WELCOM

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Introducing WELCOM: A tool to simulate the welfare impacts of competition. Version

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Abstract

This User Manual presents the **WELCOM** Stata tool. The Global Solutions Group on Markets and Institutions for Poverty Reduction and Shared Prosperity at the Poverty and Equity Global Practice has developed **WELCOM**, a novel microsimulation tool that estimates distributional effects of changes in market structure (e.g. a move from monopoly to more competitive markets) which could be induced through regulatory reform or easing of trade barriers. The WELCOM tool is a software interface that requires data from household surveys, particularly households' consumption of different goods and services, as well as information about market structure in the relevant sectors, to assess how changes in prices affect the welfare of households along the income/consumption

 distribution. In addition, the tool relies on a poverty line and a relevant welfare aggregate (income or consumption) to assess first-order effects on poverty indicators such as headcount and poverty gap, in addition to changes in inequality.

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List of Acronyms and Abbreviations

CEA—Counsel of Economic Advisers

CD—Cobb-Douglass function

CES—Constant elasticity of substitution utility function

CMA—Competition and Markets Authority

FGT—Foster-Greer-Thorbecke class of poverty measures

GP—Global Practice

GSG—Global Solutions Group

PCO—Partial Collusive Oligopoly

PERC—Perfect Competition

WB—The World Bank

Contents

1. Introduction

This User Manual presents the WELCOM module, a tool build on Stata to analyze the potential distributional impacts produced by changes in competition conditions either in specific or multiple markets. In general, analyzing the welfare effects of policy reforms aimed at correcting market imperfections is not a simple task, especially when the potential distributional impacts of such policies need to be assessed prior to their implementation. Market imperfections not only reduce economic efficiency and social welfare in both developed and developing countries, but recent economic literature suggest that market imperfections are more pernicious for households at the bottom of the income distribution (Urzua, 2013; Busso and Galiani, 2015; and Atkin et al., 2016).[5]

Market imperfections affecting competition can take multiple forms such as collusive arrangements among firms with market power,[6] vertical or horizontal agreements limiting competition at different stages of the production or distribution chain,[7] legal barriers to entry or exit markets,[8] prohibitive tariffs on imports and exports, statutory monopolies and price controls, among others. This User Manual focuses in market imperfections affecting the conditions for competition in specific markets or industries[9] such as anticompetitive behaviors by firms and government restrictions, and in the effects of development policies aimed at fostering competition.

Interventions to correct market imperfections and, more specifically, policy reforms to foster competition can have mixed effects in household's welfare given the different roles played by households in the economy as consumers, employees and producers. First, competition policy reforms can affect the overall conditions of competition between firms in the market, affecting

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[5] In spite that we use the term "income distribution," we could also organize and rank households based on their level of consumption or wealth, producing analysis based on consumption distribution or wealth distributions, respectively.

[6] Harrington (2017) argues that collusive agreements occur when firms in a market coordinate their behavior to produce a supracompetitive outcome.

[7] For a survey on the determinants and effects of vertical integration se Perry (1989).

[8] Barriers to entry generally refer to any form of advantages that have accrued to incumbents over time such as demand-side network effects (i.e. the quality of a product or service increases with the number of users), increased economies of scale that make harder for entrants to compete, or those created by successful political lobbying, among others (Furman, 2016).

[9] One non-exhaustive classification of potential anticompetitive conducts includes: (i) horizontal agreements or collusion practices such as price or geographical cartels; (ii) vertical restraints or vertical mergers like exclusive supply contracts; and (iii) other abusive practices such as predatory pricing, bundling and tying, refusal to supply, raising rival's costs and price discrimination (Motta, 2010). Also, notice that none of these practices are necessarily anti-competitive *per se*, since they could also be a consequence of a legitimate strategic response to specific market conditions; therefore, they should be independently analyzed by competition authorities.

household's wellbeing in their role as consumers through changes in prices, quality and diversity of alternatives available for purchase (Atkin et al., 2016; Begazo and Nyman, 2016). In addition, competition reforms can affect household's wellbeing in their role as employees as well as producers of good and services. For instance, competition reforms may affect the nominal wages perceived by workers, the number and composition of firms demanding labor—due to the potential entry or exit of firms—affecting employees bargaining power, the presence of oligopsonies in factor markets such as labor, or the consolidation of firms (CEAb, 2016). Moreover, competition policy reforms also affect household welfare through their effects on capital gains due to changes in firms' profits due to more intense competition or affecting small firms exposure to anticompetitive behavior from larger rivals (Outreville, 2015).[10] Furthermore, market power is also a source of production misallocation, resulting in welfare losses for the overall economy, since output ends up being produced in higher-cost (less productive) units of production, and less output in more efficient production units of the economy (Bridgman et al., 2015; Asker et al., 2017).

The impacts of competition policy interventions are often conditional on the initial characteristics of the market or industry under analysis as well as on the effective regulatory and competition framework following the intervention. Thus, the analysis of the conditions of competition in markets typically involves more than meets the eye. For instance, an increase in revenue concentration is neither necessary nor sufficient to indicate increases in market power; higher prices can either be a signal of quality or of a lack of competition; similar price movements can be evidence of either efficiency or of a cartel; and neither concentration nor large market share equal market power nor dominance (Gonzalez, et al 2015; Furman, 2016). Thus, each policy should be evaluated on its own merits, and understanding what influences the observed market outcomes and how business behave and interact in the market should be a priority.[11]

In addition, notice that the policy reforms under study involve a broad set of government interventions and private agent behaviors that can affect the functioning of markets. Moreover, this User Manual does not deal with the question of what type of behavior constitutes an abuse of market power or what are the best policies to remedy it (see Motta, 2004; or Buccirossi, 2008 for

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[10] The body of early literature in industrial organization known as the Structure-Conduct-Performance (SCP) hypothesis argues that there is a relationship between market concentration and firm profitability (Bain, 1951). For instance, according to the SCP theory dominant firms in concentrated markets are more capable of setting prices through collusion and, therefore, earn extraordinary profits. Later approaches such as the Relative-Market-Power (RMP) and the Efficient Structure (ES) also argued that market structure affects the market competition among firms (Outreville, 2015).

[11] This approach is analogous to the "rule of reason" in antitrust, that appeals to a rigorous analysis of how markets work, taking into account the specificities of particular industries; in contrast to the "per se rules", where certain behaviors are mechanically allowed or prohibited (Tirole, 2015).

discussions on these topics), but instead focuses on the distributional impacts of the policy interventions or changes in competitive conditions affecting competition in specific markets, taking the policies or behaviors under analysis as given.

Three common examples how the behavior of private firms affect competition are: (i) through the creation and exploitation of market power by individual firms, (ii) the joint exploitation of market power by a group of firms, and (iii) the partial or total exclusion of competitors from markets to create or protect the market power of a dominant or dominants firms (Buccirossi, 2008). Since competition policy reforms can have mixed impacts in households, given the institutional characteristics of the markets, the identification of the overall effects of these policies must hinge on the individual analysis of each reform or competition policy.

The User Manual for the WELCOM[12] package is part of a larger effort by the World Bank to generate knowledge to improve the understanding of the links among competition, growth and shared prosperity as well as to promote policies that foster competition, especially in developing countries. This Manual currently focuses on the **mcwel** tool for Stata—the first step of a more comprehensive project to provide a menu of flexible and user-friendly tools to analyze the effects of market imperfections in well-being—and is divided into five main sections. The first section is a general introduction that helps to motivate the importance of this User Manual, of the WELCOM package. In the second section, this Manual discusses the importance of competition policy reforms, discusses a general theoretical framework and relevant empirical studies on the relationship between competition and poverty and inequality. In section three, the User Manual shows the theoretical framework underlying the alternative methods of analysis available in the tool. This version of the tool focuses on the study of the potential distributional impacts of market concentration in consumer welfare through the prices channel. The forth section presents the WELCOM package for Stata and how it can be used as well as examples to interpret the outputs of the package. In the medium term the team plans to integrate additional modules to analyze the impact of the trade liberation and especially the entry of the foreign distribution chains on well-being.

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[12] Welfare and Competition (WELCOM).

2.   WELCOM Models

Section 2 of this user Manual discusses the theoretical framework, assumptions and data requirements of the **tool**. First, Section 3 discusses the theoretical underlying WELCOM. Then, this Section discusses the three alternative market structures—a monopolistic structure, an oligopolistic market with firms involved in a Cournot-type competition[13] and an oligopolistic market with collusion among the dominant firms (firms with largest market share)—available in the tool, their key assumptions and their associated equilibria. Finally, the third part of Section 3 discusses three alternative monetary measures of well-being that can be estimated using the tool and briefly presents an empirical example.

