCB..             CB  =E=  (1-ty)*Y - SH ;

* Wage curve

   EQPHILLIPS..       ((PL/CPI)/(PLZ/CPIZ) -1) =E= phillips*
                      ((UN/LS) / (UNZ/LSZ)-1 );

* Artificial objective
```

```
   OBJECTIVE          HOF =E= 1 ;


* Model declaration in NLP format

Model MTGETM /
          EQC
          EQSH
          EQK
          EQL
          EQPROFIT
          EQS
          EQI
          EQCG
          EQKG
          EQLG
          EQTAXREV
          EQTRANSFER
          EQEXPORT
          EQXDD
          EQPROFITT
          EQIMPORT
          EQARMD
          EQPROFITA
*           EQMARKETL
          EQMARKETK
          EQMARKETC
          EQTRADEBAL
          EQEXPRICE
          EQIMPRICE
          EQCPI
          EQINCOME
          EQCB
          EQPHILLIPS
          OBJECTIVE   / ;


* Include initial (equilibrium) levels for the endogenous variables

   PK.L          = PKZ  ;
   PL.L          = PLZ  ;
   P.L(sec)      = PZ(sec)  ;
   PD.L(sec)     = PDZ(sec) ;
   PDD.L(sec)    = PDDZ(sec);
   PE.L(sec)     = PEZ(sec);
   PM.L(sec)      = PMZ(sec);
   ER.L          = ERZ ;
   XD.L(sec)     = XDZ(sec)  ;
   XDD.L(sec)    = XDDZ(sec) ;
   X.L(sec)      = XZ(sec) ;
   K.L(sec)      = KZ(sec) ;
   L.L(sec)      = LZ(sec) ;
   C.L(sec)      = CZ(sec) ;
   CPI.L         = CPIZ ;
   UN.L          = UNZ;
   Y.L           = YZ  ;
   SH.L          = SHZ ;
   S.L           = SZ  ;
```

```
I.L(sec)      = IZ(sec) ;
E.L(sec)      = EZ(sec) ;
M.L(sec)      = MZ(sec) ;
CB.L          = CBZ  ;

CG.L(sec)     = CGZ(sec) ;
KG.L          = KGZ ;
LG.L          = LGZ ;
TAXR.L        = TAXRZ ;
TRANSF.L      = TRANSFZ  ;
HOF.L         = 1 ;


* Include lower boundaries to prevent numerical problems in optimization

PK.LO         = 0.001*PKZ    ;
PL.LO         = 0.001*PLZ    ;
P.LO(sec)     = 0.001*PZ(sec)  ;
PD.LO(sec)    = 0.001*PDZ(sec) ;
PDD.LO(sec)   = 0.001*PDDZ(sec);
PE.LO(sec)    = 0.001*PEZ(sec);
PM.LO(sec)    = 0.001*PWMZ(sec);
ER.LO         = 0.001*ERZ    ;
XD.LO(sec)    = 0.001*XDZ(sec) ;
XDD.LO(sec)   = 0.001*XDDZ(sec);
X.LO(sec)     = 0.001*XZ(sec) ;
K.LO(sec)     = 0.001*KZ(sec) ;
L.LO(sec)     = 0.001*LZ(sec) ;
C.LO(sec)     = 0.001*CZ(sec);
CPI.LO        = 0.001*CPIZ ;
UN.LO         = 0.001*UNZ ;
Y.LO          = 0.001*YZ ;
SH.LO         = 0.001*SHZ ;
S.LO          = 0.001*SZ ;
I.LO(sec)     = 0.001*IZ(sec);
E.LO(sec)     = 0.001*EZ(sec) ;
M.LO(sec)     = 0.001*MZ(sec) ;
CB.LO         = 0.001*CBZ  ;
CG.LO(sec)    = 0.001*CGZ(sec) ;
KG.LO         = 0.001*KGZ ;
LG.LO         = 0.001*LGZ ;
TAXR.LO       = 0.001*TAXRZ ;


* Exogenously fixed: capital and labour endowments

     KS.FX       = KSZ;
     LS.FX       = LSZ;


* Exogenously fixed: other transfers and government savings

     OTR.FX      = OTRZ  ;
     SG.FX       = SGZ ;


* Exogenously fixed: foreign savings

     SF.FX       = SFZ ;
```

```
* Fixing of the numeraire

     PL.FX       = PLZ;

$ontext
* Homogeneity test

     PL.FX       = 2*PLZ ;

$offtext


* Tax Policy Simulations

*$ontext
* Simulation 1: Removal of tc, ty and tm

          ty = 0;
          tc(sec) = 0;
          tm(sec) = 0 ;

*$offtext

*$ontext
* Simulation 2: Removal of ty only

          ty = 0;

*$offtext

*$ontext
* Simulation 3: Removal of tc only

          tc(sec) = 0;

*$offtext

*$ontext
* Simulation 4 Removal of tm only

          tm(sec) = 0;

*$offtext

*$ontext
* Simulation 5: Increase in tc by approx 1 percent of GDP

          tc(sec) = 1.15*tc(sec);

*$offtext

*$ontext
* Simulation 6: Decrease in ty by approx 1 percent of GDP

          ty = 0.822*ty;

*$offtext

*$ontext
```

```
* Simulation 7  Removal of import levies

          tm(sec) = 0.8*tm(sec);

*$offtext


*Option iterlim = 0 ;
MTGETM.holdfixed = 1 ;
MTGETM.TOLINFREP   = .001 ;

option nlp = pathnlp ;

Solve   MTGETM using NLP maximizing HOF ;
*Solve MTGETM using CNS;
*Solve MTGETM  MCP USING MCP;

$ontext


* Minimize objective function

        Solve MTGETM using NLP minimizing HOF ;

$offtext


* Calculate utility

scalar U ,

    U = prod( sec, (C.L(sec) - muH(sec))**alphaHLES(sec) ) ;


display
  KS.L
  LS.L
  PK.L
  PL.L
  P.L
  PD.L
  PE.L
  PM.L
  ER.L
  CPI.L
  K.L
  L.L
  X.L
  XD.L
  XDD.L
  C.L
  SH.L
  S.L
  I.L
  E.L
  M.L
  CB.L
  Y.L
  CG.L
  KG.L
```

```
 LG.L
 TAXR.L
 TRANSF.L
 UN.L
 U ;



*$ontext
* Check whether Walras Law holds

scalar   walras ;

    walras = sum(sec,L.L(sec)) + LG.L + UN.L - LS.L ;

display  walras ;
*$offtext


*$ontext
*Equivalent and compensating variation

scalars

PLESZ  Price as T benchmark
PLESL  Price of proposed change
PLESS
SIZ    Supremacy income T benchmark
SIL    Supremacy income After proposed change

EV     Equivalent variation
CV     Compensating variation  ;

PLESZ  = prod(sec, ((1+tcz(sec))*PZ(sec))**alphaHLES(sec));
PLESL  = prod(sec, ((1+tc(sec))*P.L(sec))**alphaHLES(sec));
PLESS  = PLESL / PLESZ ;
SIZ    = ((1-tyz)*YZ) - sum(sec, ((1+tcz(sec))*PZ(sec))* muH(sec));
SIL    = ((1-ty)*Y.L) - sum(sec, ((1+tc(sec))*P.L(sec))* muH(sec));
EV     = (SIL/PLESS)-SIZ ;
CV     = SIL - (SIZ*PLESS);

display
sil
siz
ev
cv
pless  ;
*$offtext


* End of GAMS code
```