THE ECONOMY IN ONE EQUATION: THE MACROECONOMIC PRIMITIVE

William Maybury **January 2020**

This paper presents a new approach to modelling the dynamic interactions of consumers and suppliers within an economy. It is developed from the observation that businesses have a pivotal role within the continuous dynamic behaviour of an economy as both consumer and supplier. As all entities within an economy are consumers, it is possible to represent all financial interactions by the consumer relationship to suppliers of goods, services, labour and assets. Termed the *macroeconomic primitive*, it is represented graphically as a consumer-centred diagram showing the transfer of supplies in exchange for money, revealing that financial transactions are not isolated events but are within a continuum of events. It is also presented as an equation in a general form, defining the interdependency between income and expenditure of any entity within the four consumer types: households, businesses, public purse and charity. The primitive equation can be used to build up the interdependencies of all consumers and suppliers of any economy. This enables the financial circumstances of all consumers to be determined for macroeconomic forecasting using the Economy Dynamics framework.

1 INTRODUCTION

1.1 ECONOMY DYNAMICS

This paper is part of the *Economy Dynamics* series defining a new approach to macroeconomic analysis and forecasting. The different elements of Economy Dynamics are summarised in Figure 1 and an overview is provided by Maybury (2020 [Paper 00]). The methodology has been developed independent of current economic theories. The concept has been based on observations of the decision-making and financial circumstances of businesses and households and defining the interdependency between consumers and suppliers. The models of the Economy Dynamics framework have been expressed using computational mathematics from engineering and data science. The framework architecture is based on recent advances in software architecture to automate complex analytical processes.

This paper addresses the interdependency between the expenditure of consumers and the income of suppliers. Resolving the interdependency between entities within an economy leads to the derivation of the *macroeconomic primitive*, which is the simplest set of functions that can be used to build an applied mathematical model of any macroeconomic system. Establishing the primitive enables a methodology for macroeconomic forecasting without the need to extrapolate predefined functions, which is a limitation in the current methods (Maybury, 2020 [Paper 00]).

A critical concept in resolving the interdependency between income and expenditure is identifying that businesses are consumers as well as being suppliers. Businesses consume input goods and services in addition to their demand for labour, land and financial services. By establishing that all

entities within an economy are consumers, it is possible to define the interdependency of income and expenditure by modelling the consumer perspective of an economy.

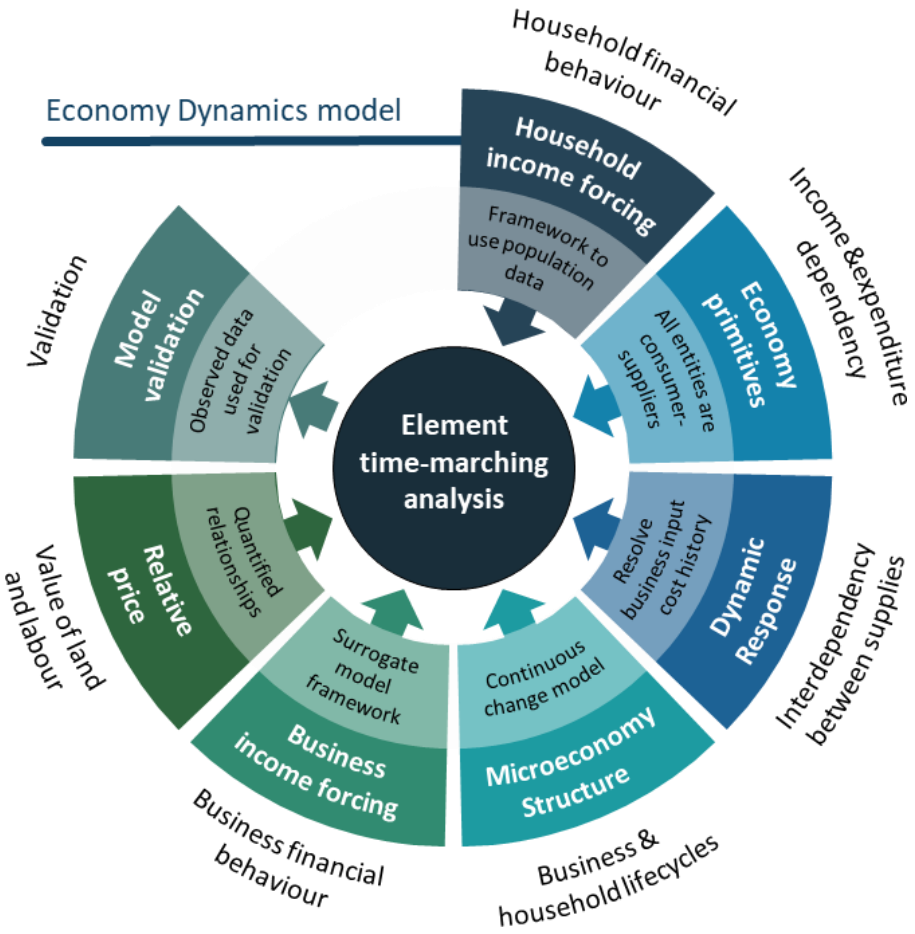

Figure 1. Economy Dynamics infographic

1.2 THE NEED FOR THIS PAPER

The study of economics is subdivided into two fields. These fields are microeconomics – the study of household and business behaviour – and macroeconomics – the study of economy behaviour. As the discipline has been arbitrarily subdivided by scale, the effects on economic theory of perspective bias from a professional viewpoint of an economy, cannot be corrected by research on the financial behaviour of households and businesses. Observations of these entities do not influence macroeconomic theories. Instead, the constituent entities that determine economy behaviour have been selected on logical *a priori* assumptions. It is seemingly self-evident which economic entities affect the output of the economy, such as credit provided by banks affecting economic output. Surely, then this is observed. Whilst this does not seem unreasonable, by following this approach, past economists have decided what they believe to be important in driving economy behaviour and how they believe this should be measured. Yet, this is not testably based on observation.

In fact, Banks providing credit is an unjustified simplification. In any company's annual accounts, such as those stored at Companies House in the UK, there are line items for,

Creditors	money the company owes to other businesses and households, including their suppliers,
Debtors	money owed to the company by other businesses and households, including invoices that have yet to be paid for supplies that have provided to customers,
Directors' loans	money owed to the company directors, which is money lent to the business by households who have a vested interest in the business.

These annual accounts show that all entities within an economy have the capacity to provide credit to any other entity. So, the relationship between creditor and debtor can be business to business, household to business, business to household and, obviously not shown in company accounts, household to household. Also, the relationship can be for a business model to generate income for the business, or it can be a service provided without the debtor incurring fees. A business supplying another business may have payment terms of 30 or 90 days, thereby providing their customer with a period of credit without a fee.