2.1   The theoretical framework of WELCOM

The current version of the WELCOM toolkit includes the **mcwel** command that was designed to help assess the impact of competition policy reforms on consumer prices. Thus, WELCOM presents an absolute and relative incidence analysis of the effects of competition reforms (i.e., changes in market power) on consumer welfare operating through the prices mechanism. A second stage of the tool is expected to introduce the potential impacts of market power on welfare through the labor market channel.

In competitive markets firms behave as price takers which are unable to affect equilibrium prices through their individual actions[14] (other assumptions of the competitive markets include the private nature of goods and services, free entry and exit in the long-run, the absence of externalities between economic agents and the existence of perfect information, as discussed in Tirole, 1988). However, the price-taking assumption does not adequately describe firm's behavior when there are only few firms on the supply side—of which monopolies are the most extreme case—or in

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[13] For details on the model of oligopoly competing via quantities see Mas-Colell et al. (1995) and Varian (2006).

[14] More precisely, in competitive markets "*all consumers and producers are assumed to act as price takers, in effect behaving as if the demand or supply functions that they face are infinitely elastic at going market prices.*" (Mas Colell et al. 1995:383).

industries where few firms with large market shares manage to collude to achieve market power and obtain "market power rents."[15]

One frequent question in this literature is what are the main factors contributing to market concentration. One can think of natural economic factors or barriers, like economic efficiency (own technology, own specific inputs, etc.), as elements that favor or limits the competition in a market. For instance, when economies of scale or network effects are strong enough, markets could naturally tend to be dominated by a monopolistic firm (Viscusi et al. 2005). Another factor contributing to market concentration and, furthermore, to generate market power, are governmental regulations that privilege few producers, distributors or importers (facilitations, large access to the public finance, unjustifiable regulation barriers for other competitors, etc.).

What are the implications of market concentration? There are several negative effects associated with the excessive concentration of markets and with the unregulated exercise of market power. Microeconomics shows that the profits of a monopolistic group are lower than the loss in the consumer surplus, generating a net well-being loss for the society (in addition from a transfer of surplus from the consumers to the producers). The transmission mechanisms between market concentration and household well-being can be summarized into two relationships. The first one is between market concentration and the potential raise in prices of goods and services. The second one is between the change in prices and the household well-being.

2.2   Market concentration structure and prices

This section of the User Manual describes three alternative models available in WELCOM to estimate the effects of competition policy reforms on welfare and their associated equilibria. Each incorporates different assumptions about the underlying structure of the relevant market and the behaviors of the firms interacting in it. The section begins by presenting a simple model of market power where a monopolist provides a good or service in the market, i.e.: a monopoly whose actions will affect the equilibrium prices in the market. Then, the analysis relaxes the assumption of a single provider to allow for a—typically—small number of firms with market power to compete imperfectly in the market (oligopoly). Then, the third discussed model allows for the

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[15] The term "market-power-rents" refers to profits that a firm earns in virtue of its market power and that would not be possible in the absence of it (Khan and Vaheesan, 2017). These rents extracted by firms exploiting their market power are also called "extranormal rents" (Rodriguez-Castelan, 2015).

presence of multiple firms, but with a small number of large firms with market power which collude to obtain market power rents, while the rest of small firms act as price takers.

a. *Monopolistic structure*

The extreme case of market concentration involves a single producer in the market (monopoly) or a group of firms colluding to operate as monopoly (the levels of prices and quantities associated with such market will include the subscript $MONO$). If the market demand faced by the monopolist is a continuous decreasing function of price, then the monopolist realizes that a small increase in its price above the competitive level may lead only to a small increase in prices (Mas-Colell et al. 1995). Thus, raising prices above the competitive level is an optimal profit maximization strategy for the firm.

The monopolist decision problem consists in choosing the level of output that it desires to sell, $q_{MONO} \geq 0$, given the *inverse demand function*[16] *"$p(q)$"*—the price that must be charged to sell q units of output—and a known cost function, $c(q)$:

$$\underset{q \geq 0}{\text{Max}}\, p(q) \cdot q - c(q) \tag{2.1}$$

Assuming differentiability conditions (both the inverse demand $p(q)$ and the cost function $c(q)$ are continuous and twice differentiable for any non-negative level of output), the monopolist optimal output (q_{MONO}) must satisfy the following first order condition:

$$p'(q_{MONO}) \cdot q_{MONO} + p(q_{MONO}) = c'(q_{MONO}) \tag{2.2}$$

The left-hand side of the previous equation is equivalent to the marginal revenue from a differential increase in q at the point q_{MONO}, while the right-hand side corresponds to the *marginal cost, $c'(q_{MONO})$,* at a similar level of output. The previous results can be reorganized such that:

$$p'(q_{MONO}) \cdot q_{MONO} + p(q_{MONO}) = c'(q)$$

$$p(q_{MONO}) \cdot \left[p'(q_{MONO}) \cdot \frac{q_{MONO}}{p(q_{MONO})} + 1 \right] = c'(q)$$

$$p(q_{MONO}) \cdot \left[\frac{1}{\eta} + 1 \right] = c'(q) \tag{2.3}$$

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[16] Following Mas-Colell et al. (1995), the monopolist faces a demand function given by $x(p)$ that is continuous and strictly decreasing at all p such that $x(p) > 0$. Then, the *inverse demand function* would be given by $p(\cdot) = x^{-1}(\cdot)$.

Where η denotes the own-price elasticity of demand faced by the monopolist, given by $= \frac{\partial q/\partial p}{q/p}$. From the previous equation, note that in a competitive market the elasticity of demand faced by an individual firm, η, should approach to infinity (i.e., if the firm decides to raise prices above the market price it would lose all its market share). This implies that in a competitive market prices should be equal to the marginal cost of producing an additional unit $(p = c'(q))$.[17] The previous equation could be further used to show that:

$$p(q_{MONO}) = \frac{\eta}{1 + \eta} \cdot c'(q) \tag{2.4}$$

Assume that we have the simple model of constant returns to scale such that the marginal cost, $c'(q)$, is a constant term (MC), i.e. is not a function of q. Then, in monopolistic markets the equilibrium price is given by the following expression:

$$p_{MONO} = \frac{\eta}{1 + \eta} \cdot MC \tag{2.5}$$

Remember that, in the case of the perfect competition (P_{PERC}) we have that prices must equal marginal costs:

$$p_{COMP} = MC \tag{2.6}$$

Therefore, it follows that the change in the price (in percentage) resulting from moving from a competitive equilibrium to a monopolistic structure is equal to:

$$dp = \frac{p_{MONO} - p_{COMP}}{p_{COMP}} \tag{2.7}$$

$$dp_{MONO} = \frac{p_{MONO}}{p_{COMP}} - 1 = p_{MONO} \cdot \frac{1}{p_{COMP}} - 1 = \left(\frac{\eta}{1 + \eta} MC\right) \cdot \frac{1}{MC} - 1$$

Where η denotes the own-price elasticity of demand at the monopoly equilibrium. In this User Manual, the **MC is normalized to be equal to one** (by extension, the price in equilibrium should also be equal to one) and it is further assumed that the demand function is linear.

$$dp_{MONO} = \frac{\eta}{1 + \eta} - 1 = -\frac{1}{1 + \eta} \tag{2.8}$$

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[17] In addition, note that equation (2.3) could be used to show that the **monopoly mark-up** (how much can a monopolist charge above the marginal cost) is given by the following relationship, also known as the *inverse elasticity pricing rule*: $\frac{p(q_{MONO}) - c'(q)}{p(q_{MONO})} = -\frac{1}{\eta}$.

The monopolist selects a quantity for which the consumer is willing to pay a higher price for any additional quantity. Around this monopoly equilibrium, the elasticity of demand should be smaller than one. It is also useful to express the final price of the monopoly market as a function of the initial elasticity (i.e. with price and quantity of the competitive market). We denote that elasticity by η^*. Then, it is possible to rewrite equation (2.8) as:

$$\eta = \frac{\partial Q}{\partial p} \frac{p_{MONO}}{Q_{MONO}} = \frac{\partial Q}{\partial p} \cdot \frac{p_{COMP} \cdot (1 + dp)}{Q_{COMP} \cdot (1 + \eta^* \cdot dp)}$$

Note that the previous expression suggests that the price elasticity of demand evaluated at the monopoly equilibrium is equivalent to the response of the demand function to changes in prices multiplied by the ratio of the competitive price and output, adjusted by factors corresponding to the effects of moving from perfect competition to a monopoly structure. Also, note (Q_{COMP}, p_{COMP}) are the values in a competitive market equilibrium and (Q_{MONO}, p_{MONO}) are the values under a monopoly equilibrium. Assuming that $MC = 1$, then:

$$\eta = \frac{\partial Q}{\partial p} \cdot \frac{p_{COMP}}{Q_{COMP}} \cdot \frac{(1 + dp)}{(1 + \eta^* dp)}$$

$$\eta = \eta^* \cdot \frac{(1 + dp)}{(1 + \eta^* dp)} = \eta^* \cdot \frac{(p_{MONO} - 1)}{1 + \eta^* \cdot (p_{MONO} - 1)}$$

$$\eta = \frac{\eta^* \cdot p_{MONO}}{1 + \eta^* \cdot (p_{MONO} - 1)}$$

$$\frac{1 + \eta^* \cdot (p_{MONO} - 1)}{\eta^* \cdot p_{MONO}} = \frac{1}{\eta}$$

$$\frac{1 + \eta^* \cdot (p_{MONO} - 1)}{\eta^* \cdot p_{MONO}} + 1 = \frac{1}{\eta} + 1$$

$$\frac{1 + 2 \cdot \eta^* \cdot p_{MONO} - \eta^*}{\eta^* \cdot p_{MONO}} = \frac{1 + \eta}{\eta}$$

$$\frac{1 + 2 \cdot \eta^* \cdot p_{MONO} - \eta^*}{\eta^* \cdot p_{MONO}} = \frac{MC}{p_{MONO}}$$

$$1 + 2 \cdot \eta^* \cdot p_{MONO} - \eta^* = \eta^* \cdot MC$$

$$p_{MONO} = \frac{(1 + MC) \cdot \eta^* - 1}{2 \cdot \eta^*}$$

As we did previously, under the assumption that $MC = 1$, then we can simplify the previous expression as:

$$p_{MONO} = \frac{2 \cdot \eta^* - 1}{2 \cdot \eta^*} \qquad (2.9)$$

and

$$dp_{MONO} = -\frac{1}{2\eta^*}$$

For instance, where the initial elasticity = -0.5, $p_{MONO} = \frac{-2.0}{-1.0} = 2$. The final elasticity is: $\frac{-0.5*2}{(1-0.5)} = -2$. Note that, by assuming a linear demand function, we have that:

$$\eta = \frac{\partial Q}{\partial P} \frac{p_1}{Q_1} = \frac{\partial Q}{\partial P} \frac{p_0(1 + dp)}{Q_0(1 + \eta^* dp)} = \eta^* \frac{(1 + dp)}{(1 + \eta^* dp)}$$

Or also:

$$\eta^* = \frac{\eta}{1 + dp(1 - \eta)}$$

In general, based on the equation (2.5), the observed elasticity must be higher than one in absolute value to maximize the profit of the monopolist (the empirical estimated elasticity is larger than -1).

b. *Oligopolistic Cournot-Nash equilibrium structure*

A second market structure available in the WELCOM tool deals with situations where there are few, but more than one, producers in the market, a structure known as *oligopoly*. In an oligopolistic market competition among firms is inherently affected by a setting of strategic interactions (Mas-Colell et al. 1995). The two typical approaches to analyze competition in oligopolies are the Cournot (1838) and Bertrand (1883) models. In the Cournot model the firms choose simultaneously the amount of output they want to supply and sell in the market at the market clearing price. In the Bertrand model the firms still choose simultaneously, but in contrast with the previous case where the strategic variable is the level of output, the firms now decide over the prices they want to charge and then must produce the output necessary to meet the demand after the price choices become known (Fudenberg and Tirole, 1991).

This section of the User Manual focuses on the equilibrium produced in an oligopoly when the firms compete following a Cournot model. This model implies a one-stage game in which firms choose their quantities or capacities simultaneously.[18] Given these quantity choices, price will adjust to the level that clears market, $p(Q)$, where $Q = q_1 + \cdots + q_n$, and $p(\cdot)$ is the inverse demand function. It is possible to assume a generalized profit function, $\Pi^i(q_1, \ldots, q_i, \ldots, q_n)$, such that the optimization problem faced by the firm can be written as:

$$\max_{q_i \geq 0} \Pi^i(Q) = q_i \cdot p(Q) - C_i(q_i) \tag{2.9}$$

Or, also can be expressed as:

$$\max_{q_i \geq 0} \Pi^i(q_1, \ldots, q_i, \ldots, q_n) = q_i \cdot p(q_1, \ldots, q_i, \ldots, q_n) - C_i(q_i) \tag{2.10}$$

Both expressions are equivalent, but the second one makes more explicit the fact that the price is a function of the aggregate output of all the firms in the market, while the cost is only a function of each firm own's production level. Each firm maximizes its profit given the quantity supplied by all the other firms in the market.

To solve equation (2.9) each firm i behaves as a monopolist who faces an inverse demand function given by $\tilde{p}(Q) = p(\bar{q}_1, \ldots, q_i, \ldots, \bar{q}_n)$. This implies that the optimally chosen quantity for firm i, q_i, is decided taking as given the level of output of the rival firms $(\bar{q}_1, \ldots, q_{-i}, \ldots, \bar{q}_n)$. To be more precise, if the profit function $\Pi^i(Q)$ is strictly concave in q_i and twice differentiable, the first-order condition for the previous Cournot model follows:

$$\frac{\partial \Pi^i(Q)}{\partial q_i} = p(q_1, \ldots, q_i, \ldots, q_n) + q_i \cdot p'(q_1, \ldots, q_i, \ldots, q_n) - C_i'(q_i) = 0 \tag{2.11}$$

We can also reorganize the results in equation (2.11) to facilitate their interpretation. In the equation (2.12) below the first two terms refer to the additional profit associated with an extra unit of output, which is equal to the difference between price and marginal cost. The third term captures the effect of this extra unit on the profitability of inframarginal ones, since this additional unit of output will decrease the price affecting the q_i units already produced:

$$p(q_1, \ldots, q_i, \ldots, q_n) - C_i'(q_i) + q_i \cdot p'(q_1, \ldots, q_i, \ldots, q_n) = 0 \tag{2.12}$$

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[18] An example of competition following a Cournot model are the "farmers *deciding how much of a perishable crop to pick each morning and send to a market. Once they have done so, the price at the market ends up being the level at which the crops that have been send are sold.*" (Mas-Colell et al. 1995:389).

To showcase this previous result, we rely on the assumptions proposed by Rodriguez-Castelan (2015), who discusses a model that shows how exogenous variations in market power could affect poverty. In Rodriguez-Castelan (2015), the competition among the oligopolistic markets follow a Cournot model and produces a Nash equilibrium. Note that the idea of Nash equilibrium[19] is implicit in the solution of the Cournot equilibrium. The equilibrium is determined by the condition that each firm choose the action that is a best response to the anticipated plays of the rest of firms in the market (Fudenberg and Tirole, 1991). To be able to solve the problem in (2.10), Rodriguez-Castelan (2015) assumes that there are $N \geq 2$ firms in the market, the firm's cost function $C_i(q_i)$ is a constant c (so the marginal cost of production, MC, would also be equal to c), and that the inverse demand function is given by $p(Q) = \frac{\beta\omega}{Q}$ such that:

$$\max_{q_i \geq 0} \Pi^i(Q) = q_i \cdot \frac{\beta\omega}{Q} - c. \, q_i = q_i \cdot \frac{\beta\omega}{\sum_{i=1}^{N} q_i} - c \cdot q_i \qquad (2.13)$$

Thus, the first order conditions are:

$$\left. \partial \Pi^i(Q) \middle/ \partial q_i \right. = \frac{\beta\omega}{\sum_{i=1}^{N} q_i} - q_i \cdot \frac{\beta\omega}{\left(\sum_{i=1}^{N} q_i\right)^2} - c = 0 \qquad (2.13)$$

In addition, if all firms are identical, then we have that $q_1 = \cdots = q_i = \cdots = q_n = \bar{q}$, and we can replace $Q = N\bar{q}$ in equation (2.13), where N denotes the number of firms in the market, such that:

$$\frac{\beta\omega}{N\bar{q}} - \bar{q} \cdot \frac{\beta\omega}{(N\bar{q})^2} - c = 0$$

$$\frac{\beta\omega}{N\bar{q}} \cdot \left(1 - \frac{1}{N}\right) - c = 0$$

$$\bar{q} = \frac{\beta\omega}{c} \cdot \left(\frac{N-1}{N^2}\right) \qquad (2.14)$$

This individual level of individual firm production implies that the aggregate output in the market should be equal to:

$$Q = \frac{\beta\omega}{c} \cdot \left(\frac{N-1}{N}\right) \qquad (2.15)$$

The equilibrium price then comes given by:

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[19] A Nash equilibrium is a "*profile of strategies such that each player's strategy is an optimal response to the other player's strategies.*" (Fudenberg and Tirole, 1991:12)

$$P = \frac{N}{N-1} \cdot c$$

Replacing the constant marginal cost, c, by MC and denoting the Nash equilibrium outcomes of the oligopoly model by the subscript $OLI - NASH$, the previous expression can be rewritten as:

$$p_{OLI-NASH} = \frac{N}{N-1} \cdot MC \qquad (2.16)$$

It follows that the change in price resulting from the oligopolistic structure, assuming a competition price equal to the marginal cost, is given by:

$$dp = \frac{p_{OLI-NASH} - p_{COMP}}{p_{COMP}}$$

$$dp_{OLI-NASH} = \frac{\frac{N}{N-1} \cdot MC - MC}{MC}$$

$$dp_{OLI-NASH} = \frac{1}{N-1} \qquad (2.17)$$

However, in practice we may not have the full information on the demand and the inverse demand function. Assume that all what we dispose is the price elasticity of demand, $\eta = \frac{\partial q/\partial p}{q/p}$. Given the quantity of the rest of firms, producer "n" maximizes the profits function:

$$\pi_n = p(Q) \cdot q_n - C q_n \qquad (2.18)$$

For simplicity, assume that $AC = MC = C$

$$\begin{aligned} \frac{\partial \pi_n}{\partial q_n} &= \frac{\partial p(Q)}{\partial q_n} \cdot q_n + p - c = 0 \\ &= \frac{q_n p}{Q} \cdot \left(\frac{\partial p(Q)}{\partial Q} \cdot \frac{\partial Q}{\partial q_n} \cdot \frac{Q}{p} \right) + p - c = 0 \qquad (2.19) \\ &= \frac{q_n}{Q} \cdot \frac{p}{\eta} + p - c = 0 \end{aligned}$$

Under the assumption that all firms are identical, each firm will produce the same amount of output in equilibrium, such that: $q_n = \frac{Q}{N}$, so it is possible to reorganize equation (2.19) to obtain:

$$-\frac{q_n}{Q} \cdot \frac{p}{\eta} = p - c \qquad (2.20)$$

$$-\frac{1}{N} \cdot p = \eta \cdot (p - c)$$

$$-\frac{1}{N} \cdot p = \eta \cdot p - \eta \cdot c$$

$$p + N \cdot \eta \cdot p = N \cdot \eta \cdot c$$

Using equation (2.20) and denoting the results from this model with the subscript $OLI - NASH$ is possible to find that at equilibrium:

$$p_{OLI-NASH} = \frac{\eta N}{1 + \eta N} \cdot MC \qquad (2.21)$$

Relying in (2.21) and assuming that in competitive markets prices are equal to the marginal cost is possible to find that:

$$dp = \frac{p_{OLI-NASH} - p_{COMP}}{p_{COMP}}$$

$$dp_{OLI-NASH} = \frac{\frac{\eta N}{1 + \eta N} \cdot MC - MC}{MC}$$

$$dp_{OLI-NASH} = -\frac{1}{1 + \eta \cdot N} \qquad (2.22)$$

c. *Partial collusive oligopolistic structure*

So far, this User Manual has discussed two classical market structures in the industrial organization literature dealing with market concentration and market power. The first is the case of monopoly where a single firm controls the whole market and charges monopoly prices extracting market-power rents from the price-taking consumers. The second market structure considers the case where few identical firms with market power compete—either by choosing quantities, in a Cournot model, or through prices, as in a Bertrand model—in an oligopoly, whose strategic interaction produces an outcome that can be characterized as a Nash equilibrium (see Tirole, 1988; Fudenberg and Tirole, 1991). Even though these two cases are widely taught in standard microeconomic courses, it is seldom that we observe a unique firm that control the whole market (monopoly), or a set of few identical firms competing through quantities, as assumed in the Cournot-Nash equilibrium.

This section of the User Manual introduces another model of market concentration that can be more realistic and that will require a limited level of information to assess the impact of market

concentration on prices. A common structure of concentrated markets—that this User Manual refers to as Partial Collusive Oligopoly Structure (PCO)—involves few firms with a significant share of the market and multiple smaller firms with no market power and small market share (i.e., this large number of small firms that can contribute in the provision of the good, but without any market power). This structure is not too different from the concept of a dominant firm and competitive fringe discussed in Perloff (2013). In this latter model, a monopoly with competitive fringe could occur when a former monopoly maintains a cost advantage over later entrants (e.g., after the end of import restrictions, foreign firms enter the market, but they might face higher costs than the former monopoly), which in turn can only supply a small part of the market acting as price takers. Thus, these price-taking firms are called the *competitive fringe*. In this model, the former monopoly acts as a price-setting firm that competes with price-taking firms, maximizing its profits based on a residual demand curve, i.e. the demand that is not met by the competitive fringe at any given price.[20] The PCO model proposes in this User Manual requires four basic assumptions:

- **Assumption 1:** A small number of large firms have a significant share of the market. The rest of the market is supplied by many smaller firms that lack market power. The user manual will refer to this case as: *the partial collusive oligopoly structure*.

- **Assumption 2:** In the shorter or medium term the small firms cannot easily update their produced/supplied quantities. Their quantities are assumed to be fix or highly rigid for the adjustments. There are a lot of reasons that can explain this rigidity:
  - ➢ The limited supply of some specific production inputs: specialized labor, specific intermediate inputs, etc.
  - ➢ A prohibitive cost of entry for new firms, and this, by converting their observed activities.
  - ➢ Consequently, it is assumed that the supplied quantity by the small firms is constant. Note that without the entry constraint, the outcome of this model would be similar to the Bertrand model (Tirole, 1988; Fudenberg and Tirole, 1991) where firms compete their prices down such that in equilibrium: $p = MC$. This can be explained by the gradual entry of firms that are attracted by the profit, and this will increase the quantity, and then, reduces the price until the level: $p = AC = MC$. However, this *Bertrand paradox* is not consistent with what we observe empirically.

- **Assumption 3:** The firms with market power (the oligopoly part of the market) coordinate to maximize their profits. Their predefined market share—if they act as in a competitive market—

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[20] See Perloff (2013): http://wps.aw.com/aw_perloff_microcalc_3/235/60177/15405461.cw/index.html

is (ϕ_O). An additional assumption is that firms know the market reaction or the price elasticity of demand (η).

- **Assumption 4:** The group composed by the smaller firms with no market power behave as followers. Firms of this groups will benefit from the increase in price implied by the reduction in the supplied quantity of the oligopoly group.

In addition, assume that the cartel (the oligopoly group) will act as a leader, and decides to reduce its supplied quantity share by $d\phi_O$. As indicated, the cartel cannot influence the quantity produced by the small firms (Q_S) that behaves as price takers when $p \geq MC$. Starting from the known price elasticity η, what would be the level of $d\phi_O$ that maximizes the profit of the oligopoly group? For simplicity, suppose that the marginal cost is constant and equal to the price of the full competitive market. The profit of the oligopoly group is:

$$\pi_O = p(Q = Q_O + Q_S) \cdot Q_O - C(Q_O) \tag{2.23}$$

Assume that the cartel (the oligopolistic group) acts as a leader, and decides to reduce its supplied quantity share by ϕ_O. As indicated, the cartel cannot influence the produced quantity of the small firms (Q_S) when $p \geq MC$. Starting from the known price elasticity η, what can be the level of $d\phi_O$ that maximizes the profit of the partial-oligopolistic group? For simplicity, assume that the marginal cost, MC, is constant such that the maximization problem that firms with market power face is equivalent to:

$$\pi_O = p(Q_O + Q_S) \cdot Q_O - cQ_O \tag{2.24}$$

Under the previous conditions, and assuming that π_O is a concave and twice differentiable continuous function, the first order condition are given by:

$$\frac{\partial \pi_O}{\partial Q_O} = \frac{\partial P}{\partial Q} \cdot \frac{\partial Q}{\partial Q_O} \cdot Q_O + p - MC = 0 \tag{2.25}$$

$$\frac{\partial P}{\partial Q} \cdot \frac{\partial Q}{\partial Q_O} \cdot Q_O + p = MC$$

$$\frac{\partial P}{\partial Q} \cdot \frac{\partial Q}{\partial Q_O} \cdot \frac{Q_O}{Q} \cdot Q = MC - p$$

$$\frac{\partial P}{\partial Q} \cdot \frac{Q}{p} \cdot \frac{\partial Q}{\partial Q_O} \cdot \phi_O = \frac{MC}{p} - 1$$

$$\frac{1}{\eta} \cdot 1 \cdot \phi_O = \frac{MC}{p} - 1$$

$$\frac{1}{\eta} \cdot \phi_O + 1 = \frac{MC}{p}$$

$$p_{PCO} = \left(\frac{1}{1 + \phi_O/\eta} \right) \cdot MC \tag{2.26}$$

This formula reproduces some familiar results. For instance, it follows from formula (2.26) that if $\phi_O \to 0$, then $p = MC$, the classical result in competitive markets. Also, this formula could be used to infer some information on the proportion of increase in the price implied by the market concentration.