The choice of current economic theory to focus on banks, whereby the predominant credit service is business to household for a fee, neglects information about other forms of credit provision. Economists have not determined that the credit mechanism represented in current economic forecasting frameworks by banks is the most important mechanism. No justification is given for neglecting the other mechanisms. So, neglecting this information contributes to the failure of current economic theory as it will produce unknown errors between predictions and observed data.

To understand economy behaviour, we cannot arbitrarily declare that the study of economics is split into two separate, unrelated disciplines: micro- and macroeconomics. We must assume that there is a relationship between household and business behaviour and economy behaviour. To do so, we must define the perspective of the economy from the point of view of a consumer and of a procedure. In fact, contrary to current economic theory, we discover they have the same perspective, as quite simply a consumer must have an income, and a producer must consumer. By appropriately representing this simple relationship, we can model any economy in the world, throughout history. The function that allows us to do this I have termed the macroeconomic primitive.

2 CONSUMER ECONOMICS

The consumer can be any legal entity within the economy. The most basic legal entity is a natural person and generally all non-human legal entities must have at least one natural person responsible for the entity. Within the UK the non-human legal entities include the self-employed, sole traders, partnerships, limited liability partnerships, private limited companies (ltd), public limited companies (plc) and charitable incorporated organisations. The difference between legal entities is their treatment of tax and their eligibility for government benefit payments, tax credits, grants and loans. For legal entities that are not incorporated, such as the self-employed, sole traders and partnerships, they also have a limit to their level of borrowing and cannot issue shares. The definition of a household and a business must be in terms of the legal entities of the economy in order to determine their relative perspective of the economy due to variation in the rate of tax, availability of benefits and cost of borrowing.

Households are the financial unit of interdependent human legal entities that provide the economy with the resource of labour. Households have different structures variously comprising adults of working age, children below working age, pensioners above working age, adults in employment, education or training and adults unable to work or unable to find work. A detailed discussion of the subgrouping of households within an economy is provided by Maybury (2020 [Paper 01]). Households can be domestic or foreign, with the distinction based on the economy in which the household income was generated in, regardless of where the supply is consumed or used. Therefore, foreign spending includes tourists and the spending of income generated by foreign investments.

Businesses are any non-human legal entity that produces goods or services in exchange for money. Businesses include all supply producing organisations in both the public and private sectors, that can be either for-profit or not-for-profit organisations. If household income from selling goods or services are declared in their tax returns then they are treated as a business in the declared economy. If this income is not declared then they are a business in the undeclared economy, and therefore do not pay tax. Businesses can be domestic or foreign, and the distinction is based upon where the goods or services are produced.

The taxes within an economy align with either households or businesses. Household taxes are applied to income (and inheritance) and land usage or other local taxation methods. Business trading tax is based on the location of the manufacturing or trading facility and is applied to employment, import of goods and services, and land usage or other local taxation methods. Business governance tax is applied to the declared business profits and is based on the location of the business headquarters. There is also a tax that occurs at each transaction stage in the declared economy, such as value added tax *VAT*[1] that is applied to the purchase of all goods and services, and asset ownership transfer duty[2] that is applied to all asset purchases.

Asset ownership transfer duty in the UK does not distinguish between legal entities, although businesses can offset the total asset cost against future corporation tax over a justifiable depreciation period set by the company directors. In contrast to asset transfer duty, VAT is paid by any entity that is not VAT registered and all non-human legal entities can be VAT registered. The concept of VAT is based on the principle that the end consumer is charged the tax to pay for shared services provided by local or national government, though in practice VAT rates may be used to offset other taxes (see for example Pope and Waters, 2016). The underlying assumption of the VAT philosophy is that human legal entities (i.e. households) are the end consumer, which follows the traditional economic distinction between households and businesses being consumers and suppliers respectively.

3 ECONOMY DYNAMICS

Economies are a dynamic system involving the interaction of the producers and consumers. The producers are businesses that are governed by households, that use the resource of labour provided by households and use the resource of land owned by households and businesses, to transform input supplies into output supplies. The consumers are households and businesses, as well as spending from the public purse and spending from charity revenues which will be addressed in Section 4. Household

[1] Also referred to as goods and services tax *GST*.

[2] Commonly referred to as stamp duty, whereby asset ownership documents once required a proof of taxation payment in the form of a physical revenue stamp to make the document legally binding.

income is generated from labour or by having a profit sharing stakeholding in a business. The business income is generated by selling supplies, services or assets.

The economy dynamic cycle is represented as a supply and demand flow diagram in Figure 2. The producer is shown on the right and requires a business to transform input supplies into output goods and services through the use of land and labour resources. Businesses generally require household labour and the demand for labour is shown as a gold line from households to businesses. However, as a business can operate without employees, through profit-sharing ownership or through automation of production or services, the money transferred from businesses to households for the demanded labour is a dashed line to show that this payment is optional. The payment from a business to its staff will generally be minimised and avoided where possible, such as through the use of labour-to-revenue ratios as an evaluation metric of business efficiency.

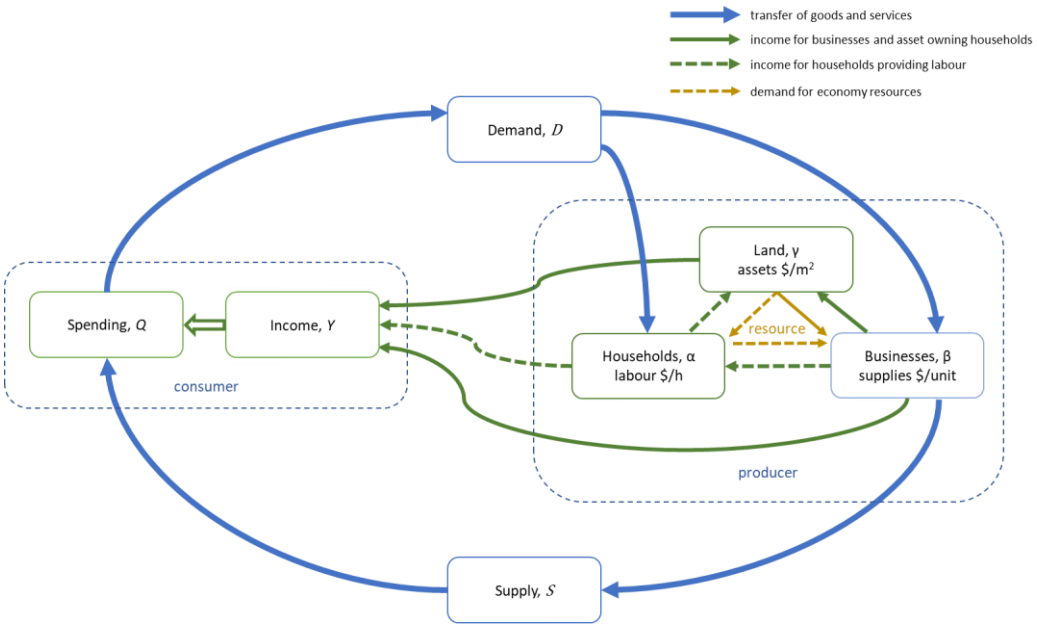

Figure 2. Continuous dynamic cycle has asymmetry of household dependency on business.

Households demand land resources, which is shown by a dashed gold line from land to households and there is a transfer of payment in the opposite direction shown by a dashed green line. The payment is a dashed line as not all households can afford to pay the cost for the land required to live on. Businesses also demand land, which is used in the production of every supply, and so this demand is shown by a solid gold line from land to businesses. The solid green line represents the transfer of money from businesses to land, which is not optional in the production of supplies.

The green income lines transfer money from the producer on the right to the consumer on the left. The consumer can be any legal entity, but to be able to consume they must receive an income. The green income lines represent the income of a household for labour, the turnover of a business used to purchase input supplies and provide asset income to households and businesses and the return on land investment. The income for labour is a dashed line to show that it is an optional payment from business, whereas consumer income (which is the income that enables expenditure) from businesses and land are solid as the transactions are involved in the production of every supply. Therefore, the

response of household income to economic growth will be different for households whose main income is from assets and households whose main income is from employment. The distribution of consumer income will affect the demand for a set of goods and services, which influences the producers and thus the demand for land and labour resources.

4 PRIMITIVES

In engineering, the analysis of the physical environment can use primitive equations to build analytical models of large complex systems. For example, in computational fluid dynamics (including those used for meteorological analysis) the fluid is represented by the primitive equations for the conservation of mass, the conservation of momentum and the conservation of energy. The computational model topology is discretised to form numerous small discrete volumes or elements. The primitive equations are solved within each element to calculate physical characteristics taking account of the effects of the neighbouring elements.

Analogous primitives for macroeconomics forecasting can be identified. As discussed in Section 1.2, the consumer can be any legal entity and will participate within every transaction within in the economy. Therefore, by systematically tracing the transfer of supplies (and labour and assets) to any output supply that results in consumer expenditure, the system must reveal the transfer of money in the opposite direction that constitutes the income of other consumers. Thereby, the interconnecting primitive equations can be established.

The objective of this section is to define the economy primitive in universal terms, applicable to any economy. The terminology is intended to be non-economy specific but may be biased to the UK economy as this is the economy with which the author is most familiar. The important aspect of tax within the primitive are the optional collection points and distribution points, regardless of differences in the names of taxes and duties between economies.

4.1 DEFINITION OF CONSUMER TYPES

As with the engineering primitive equations, the computational model topology of an economy must be subdivided into smaller elements. Within an economy there are distinct geographical regions based on the cost of supplies or local tax. In most economies there are four consumer types differentiated by their income and expenditure transactions, which are households (α), businesses (β), tax (τ) and charity (ϕ). The division of the geographical regions can be different for each consumer type. These regions, called *economy elements*, will be identified within Economy Dynamics by index i_α for households, index i_β for businesses, index i_τ for tax (or more accurately termed the public purse) and index i_ϕ for charity. To enable the primitive equation to be in a general form for all consumers, the definition of the consumer types is critical. These definitions are provided below.

4.1.1 HOUSEHOLD

Households are the financial unit of interdependent human legal entities that provide the economy with the resource of labour. Households cannot sell goods they have produced nor can they sell services they provide. If the household sells supplies, then the income generated is treated as business turnover under the business category of self-employed. If the income is declared for tax purposes then the business is trading within the declared economy and if not it is trading within the undeclared

economy. This enables Economy Dynamics to consider only businesses as suppliers of new supplies. Although a household can't sell new supplies, they can sell assets, such as land, and durable supplies that have depreciable residual value. The main income for the majority of households is payment for labour.

Households within economy elements are divided in groups that have a similar standards of living i_e and are further subdivided by likely financial characteristics and behaviour, based on composition of the household i_h, the skill category of the main income provider i_s, the stage of family and working life based on the age of the main income provider i_a, their minority grouping i_m and their parental living standard i_{ep}. A detailed discussion of the subgrouping of households within an economy is provided by Maybury (2020 [Paper 01]). For convenience the index i_{e+} will be used to represent the household economic group living standard i_e and all subgroups (i_h, i_s, i_a, i_m and i_{ep}).

4.1.2 BUSINESS

Businesses are any non-human legal entity that produces goods or services in exchange for money. Businesses include all supply producing organisations in both the public and private sectors that can be either for-profit or not-for-profit organisations. In contrast to current economic models, the role of banks and government organisations, in addition to charities, households selling new supplies and households with employer responsibility, are grouped within the business category. The characteristics of organisations within the Economy Dynamics analytical framework are defined below:

Banks are businesses that provide financial services. Banks are included amongst the business models. Financial services can also be provided by other businesses, such as crowd funding platforms. Special conditions of trading that affect behaviour will be defined within the business behaviour models (see Maybury, 2020 [Paper 00]). Debt amongst households, businesses, the public purse and charity will be accumulated for the respective consumer subgroups at each timestep.

Government are the public sector businesses responsible for delivering goods or services. The provision of goods and services by government in the model is handled under the business entities. The government responsibility for determining tax collection and spending policy is referred to as the *public purse* or *tax*. Public sector businesses receive income from tax spending, which is shown as business benefit income provided by the public purse.

Charities are businesses that are registered with a charitable purpose and are responsible for delivering charitable services and goods. The term charity within the model is the collection and spending of donations, which is similar to the public purse.

Household employer is a household that employs staff and has employer responsibilities. In the model it is treated as a business providing services to the household. This is to ensure that supply and demand characteristics of labour will be represented in employment dynamics modelling.

The business population of the economy elements are divided in groups that have a similar business type i_B based on output supplies and are further subdivided by the enterprise class i_E, the stage of business operations based on the business age i_A, brand differentiation subgroups based on supply quality and ethics i_Q and large national and multi-national organisations requiring multi-element

indexing i_M. For convenience the index i_{B+} will be used to represent the business group i_B and all subgroups (i_E, i_A, i_Q and i_M).

4.1.3 PUBLIC PURSE

The public purse consumer, also referred to as the tax consumer, reflects fiscal policy. Fiscal policy must determine the collection points of tax, represented within the primitive, which can be differentially distributed between legal entities. Fiscal policy must also set the distribution of tax spending in benefits to households, businesses and charity in domestic and foreign economies and to supplement tax spending by foreign governments and pay fees for membership of international coalitions. Subdivision of the tax consumer type is identified by the fiscal policy responsibility of the different government organisations i_G at local and national (and federal) levels for collection and distribution of public purse funds, which is a subset of business group characteristics i_B.