Going from the competitive market outcome, $(p_{CM} = MC)$, to the partial collusive oligopoly, $\left(p_{PCO} = \frac{MC}{1 - \phi_O \eta} \right)$, implies a proportional price increase of:

$$dp = \frac{p_{PCO} - p_{CM}}{p_{CM}}$$

$$dp = \frac{\frac{1}{1 - \phi_O \eta} \cdot MC - MC}{MC} = \frac{MC \cdot \left(\frac{1}{1 + \phi_O/\eta} - 1 \right)}{MC}$$

$$dp = \frac{1}{1 + \phi_O/\eta} - 1 = \frac{1 - 1 - \phi_O/\eta}{1 + \phi_O/\eta}$$

$$dp = \frac{p_{PCO} - p_{CM}}{p_{CM}} = -\frac{\phi_O/\eta}{1 + \phi_O/\eta} = -\frac{\phi_O}{\eta + \phi_O} \tag{2.28}$$

Empirically, it is assumed that the observed market share of the oligopoly group with PCO (ϕ_o^{PCO}) is lower than in the competitive market (ϕ_o^{COMP}). Precisely, the observed market share is:

$$\phi_o^{PCO} = \frac{\phi_o^{COMP} + \eta^* \cdot dp}{1 + \eta^* \cdot dp}$$

Thus, we have:

$$\phi_o^{COMP} = \phi_o^{PCO} \cdot (1 + \eta^* \cdot dp) - \eta^* \cdot dp$$

In general, while in the monopoly case a positive change in price implies that: $\eta < -1$, in the PCO model the constraint becomes $\eta < -\phi_O$. The PCO model can justify existence of the market power even if the elasticity is lower than one, and this what makes such a model attractive.

Based on 2.5 and 2.28, we find the following result:

$$\eta = \frac{\partial Q}{\partial P}\frac{p_1}{Q_1} = \frac{\partial Q}{\partial p} \cdot \frac{p_{COMP}}{Q_{COMP}} \cdot \frac{(1+dp)}{(1+\eta^*dp)}$$

$$\eta = \frac{\partial Q}{\partial p} \cdot \frac{p_{COMP}}{Q_{COMP}} \cdot \frac{(1+dp)}{(1+\eta^*dp)} = \eta^* \cdot \frac{(1+\frac{-\phi_O}{\eta+\phi_O})}{(1+\eta^* \cdot \frac{-\phi_O}{\eta+\phi_O})}$$

$$\eta = \eta^* \cdot \frac{\frac{\eta+\phi_O-\phi_O}{\eta+\phi_O}}{\frac{\eta+\phi_O-\eta^* \cdot \phi_O}{\eta+\phi_O}} = \frac{\eta^* \cdot \eta}{\eta+\phi_O-\eta^* \cdot \phi_O} \qquad (2.29)$$

$$1 = \frac{\eta^*}{\eta+\phi_O-\eta^* \cdot \phi_O}$$

$$\eta^* + \eta^* \cdot \phi_O = \eta + \phi_O$$

$$\eta^* = \frac{\eta+\phi_O}{1+\phi_O} \qquad (2.30)$$

Next, the User Manual reports two illustrative examples for the two suggested methods of the PCO model. Let $\eta = -0.8$, $\tilde{\phi}_O = 0.20$, the observed exchanged total quantity is 1000. For the monopoly example, we assume that the elasticity is -1.2. The following table gives the results of the two examples.

Competitive market	PCO market
$\eta^* = -1.5/(1+0.25*2.5) = -0.9231$ $\eta^* = \eta/(1+dp(1-\eta))$	$\eta = -1.5$
$p_{comp} = 1.00$	$p_{OLI} = \left(\frac{1}{1+(\phi_O/\eta)}\right) = 1.25$
$MC = 1.00$	$MC = 1.00$

$\phi_R = 0.7$	$\tilde{\phi}_0 = 0.3$
$Q_R = 700$	$Q_{o\_OLI} = 300$
$Q_{o\_OLI} = (1 - 0.9231 * 0.25) * Q_{o\_COMP}$	
$Q_{o\_COMP} = 390$	
Profit = (1-1)*390=0	Profit = (1.25-1)* 300≈75

Competitive market	MONOPOLY market
$\eta^* = -1.2/(1 + 5 * 2.2) = -.1$ $\eta^* = \eta/(1 + dp(1 - \eta))$	$\eta = -1.2$
$p_{comp} = 1.00$	$p_{MONO} = \left(\dfrac{1}{1 + 1/\eta)}\right) = 6$
$MC = 1.00$	$MC = 1.00$
$Q_{o\_MONO} = 1000$ $Q_{o\_MON} = (1 - .1 * 5) * Q_{o\_COMP}$ $Q_{o\_COMP} = 2000$	
Profit = (1-1)*2000=0	Profit = (6-1)* 1000≈5000

The suggested PCO model offers three main advantages:

i. The User not need to know the exact number of firms, but can model the market using information on the share of the largest firms.

ii. This market structure requires moderate information to assess the impact of market concentration on prices. Mainly, it requires the elasticity of demand and the market share of the oligopoly group.

iii. The suggested model mimics the real life and where we observe that small and large firms realize some profits.

d. Partial market adjustment

The three previous subsections discuss cases of complete movements from a market concentration situation to a perfective competitive market, or vice versa. However, it may be helpful to cover the case of a partial or stepwise movement. For instance, suppose a situation when starting from a given number of oligopoly firms, the user is interested in assessing the impact of a discrete increase in the number of firms. In addition, notice that the monopoly model is similar to

the PCO model when the oligopoly market size is equal to 100%. In general, for the monopoly and PCO models, it is possible to assume that a partial movement implies a decrease in the market size from ϕ_o^1 to ϕ_o^m.

Starting from the equation (2.30), is possible to show that:

$$\eta^m = \eta^* \cdot (\phi_o^m + 1) - \phi_o^m$$

Then:

$$dp_{PCO}^m = \frac{-\phi_o^m}{\eta^m + \phi_o^m}$$

Finally, for the case of oligopoly with the Nash equilibrium:

$$\eta^m = \frac{1 + \eta^*(1 + N^m)}{N^m}$$

Such that:

$$dp_{NASH}^m = \frac{1}{1 - \eta^m \cdot N^m}$$

2.3   Price changes and the household well-being

This User Manual focuses in estimating the welfare impacts derived from changes in prices following the tradition of indirect welfare measurement. The essential empirical problem that this section of the User Manual discusses is how to measure welfare changes when the price of at least one of the goods considered changes and if utility, demand or both are unknown (Abdelkrim and Verme, 2016). There are three alternative money-metric well-being measurements in the **mcwel** Stata module:[21] the Laspeyres measure, the equivalent variation measurement and the compensated variation measurement. This section briefly discusses the characteristics of each of the measurements.

The indirect utility depends on the level of income and that of prices of goods and services. According to King (1983), the *equivalent income* is a level of income for which one can keep the level of utility unchanged after the change in prices. Formally, if the indirect-utility function is denoted by *V*, we can write:

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[21] Hicks (1942) discusses five common measures of welfare changes: (i) Consumer's surplus variation, (ii) compensating variation, (iii) equivalent variation, (iv) Laspeyres variation, and (v) Paasche variation. For a recent discussion of alternative welfare measures see Abdelkrim and Verme (2016).

$$V(\mathbf{p}^r; m_e^t) \equiv V(\mathbf{p}^t; \mathrm{m}^0)$$

where $\mathbf{p^r}$ and $\mathbf{p^t}$ denote the vectors of prices in r and t periods respectively and m_e^t denotes the equivalent income.

$$m_e^t = f(\mathbf{p}^r; \mathbf{p}^t; \mathrm{m}^0)$$

The reference period can be the initial ($r = 0$) or the final ($r = 1$). The equivalent variation is equal to:

$$EV = f(\mathbf{p^0}; \mathbf{p^1}; \mathrm{m}^0) - f(\mathbf{p^0}; \mathbf{p^0}; \mathrm{m}^0),$$

and the compensated variation is equal to:

$$CV = f(\mathbf{p^1}; \mathbf{p^1}; \mathrm{m}^0) - f(\mathbf{p^1}; \mathbf{p^0}; \mathrm{m}^0).$$

a. *The Laspeyres measurement*

The Laspeyres measurement of the change in well-being resulting from the change in prices is simply equal to the change in the total expenditures where the initial quantities are maintained. This measurement is also equal to the first order Taylor approximation of the price impact on well-being (see Abdelkrim and Verme (2016) for more details). Formally, if we denote the expenditures of the household (h) on the product of interest (k) by $e_{h,k}$, we have that:

$$dw_h^{Laspeyers} = -e_{h,k} \cdot dp_k \qquad (2.32)$$

b. *The equivalent variation measurement[22]*

The user can select among two consumer preferences functional forms. The first is that of Cobb-Douglas function (CD). The second is the *constant elasticity of substitution* (CES) *functional form*. Let $\alpha_{k,h}$ denotes the expenditure share of household h on the product of interest k. Using