4.1.4 CHARITY

The charity consumer type reflects charitable fund generation and the distribution of charitable funds as benefits to households, businesses and charity in domestic and foreign economies and supplementing tax spending by foreign governments. Subdivision of the charity consumer type is identified by the purpose of the charity i_C which is a subset of business consumer group characteristics i_B.

4.2 PRIMITIVE DIAGRAM

This section uses a visual approach to establish the macroeconomic primitive. By graphically representing the transfer of supplies, assets and labour to any output supply that results in consumer expenditure, the system must reveal the transfer of money in the opposite direction that constitutes the income of other consumers. The objective of the primitive diagram is to be able to represent any transaction within an economy in the simplest form.

4.2.1 CONSUMER EXPENDITURE

Within each economy element, the economy dynamics behave as a transfer of supplies toward the consumer and a transfer of money away from the consumer. The consumer purchases goods and services from a business (see Figure 3), which results in a transfer of money in the opposite direction to the transfer of supplies. This transaction generates profits for business and value added tax and business tax revenues for the public purse. The consumer may choose to donate money to charity. If the consumer has insufficient income to meet their running costs, they may require an unsecured loan to manage their cash-flow short fall.

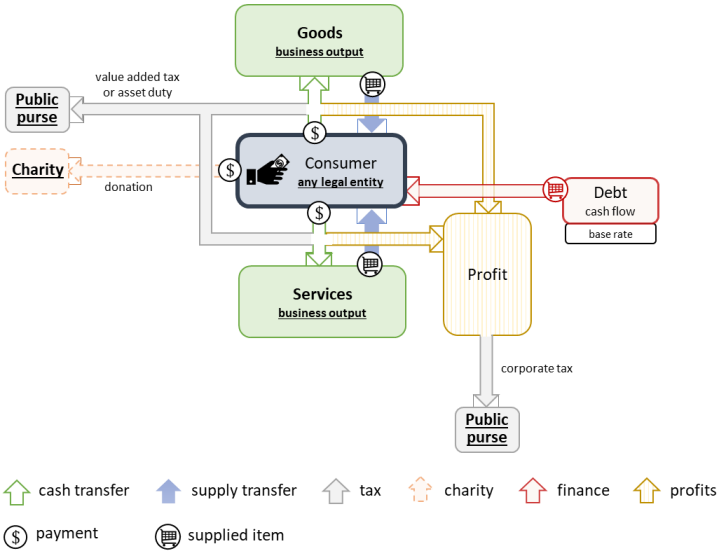

Figure 3. Consumer transactions

Producing the output supply requires input supplies, assets and labour to be transferred into a business as shown in Figure 4. The business operational costs are the exchange of money for input supplies, staff and land. When purchasing input supplies (and assets) the business producer becomes the consumer. The use of land or assets may generate property tax revenues whilst the sale of land or assets may generate asset duty revenues. The employment of staff may generate employer tax revenues and being employed may generate employee (or income) tax revenues.

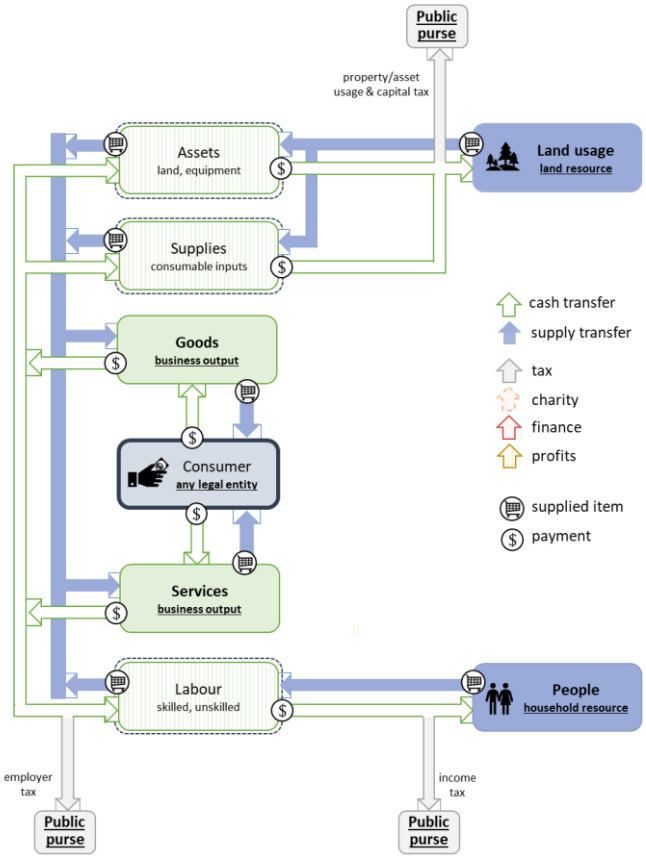

Figure 4. Production of goods and services

Figure 5 shows interactions with other economy elements or economies represented by the relocation of the consumer household or business or through the importing and exporting of goods and services. The consumer has the freedom to migrate into another economy element and relocate their household or business. Consumer migration is represented in the diagram as solid dark blue horizonal opposing arrows travelling across the economy element border. Similarly, business input supplies and assets can be imported and exported between economy elements, which is a transfer of supplies (light blue arrows) and money (green outlined white arrows) between economy elements and may include exchange rates mechanisms. Importing goods, services and assets may generate import duty tax revenue.

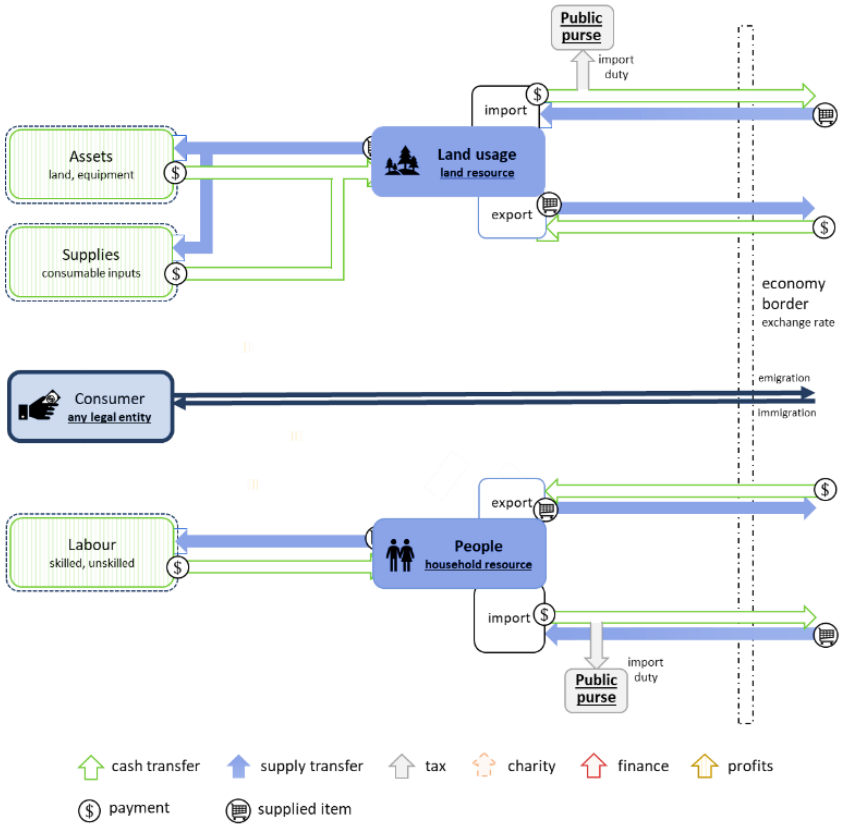

Figure 5. Migration of consumer and import and export goods and services

Figure 6 shows the different types of household income, which are land assets including infrastructure and equipment, finance assets, stakeholding in private business, benefits from government and charity, intellectual property and labour rate adjusted by skill level assets.

The top half relates to the economy asset of land resources and the bottom half relates to the economy asset of household resources. In many respects, public purse spending is mirrored by charitable spending. Funds are used to develop infrastructure and procure equipment in the top half of the diagram, and to provide households with benefits, welfare, aid, education and to support innovation and creative endeavours in the bottom half.

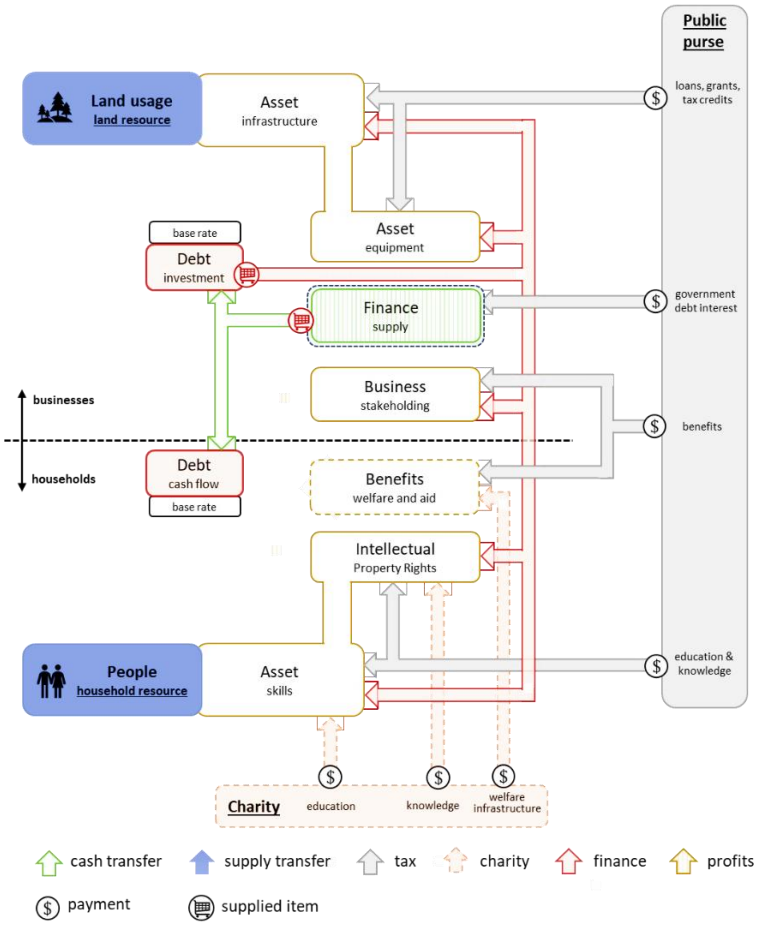

Figure 6. Sources of household income

Finance supply provides money to facilitate borrowing by any consumer type, including the public purse, and is shown in red as debt. For all consumer types, debt financing enables investment in land, infrastructure, equipment, businesses, intellectual property and skills and training. The finance supply is unique as it is a cost for entities that have a net debt relationship and it is an income for entities that have a net asset relationship. Government borrowing using central markets has important ethical aspects to consider as it imposes a net debt relationship with finance supply amongst the majority of taxpayers to the benefit of private investors who have a net asset relationship. For example, households living below the poverty level who pay tax (including VAT) are having their poverty exacerbated to augment the income of others.

The transfer of supplies and money shown from Figure 3 to Figure 6 can be combined into a single consumer and producer diagram presented in Figure 7.