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the King (1983) approach, and assuming initial prices are normalized to one in the initial period, the change in well-being of household h, measured by the equivalent variation, is equal to:

$$dw_h^{EV:CD} = w_h \cdot \left[\frac{1}{(1+dp_k)^{\alpha_{k,h}}} - 1\right] \tag{2.33}$$

$$dw_h^{EV:CES} = w_h \cdot \left(\frac{\pi_{0,h}}{\pi_{1,h}} - 1\right) \tag{2.34}$$

where $\pi_{0,h} = \left(\alpha_{k,h}{}^\sigma + (1-\alpha_{k,h})^\sigma\right)^{\frac{1}{1-\sigma}}$ and $\pi_{1,h} = \left(\alpha_{k,h}{}^\sigma (1+dp_k)^{1-\sigma} + (1-\alpha_{k,h})^\sigma\right)^{\frac{1}{1-\sigma}}$.

c. *The compensated variation measurement*

The change in well-being of household h, measured by the compensated variation, is equal to:

$$dw_h^{CV:CD} = w_h \cdot (1 - (1+dp_k)^{\alpha_{k,h}}) \tag{2.35}$$

$$dw_h^{CV:CES} = w_h \cdot \left(1 - \frac{\pi_{1,h}}{\pi_{0,h}}\right) \tag{2.36}$$

2.4

3. The WELCOM Stata Package

The fourth section of this User Manual discusses the installation, preparation of data and alternative methods of analysis available in **mcwel** tool to estimate the impacts of competition policy reforms in welfare.

3.1   Installation

To install WELCOM execute the following commands in the Stata command line. Note that it is possible to either copy and paste these lines directly in the command window or in the dofile editor preferred by the User:

Commands 01
set more off
net from http://dasp.ecn.ulaval.ca/welcom/Installer
net install welcom, force
cap addmimenu profile.do _ welcom_menu
_ welcom_menu

Note: The Stata command lines in the chart **Commands 01** tries to add the file profile.do automatically or add the command **_welcom_menu** in this profile file, if the latter already exists. However, if the previous commands do not function, the User needs to manually copy and paste the profile.do file in the following locations (based on the operating system of the computer):

a.   *Windows OS system:* copy the file in **c:/ado/personal/**

b.   *Macintosh system:* copy the file in one of the Stata system directories. To find these directories, type the command **sysdir**.

Once the previous steps were executed, the User should close all Stata sessions and restart the program. After opening a new window, the User should be able to go to the menu bar in Stata, click on the User option, choose the WELCOM package, select the Market concentration option and launch the **mcwel** tool by clicking on Market concentration and well-being:

Point and click 01
User > WELCOM > Market concentration > Market concentration and well-being
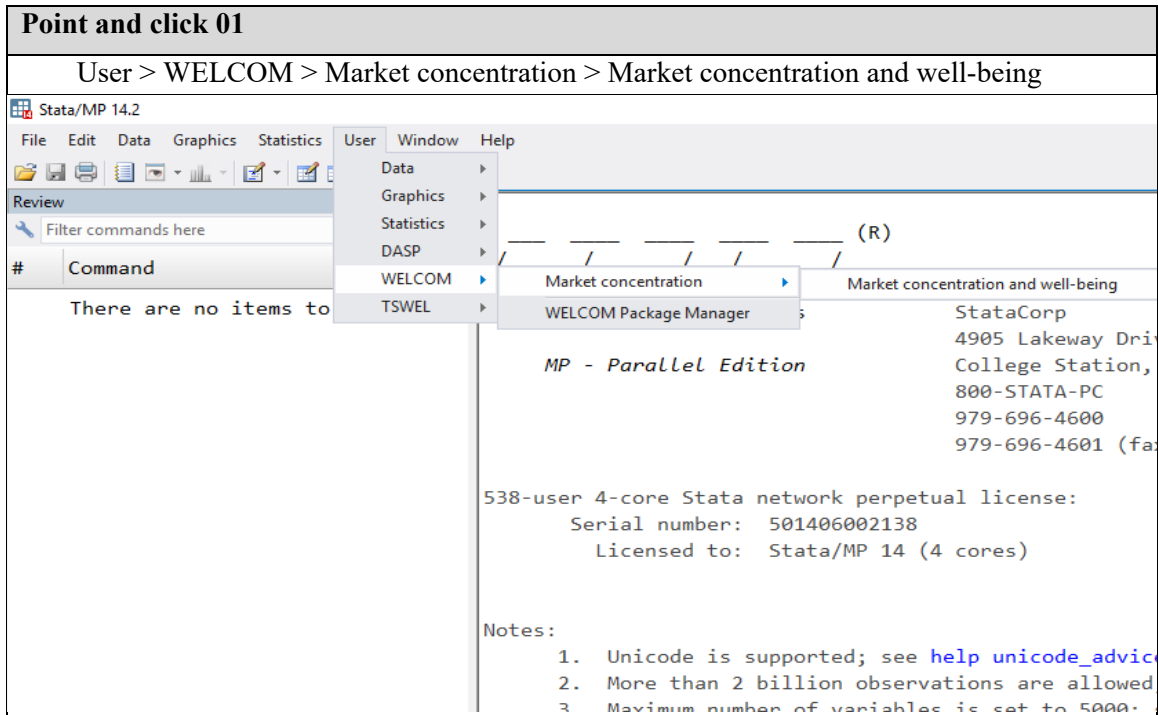
After selecting the "Market and well-being" option, a window with the main user interface of the **mcwel** module will open and the User can start interacting with the program:

Figure 4.1: Main tab in **mcwel** module interface

Note that the WELCOM package also provides the option of "WELCOM package manager" to manage updates in the tool, read the reference material or visit the WELCOM website[23] as shown in Figure 3.2 below:
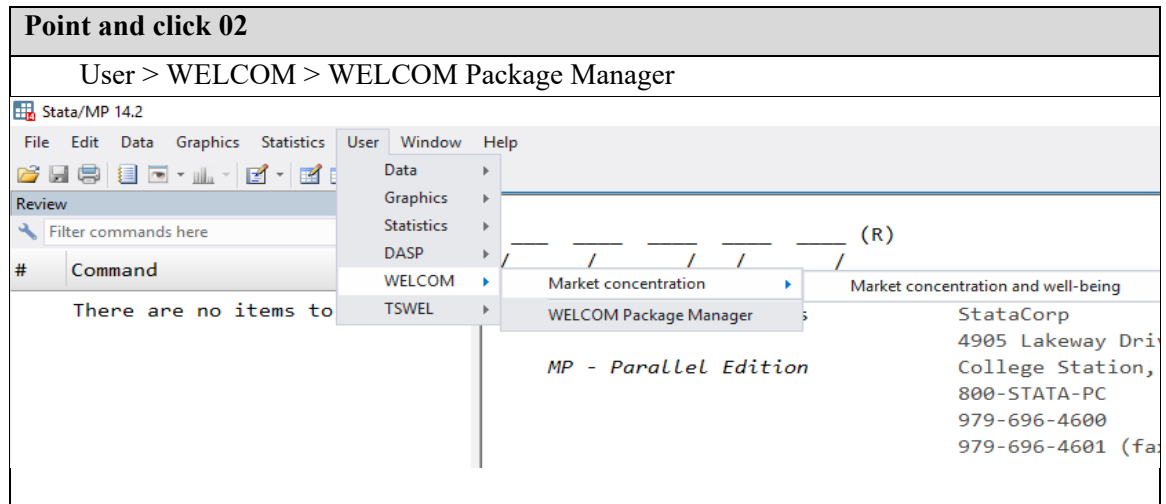
The following window corresponds to the user interface of the WELCOM: Package Manager, showing alternatives to manage the version of the WELCOM Package and of the **mcwel** Stata tool:

Figure 3.2: WELCOM: Package Manage Window
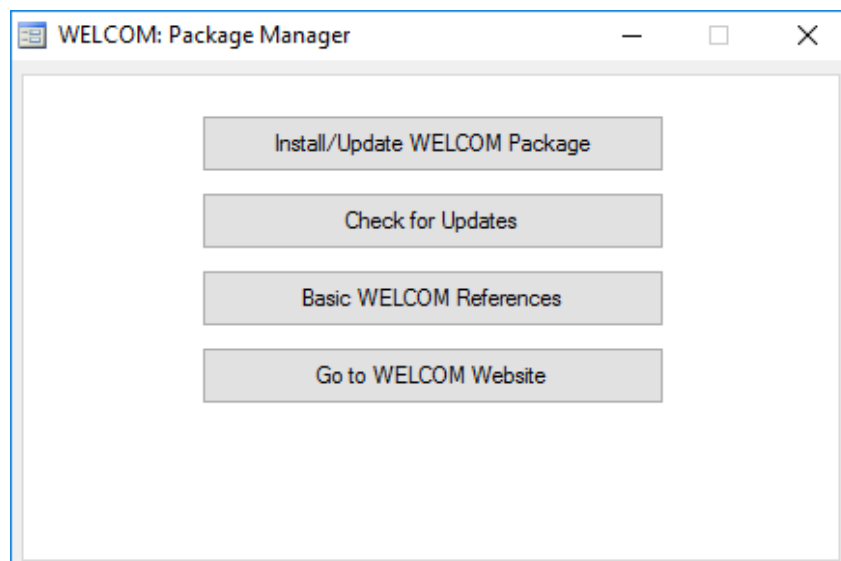
After the User executes the commands in the table **Commands 01** and launches the **mcwel** tool following the instructions in **Point and click 01**, the tool is ready for use. The next section will discuss in more detail the user interphase of the **mcwel** module for Stata.