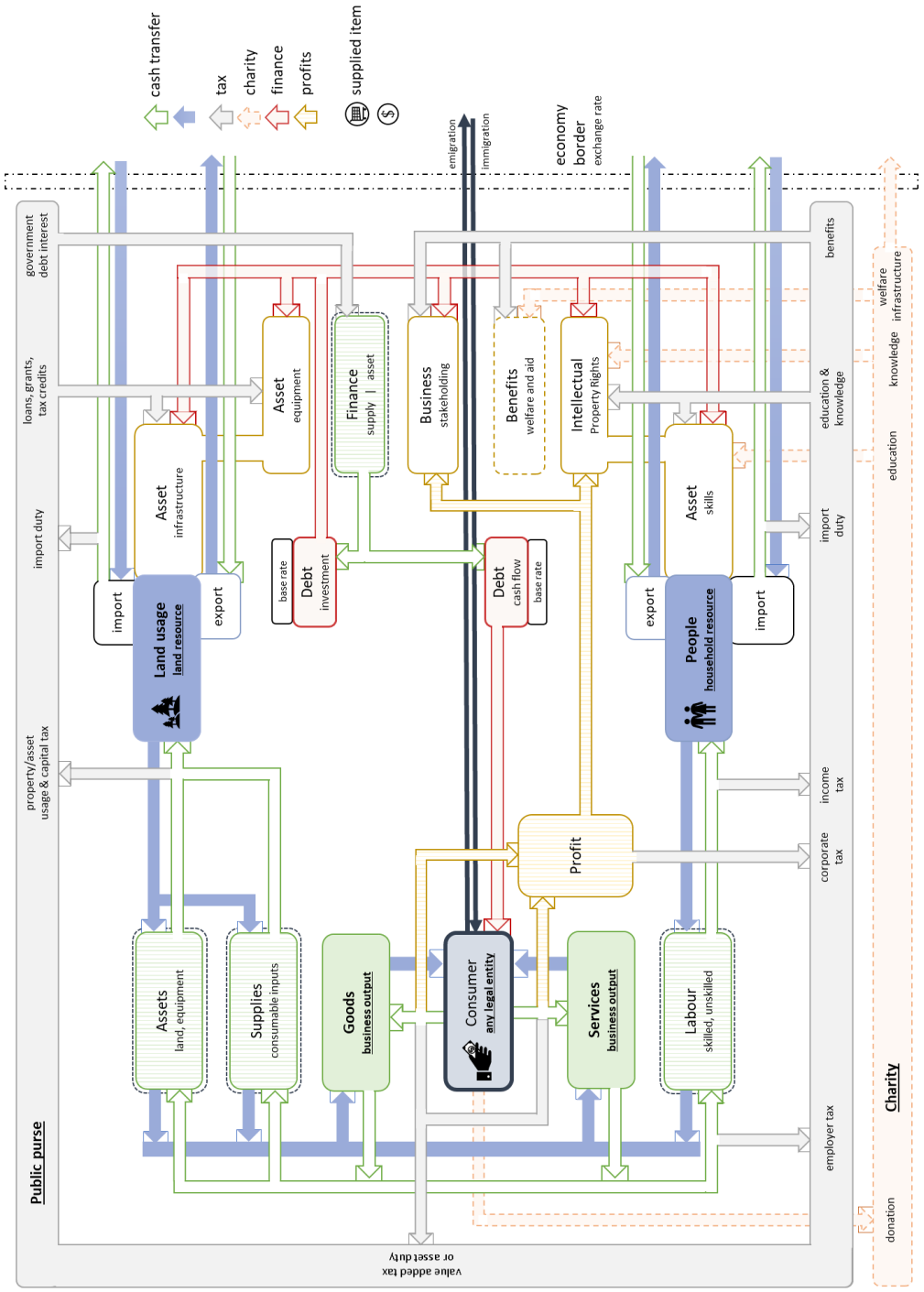

Figure 7. Macroeconomic primitive diagram: consumer expenditure

4.2.2 INCOME SOURCES

Figure 8 shows the consumer income block receiving money from resources and assets on the right-hand side. Rotating clockwise from land usage at the top of the diagram to people at the bottom, there are six potential sources of income: return on investment from land usage; return on investment from finance assets; return on investment from business assets; benefit, welfare and aid payments; income from intellectual property rights; and income from people's skills and effort. These sources of income are described in turn below.

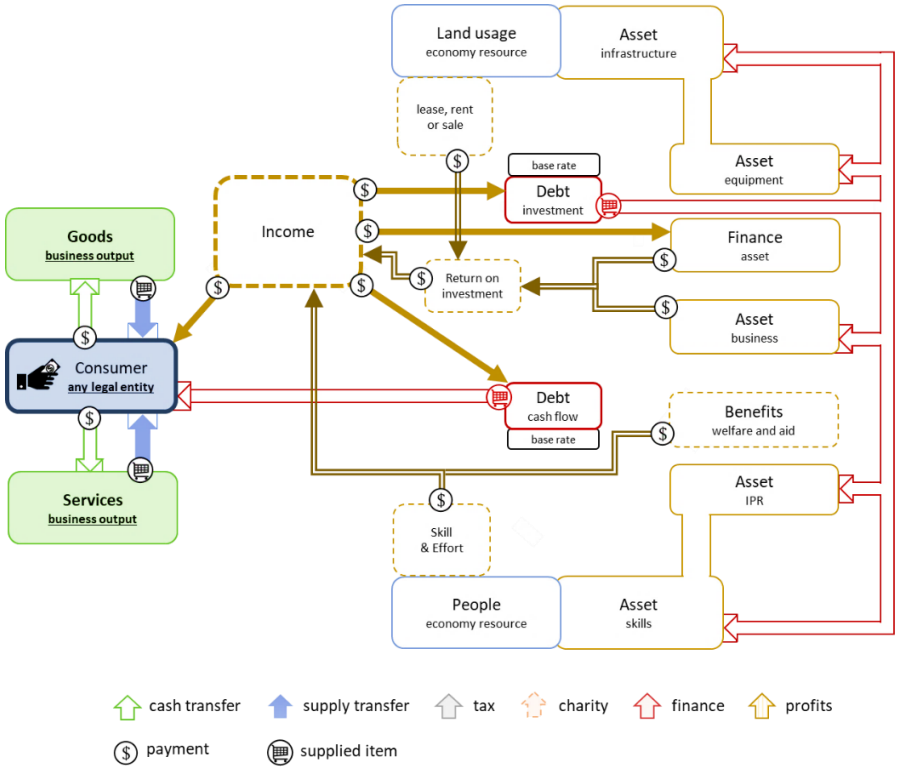

Figure 8. Macroeconomic primitive diagram: consumer income

4.2.2.1 Land usage

Land usage is the fundamental resource of an economy element. Within the Economy Dynamics framework, land assets include land, buildings, infrastructure and equipment as these are physical resources dependent on land usage of an economy element. Income can be generated for any consumer type by leasing, renting or from capital gains through the sale of any land assets. However, the Economy Dynamics framework requires the land income transaction to be facilitated via a business, such as through asset management or asset trading businesses.

4.2.2.2 Finance assets

Financial assets include stocks, bonds and shares in public companies and other goods traded through central markets that do not have physical form. The traded unit value of these commodities to some extent may be influenced by investor speculation. The Economy Dynamics framework requires the finance asset income transaction to be facilitated via a business, such as asset management or asset trading businesses. Finance assets include employer pension schemes, which is a significant factor in the variation of household wealth after retirement (Gov.uk, 2019).

4.2.2.3 Business assets

Business assets, which are distinct from financial assets, are specifically a form of stakeholding in a private business or a significant control of a publicly traded business. Business assets can be accumulated by households through both paid and unpaid effort as well as being directly bought or sold. This is important for macroeconomic modelling, based on evidence from the UK where 17% of the workforce are self-employed and a total of 33% of the workforce are employed in businesses with less than ten employees (Rhodes, 2018). At the other end of the scale, 0.1% of UK businesses employ more than 250 peoples, which accounts for 40% of the total employment and 48% of business

turnover. These large businesses, and any business with high turnover to staff ratios, will deliver considerable asset income to the stakeholding households with significant control of the business.

4.2.2.4 Benefits, welfare and aid

Benefits, welfare and aid are payments from any household, public purse or charity to any other household, government or charity or to any business. When a business gives a share of profits to households or other businesses this is called a return on investment, usually in the form of a dividend. However, businesses can gift profits to government and charity, which is particularly pertinent for public sector and non-profit businesses.

Households may receive financial support from other households, usually between family members. Households can give money to businesses, usually in the non-profit sector. In principle there is no reason that a household could not give money to a for-profit business, though it would be unusual. Generally, money transferred from a household to a business is in exchange for a stakeholding in the business or is from a business stakeholder providing the business with a loan.

Benefit payments from the public purse to households provides welfare support and enhances people skills through education and training opportunities. Benefit payments to businesses from the public purse enables the public sector to provide goods and services and, in the private sector, enhances know-how and IP through grant systems. Benefit payments from the public purse also supplement the spending of charities in exceptional circumstances, such as emergency disaster relief.

In developing economies, the role of charity can provide infrastructure, goods and services that the government is unable to provide. In developed economies the role of charity is to supplement government spending, particularly in areas of household welfare, education, conservation and culture (for example see Gov.uk, 2013). In developed countries, charities may provide income to specific household groups to facilitate independent living. Charities also alleviate household running costs, such as providing hot meals for school children, food banks for households suffering from food poverty and night shelters for the homeless.

4.2.2.5 Intellectual property rights

Intellectual property rights *IPR* provide income from royalties or from their sale. Rights are purchased by other entities to use or own patent rights for an invention or copyrights for creative works. There is little data available on household income from Intellectual Property, so it is likely to be small proportion of households. However, for some households it could represent a substantial income. The reason for including it within Economy Dynamics is that, similar to a stakeholding in private business, the creation of IP can be achieved by households through both paid and unpaid effort and this represents a potential opportunity for economic mobility.

4.2.2.6 People, skills and effort

Income from labour is generally proportional to effort undertaken and the pay rate is dependent on the economy element and the person's skillset. Although income from labour is only applicable to households, businesses can gain in efficiency or gain a competitive edge through enhancing the skillset of their employees.

4.2.3 EXPENDITURE FROM THE INCOME

The expenditure from the income block in Figure 8 is represented as gold arrows pointing to investment debt, finance asset, cash-flow debt and consumer costs. Investment debt can be capital and interest repayment on a mortgage. Paying for finance assets can be the provision of a pension for retirement. Paying interest on cash-flow debt can be a productive means of spreading payments when replacing high value goods or it can be an inefficient financial burden necessary to manage day-to-day living costs. The consumer costs include the household (or business) running costs.

Beyond the typical purchasing or development of properties, debt can be used to finance the development of skills, IP and businesses. A person's skillsets can be enhanced through education, training and experience. To some extent education may be provided by government or charity. Beyond this, households can facilitate further development of skills by borrowing money against future earnings to pay for education fees and bridge short-term living costs. However, this places a financial risk on the household by committing them to repay the debt regardless of the uncertainty of job opportunities upon completing the course or training.

Households can also develop business assets or IP by borrowing money to meet the asset development costs and to bridge short-term living costs. In practice this type of debt will need to be secured against an asset such as a house, and therefore will be at the financial risk of the household.

Generally, debt is not used to fund the acquisition of finance assets as this could lead to negative equity, with the potential to lose the asset whilst committing to regular outgoing interest and capital payment costs. However, this may need to be included in the Economy Dynamics model if a significant portion of households are financing the repayment of mortgage capital (on a physical asset such as a house) through an endowment policy. In the case of an endowment policy at maturity failing to cover the capital cost then the negative equity may be mitigated or could be exacerbated by the market value of the asset.

4.3 PRIMITIVE EQUATION

The primitive diagrams show all financial transaction that relate to expenditure (Figure 7) and income (Figure 8). There is a financial action that is not a transaction, which is the decision to save surplus income (as retained money) for future spending. Therefore, we should consider the consumer budget and not just their income within the primitive equation.

The primitive equation can be defined with the budget on the left-hand side and the expenditure on the right-hand side. The budget will be the sum of the income y, the value of assets sold $\Delta_s z_A$ and the change in value of the retained money Δm minus the change in the value of borrowing Δz_D. As debt is negative relative to income the one-off supply of money that increases debt must be subtracted from the income to reflect an increase in available budget. However, it is important to recognise that any entity can provide credit to any other entity, as demonstrated by company accounts. So, Δz_D is not just for profit but can be a fee free service for cashflow purposes or as an indefinite loan from family.

The consumer expenditure will be the sum of the cost of supplies $q_{\Sigma d}$, the value of assets bought $\Delta_d z_A$, the cost of staff income y_{α_L} (for the business consumer only), debt interest payments on unsecured

loans and capital and interest repayments on secured loans q_D, the cost of national tax q_{T_Y} and local tax $q_{T_{A_L}}$, payments of financial gifts from surplus income that are provided as benefits to households y_{α_B}, businesses y_{β_B}, tax y_{τ_B} and charity y_{ϕ_B} and the value of money unspent from the budget m_λ is retained for future spending.

The generalised form of the primitive equation for any consumer is

$$y + \Delta_s z_A + \Delta m - \Delta z_D = q_{\Sigma d} + \Delta_d z_A + y_{\alpha_L} + q_D + q_{T_Y} + q_{T_{A_L}} + y_{\alpha_B} + y_{\beta_B} + y_{\tau_B} + y_{\phi_B} + m_\lambda$$

Equation 1. Generalised macroeconomic primitive equation for any consumer within an economy

The income y is specific to each consumer type and Table 1 shows the interdependencies between consumer type income and the expenditure of the other consumers. The income of the different consumer types is also discussed below.

				consumer type			
	component	**transaction**	**var**	**household** $\boldsymbol{\alpha}$	**business** $\boldsymbol{\beta}$	**public purse** $\boldsymbol{\tau}$	**charity** $\boldsymbol{\phi}$
budget	Funds	income	y	$y_\alpha = y_{\alpha_L} + y_{\alpha_A} + y_{\alpha_B}$	$y_\beta = q_{\Sigma d} + q_D + y_{\beta_A} + y_{\beta_B}$	$y_\tau = q_{T_Y} + q_{T_{A_L}} + y_{\tau_B}$	$y_\phi = y_{\phi_B}$
		assets sold	$\Delta_s z_A$	$\Delta_s z_{\alpha_A}$	$\Delta_s z_{\beta_A}$	$\Delta_s z_{\tau_A}$	$\Delta_s z_{\phi_A}$
		change in money	Δm	Δm_α	Δm_β	Δm_τ	Δm_ϕ
		change in debt	Δz_D	Δz_{α_D}	Δz_{β_D}	Δz_{τ_D}	Δz_{ϕ_D}
expenditure	input supplies	supplies purchased	$q_{\Sigma d}$	$q_{\Sigma d_\alpha}$	$q_{\Sigma d_\beta}$	$q_{\Sigma d_\tau}$	$q_{\Sigma d_\phi}$
		assets purchased	$\Delta_d z_A$	$\Delta_d z_{\alpha_A}$	$\Delta_d z_{\beta_A}$	$\Delta_d z_{\tau_A}$	$\Delta_d z_{\phi_A}$
		labour purchased	y_{α_L}	-	y_{α_L}	-	-
	debt interest	cost of debt	q_D	q_{D_α}	q_{D_β}	q_{D_τ}	q_{D_ϕ}
	Tax	national tax	q_{T_Y}	$q_{T_{\alpha_Y}}$	$q_{T_{\beta_Y}}$	-	$q_{T_{\phi_Y}}$
		local tax	$q_{T_{A_L}}$	$q_{T_{\alpha_{A_L}}}$	$q_{T_{\beta_{A_L}}}$	-	$q_{T_{\phi_{A_L}}}$
	payments from surplus income	household benefits	y_{α_B}	$y_{\alpha_{B_\alpha}}$	y_{α_A}	$y_{\alpha_{B_\tau}}$	$y_{\alpha_{B_\phi}}$
		business benefits	y_{β_B}	$y_{\beta_{B_\alpha}}$	y_{β_A}	$y_{\beta_{B_\tau}}$	$y_{\beta_{B_\phi}}$
		public purse gifts	y_{τ_B}	$y_{\tau_{B_\alpha}}$	$y_{\tau_{B_\beta}}$	$y_{\tau_{B_\tau}}$	$y_{\tau_{B_\phi}}$
		charity donations	y_{ϕ_B}	$y_{\phi_{B_\alpha}}$	$y_{\phi_{B_\beta}}$	$y_{\phi_{B_\tau}}$	$y_{\tau_{B_\phi}}$
	retained money	unspent budget	m_λ	m_{α_λ}	m_{β_λ}	$m_{\tau\lambda}$	m_{ϕ_λ}