3.2   The **WELCOM package** for Stata

The WELCOM package for Stata and was designed to assess the impact of changes in consumer prices resulting from policy interventions to strengthen competition in specific markets relying on the alternative theoretical models discussed in Section 3.2 of this User Manual. The current version of the tool is flexible enough to accommodate three alternative market structures and firms' competitive behavior:

- *Monopoly:* probably the simplest situation, when a single firm or a group of collusive firms acting as a single supplier have market power on the supply side.
- *Oligopoly:* in this scenario, a small number of firms with market power control the supply side and compete generating a Cournot-Nash equilibrium.
- *Partial collusive oligopoly*: a small number of firms with market power control a given share of the market supply side and several smaller firms with no market power behave as price takers.

The empirical analysis produced by the tool is based on micro-economic models where the household is the unit of reference. One of the advantages of the tool is that it has mild minimum data requirements that allow the User to run *ex-ante* analysis of policies aimed at strengthening competition. The data requirements of the tool include:

- A representative sample of the population (i.e., a consumption survey).
- Information on total household expenditures (i.e., a variable representing a consumption aggregate).
- Data on household expenditures on the product of interest where we observe the market concentration or expect a competition policy reform.
- Information on one of the following parameters of the model (market structure), based on the characteristics of the industry under study:
  - ➢ Monopoly: demand price elasticity.
  - ➢ Oligopoly: number of firms in the market and demand price elasticity.
  - ➢ Partial collusive oligopoly: market share of the firms colluding and the demand price elasticity they face.

Note that the data requirements of WELCOM can typically be met with data from two alternative sources. On one hand, a household survey with a consumption module should provide enough information on total consumption and expenditure in the type of good of interest. On the other hand, basic information on the characteristics of the market and market structure can be obtained from industry reports (such as the number of firms and market shares), studies from government agencies (market shares, elastic of demand, collusive agreements) and firms or industry surveys (number of firms, market shares), among others.

The rest of this section of the User Manual presents the different elements and features of the tool in five parts:

    a.   Preparing the dataset
    b.   Launch the dialog box
    c.   Load the key variables
    d.   The "Main" tab
    e.   The "Items" tab
    f.   Select options to produce tables
    g.   Select options to produce graphs
    h.   The "if/in" tab

a. *Preparing the dataset*

Prior to launching the dialog box it is necessary to load in the memory of Stata a database including variables with the relevant information on consumption in the format required by the tool as well as additional characteristics on the market structure for the alternative options that the user would like to estimate.[24] The tool requires information on the following dimensions of household characteristics and poverty measurement in the market:

- **Expenditure per capita in the product of interest:** to analyze the effects of competition policy interventions, the dataset available should include information on expenditure per capita in the good or service where a firm or group of firms have market power or where a competition policy reform is expected to have impact.

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[24] Please notice that if the database of interest already includes all the necessary variables to use the **mcwel** command it can be directly load to memory from the mc dialog box.

- **Per capita expenditures:** since the estimation of the effects of the competition policies rely on a relative incidence analysis, information regarding the overall level of expenditure per capita is also required.
- **Household size:** the tool also requires to identify a variable capturing the size of the household.
- **Poverty line:** a variable representing the relevant poverty line (alternatively, other line such as extreme poverty, vulnerability or middle class could be used) is necessary to assess the effects of the intervention on poverty.[25]

In Figure 3.3. the User Manual shows a simple example of the kind of data on consumption that the tool requires:

Figure 3.3: Data Requirements

In addition, the **mcwel** command allows to include the sample weights of the survey and, ideally, additional variables indicating the Primary Sampling Unit (PSU) and Strata. Moreover, the tool also allows the user to include a variable with information on the finite sample population

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[25] The current version of the tool expects that the three monetary variables (expenditure in the relevant good, total expenditure and poverty line) are expressed in comparative terms, for instance in current local currency units or in real terms using the same base year.

correction. However, if no information on the sample design of the survey is entered (the sampling design is not initialized), the simple random sampling is used by default.

Moreover, by default the tool will analyze the impacts of the policies by expenditure quintiles, however we may want to include a variable capturing a different disaggregation such as income deciles (to perform a relative incidence analysis by income decile), the urban/rural divide, bottom 40 and top 60, or an indicator of ethnicity, among others.

b. Launch the dialog box

Once the relevant database is loaded in the memory of the Stata program, the dialog box of the tool enables the User to interact with the tool and identify the variables with the required information on household consumption, as well as to select the appropriate models—and their parameters—for the alternative market structures and estimations. Thus, after the User loaded to memory the database with the relevant variables for the analysis, she can launch the dialog box following the steps discussed in the following **Point and click 03** table:

| Point and click 03 |
| --- |
| User > WELCOM > Market concentration > Market concentration and well-being |

Once the tool in Stata is launched the user interface will show a window with the "Main" tab, where the variables and parameters of the models to be analyzed can be selected. In addition, there is a second tab labeled "Items" where the User can indicate the markets or products under analysis. A third tab is optional and called "Table Options" to select the tables to be produced as

well as the location to save an Excel file with such tables. The "Graph Options" tab allows the User to choose alternative options to produce graphs. Finally, the "if/in" allows the User to select a subsample of the observations for the analysis. The "Figure 3.4: Tabs in the **mcwel** window" shows the location and main view of each of the tabs available in WELCOM.

Figure 3.4: Tabs in the main window
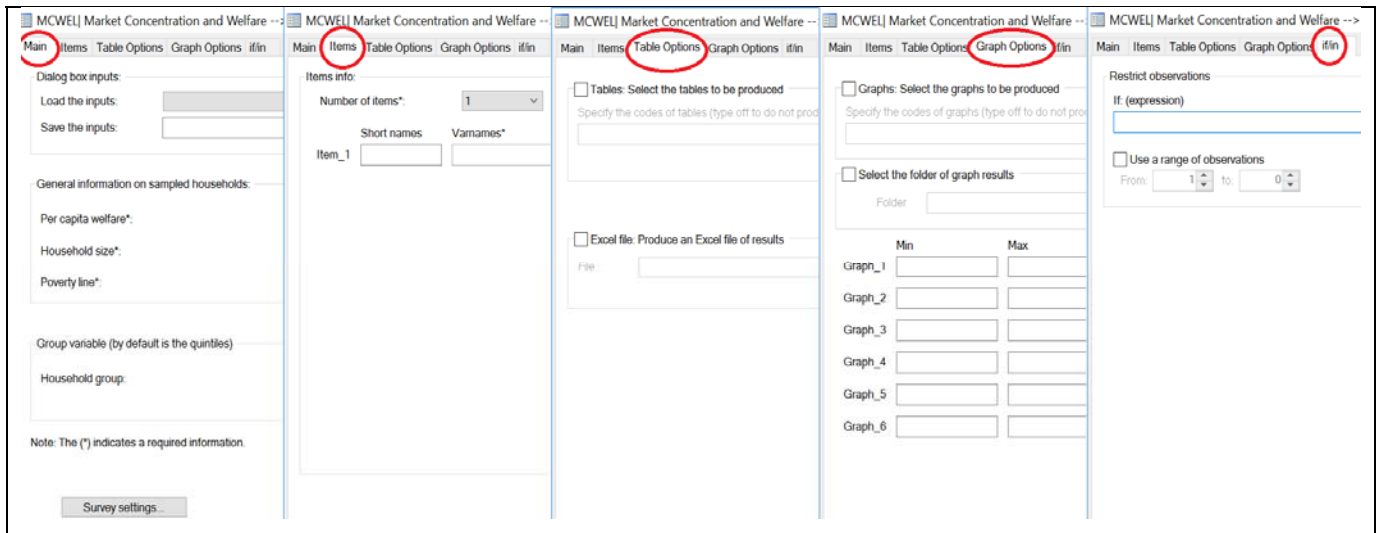
In the rest of this section, the User Manual will discuss the different elements that compound each of the tabs available in the dialogue box of the tool.

c. The "Main" tab

The "Main" tab of the tool is organized in seven sections, as indicated by the red circles in Figure 3.5, each associated to a different element of the data available, characteristics of the sample design, market structure and survey design, among others.