Table 1. Interdependency between income and expenditure of all individuals within the four consumer types

4.3.1 HOUSEHOLD INCOME

Household income y_α comprises payment for labour y_{α_L} plus the payment of benefits y_{α_B} from any consumer type except business, where this payment is for asset ownership and is received as dividends, profit sharing or other payment from business profits y_{α_A}. Therefore, household income can be expressed as

$$y_\alpha = y_{\alpha_L} + y_{\alpha_A} + y_{\alpha_B}$$

Equation 2. Household income

4.3.2 BUSINESS INCOME

Business income y_β is equivalent to conventional business turnover, except that the value of assets traded are excluded from the income as this is handled separately within the primitive equation. Business income comprises the sum of the sale of all supplies purchased by all consumer types $q_{\Sigma d}$, plus all debt interest payments (excluding capital repayments) q_D, plus the payment of benefits y_{β_B} which may be the main income for public sector businesses, plus payments from others businesses for asset ownership y_{β_A}. Therefore, business income can be expressed as

$$y_\beta = q_{\Sigma d} + q_D + y_{\beta_B} + y_{\beta_A}$$

Equation 3. Business income

4.3.3 PUBLIC PURSE INCOME

Public purse income y_τ is the sum of national tax receipts q_{T_Y}, local tax receipts q_{T_Y}, and benefit payments y_{τ_B}. Benefit payments include profits from state owned businesses $y_{\beta_{B_\tau}}$ and aid from charities $y_{\tau_{B_\phi}}$ and aid from external governments $y_{\tau_{B_\tau}}$. Therefore, public purse income can be expressed as

$$y_\tau = q_{T_Y} + q_{T_{A_L}} + y_{\tau_B}$$

Equation 4. Public purse income

The cost of tax q_T is nominally represented within the primitive for the national tax receipts as a function of consumer income (subscript Y) and for the local tax receipts as a function of consumer land asset ownership (subscript A_L). The selection of taxation collection points within the macroeconomic primitive is the role of fiscal policy and it can be a function of any combination of the variables within the budget and expenditure. To use the primitive equation to analyse a given economy, the tax collection points must be adjusted appropriately.

4.3.4 CHARITY INCOME

Charity income y_ϕ is the aggregate of all benefits y_{ϕ_B} provided by households $y_{\phi_{B_\alpha}}$, businesses $y_{\phi_{B_\beta}}$, from the public purse $y_{\phi_{B_\tau}}$and from other charities $y_{\tau_{B_\phi}}$. Therefore, charity income can be expressed as

$$y_\phi = y_{\phi_B} = y_{\phi_{B_\alpha}} + y_{\phi_{B_\beta}} + y_{\phi_{B_\tau}} + y_{\tau_{B_\phi}}$$

Equation 5. Charity income

5 DISCUSSION

5.1 MACROECONOMIC PRIMITIVE

Establishing that the consumer can be any legal entity and that the consumer is involved in all financial transactions within an economy (see Figure 2) enables the development of an applied mathematical approach to the computational simulation of economies. The economy can be represented as a consumer-centred diagram for expenditure (see Figure 7) and income (see Figure 8). By tracing the transfer of supplies, assets and labour in exchange for money, and by allocating the taxation collection points and the distribution of funds from the public purse and charity funds, the primitive equation defining the budget and expenditure of all consumers has been established (Equation 1). Because all financial transactions require a consumer, who in turn must receive an income, the primitive equations can be used to build a macroeconomic model of any economy. This enables the financial circumstances of all consumers to be determined for macroeconomic forecasting using the Economy Dynamics framework.

5.2 SUPPLIER INCOME ASYMMETRY

Households and businesses have an asymmetric relationship within an economy. Households supply labour and businesses supply goods and services. Businesses are involved in every supply and demand interaction, whereas not all supplies require household labour: all businesses must be owned by households, but not all businesses require salaried staff. Therefore, there are financial interactions within an economy that exclude households that do not own business assets. This results in a potential bias in the benefit households gain from growth in the economy between households whose main income is from assets and those whose main income is from wages for labour. The aggregate of business profits distributed to households who own businesses will always reflect the growth in the economy, whereas the median of household income, which is dependent on employment, may be disadvantaged by economic growth in some sectors, masking decline in the availability and range of employment in others.

6 FURTHER WORK

The primitive is a function interlinking the income and expenditure of all consumers within an economy. The function represents the options and constraints on expenditure based on budget. The primitive equation requires testing against population data within a range of economies to ensure the budget and expenditure sides of the equation are balanced and capture the full range of financial transactions available to the different consumer types. Obtaining data from households and businesses in a form consistent with the equation variable definitions is required. However, the primitive function is not a static function, because there are time intervals between the transfer of supplies, assets and labour and the respective payment. For example, the cost of tax for households and businesses will have a time delay relative to the taxable event or provision of supplies and labour. Therefore, there is an associated delay between income being received and expenditure being paid for all consumer types. Resolving these time effects will be discussed in a future paper. Once the balancing of the equations has been verified to an appropriate confidence level, then the interdependencies between the income and expenditure of the consumer types must be tested, which

may need to consider the time dependencies. This will lead to an applied mathematical approach to macroeconomic simulation, enabling evaluation of innovative monetary and fiscal policies.

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REVISION NOTES

Addition of Section 1.2 to explain why the macroeconomic primitive is important.

Addition of sentence to Section 4.3 to highlight that any entity can provide credit to any other entity and that this is not always for profit.

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CORRESPONDENCE

email: william.maybury@axsym.co.uk

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