In addition, the "Main" tab also includes a box at the bottom right that the User can check if she wants to "Generate the variable for the impact on well-being", in case the User wants to generate a new variable in Stata to store the results of the analysis of the impacts of competition policy reforms.

Figure 3.5: Elements of the Main Tab Window

In the rest of this section each of the options in the seven section of the Main tab showed in Figure 3.5 will be discussed in detail:

- Dialog box inputs
- General information on the sampled households
- Group variable
- Prices and well-being model
- Estimated impact
- Parameters of inequality indices

- *The Dialog box inputs*

This is to load and save the dialog box information. The box enables the user to load information already saved into the WELCOM window, or to save the information inserted in the dialog box in a file to be stored for future simulations. This information is stored in text files with

the extension *.mcw. You can test this feature by uploading the file "mcwel_example.mcw" provided with the toolkit. Note that you can load the file from one directory ("Load the Inputs") and save it in a different directory with a different name ("Save the Inputs").

Point and click 04
User > WELCOM > Market concentration > Market concentration and well-being > Main > Dialog box inputs

- *General information on the sampled households*

The box "General information on sampled households" is located at the top left of the window. This box includes 4 options to select the relevant variable from the database in memory using a dropdown menu such as the one showed in **Point and click 04** chart. At a minimum, the tool requires the user to introduce information about the following three variables of interest:

i. Per capita expenditures: continuous numerical variable with monetary values.
ii. The household size: integer variable.
iii. The poverty line: continuous numerical variable with monetary values.

Point and click 05
User > WELCOM > Market concentration > Market concentration and well-being > Main > Per capita welfare / Household size / Poverty line

Notice that these variables should be included in the database in memory and need to be prepared in advance in the required format as discussed in the section "Preparing the dataset." In addition, the three monetary variables (Per capita expenditures on the product of interest, Per capita expenditures and Poverty line) should be expressed in comparable terms such as current currency units or in real terms using the same base year.

- *Group variable (by default is quintiles)*

The main information required by the tool to estimate the effect of policies that promote competition in markets were discussed in the "General information on sampled households" and "Market structure" sections. So far, the User was expected to introduce information based on the data on consumption and characteristics of the industry available in household surveys, market

studies, firm surveys or other sources. Now, the User is expected to introduce information on the way she wants the data to be analyzed and the estimates and results to be presented.

The box "Group variable" enables the User to select a population group variable in a dropdown menu from the database in memory or by directly introducing the number of groups to classify the households given their expenditure levels, as shown in the **Point and click 06** chart.

Notice that, in contrast with the previous boxes where the User had to either select an alternative or introduce a value, now she can either choose to select a variable or directly introduce an integer value representing the number of groups required. If the User decides to group the estimates using a variable, the results could show the differences by socio-demographic group such as gender or urban-rural area of residence. In contrast, if the user indicates an integer such as 10 in the "Household group" option, the population is organized by decile groups based on their level of expenditure. If the "Household group" option is left empty, then the results are shown organized by expenditure quintiles by default.

- *Price and well-being model*

Once the data on consumption, the parameters on the characteristics of the market and the organization of the results is selected, the User needs to decide the type of measurement to use to estimate the impacts of the policy fostering competition. More precisely, this implies choosing the main approach to be adopted to assess the impact of price change on well-being. The user can select among the three following alternative measurements (see the Section 3.3 for more details on the characteristics of these measures).

- The Laspeyres measurement (linear approximation).
- The equivalent variation measurement.
- The compensated variation measurement.

Point and click 07
User > WELCOM > Market concentration > Market concentration and well-being > Main > Select the structure > Prices and well-being model

- *Estimated impact*

So far, this User Manual has implicitly assumed that the base scenario under analysis is one where a concentrated market exists, such that the authorities responsible of policy design have identified the presence of market power and are planning to implement a policy to promote competition in the market. Therefore, the analysis of the effects of the policy implicitly assume moving from an industry where a group of firms exploit their market power, to a competitive market

where firms are not able to extract market power rents and charge prices according to their marginal costs.

Point and click 08
User > WELCOM > Market concentration > Market concentration and well-being > Main > Estimated impact

However, the tool is flexible enough to accommodate the analysis of policies aimed at fostering competition in the market (e.g., by selecting the "Concentrate to Competitive Market" option in the "Select the direction" box) as well as the opposite scenario, where a policy is expected to somehow reduce competition in the market (e.g., limit imports, setting price ceilings, creating artificial monopolies, etc) and the User needs to assess the impact on welfare of moving from a competitive market to a more concentrated one.

To switch between the base scenarios that the User wants to run for the analysis, she can go to the "Estimated Impact" box and follow the indications in the **Point and click 08** chart below. Notice that as the User change the base scenario, the interpretation of the results should also be adjusted to reflect the relevant conditions.

In addition to estimating the impact of moving from the initial to the final state (for instance from the concentrated market to the competitive market), the module can estimate the intermediate states of the partial movements toward the final state. This is can be achieved by indicating the number of steps of adjustments. For instance, assume that we have a case of a PCO model for which

the market size of the oligopoly firms is equal to 60%. If the selected number of adjustment is zero, then the tool estimates directly the impact of a full impact. If the number of steps is one, then the impact is estimated from a change of the market change from 60% to 30% and then from 60% to 0%. As a general rule, if we denote the initial market share by ϕ^I and the number of steps by s, then, the intermediate steps are: $\phi^I \rightarrow \frac{\phi^I}{(1+i)}$ $and\ i \in \{1;\ s\}$. The monopoly is a special case when $\phi^I = 100\%$.

Now, assume the case of the oligopoly market structure which a Nash equilibrium that depends on the number of firms. For instance, if the initial number of firms is $N^I = 4$, and the number of steps is three, the intermediate steps are: for $N = 6, 8\ and\ 12$. As a general rule, when the number of steps is s, then, the intermediate steps are:

$Step\ 1$: $N^I \rightarrow N^I * 1.5$ // **Step 2 to s:** $N^I \rightarrow N^I * i\ \ and\ i \in \{2;\ s\}$.

As an additional example, in table ##, we present some displayed results for the case of two product items (Combustible and Communication). In this case, the indicated number of steps is 3. For the combustible item, the initial marker size is 42.31%. The step1 is by moving toward the competitive market by a decline is the size from the 42.31 to 42.31/2, the step 2 is a decline in size until 42.31/3 and the step 3 is a decline until 42.31/4=10.57%. For the Communication item, the initial number of the oligopoly firms is 8, in the step 1 it increases by 50% to 12, and then it doubles in step 2 and triple in step 3.

The number of adjustment steps and results

	Combustible			Communication		
	Market size (in%)	Elasticity	Price	# of firms	Elasticity	Price
Concentrated_Market	42.3100	-0.9040	1.8798	8.0000	-0.6430	1.1628
Step___1	21.1550	-0.6210	1.5167	12.0000	-0.5821	1.1252
Step___2	14.1033	-0.5266	1.3658	16.0000	-0.5517	1.1018
Step___3	10.5775	-0.4794	1.2831	24.0000	-0.5213	1.0740
Competitive__Market	0.0000	-0.3379	1.0000	.	-0.4604	1.0000

Table 1.1: Models and parameters

The user can select another number of steps of adjustments, and this to have more refined results if needed.

- *Parameters of inequality indices*

In the "Parameters of inequality indices" the tool offers the option to select some of the parameters necessary to estimate the two alternative inequality indices:

a. The Atkinson index

b. The Generalized Entropy

Point and click 09
User > WELCOM > Market concentration > Market concentration and well-being>Survey settings

- *Survey settings*

Notice that to use the options for survey settings, the User needs to prepare the variables associated with the different dimensions of the survey design before launching tool. These settings include information on the sampling weights, sampling design, adjustment for finite population, among others. This can be done with the command "svyset" in Stata or using the button "Survey Settings…" located in the bottom right-hand corner of the "Main" tab, as shown in the **Point and click 08** chart.

Point and click 10
User > WELCOM > Market concentration > Market concentration and well-being>Survey settings

For more information on the alternative survey settings available in the tool, see the Stata Reference Manual on [Survey Data](#).

Figure 3.6: Survey Settings Options in the tool

d. The "Items" tab

Among the main improvements in the version 2.0 is the possibility of estimating the impacts of different market concentrations. The tab "Items" enables to indicate the number or products of interest with concentration markets, as well we, the market structure of each product/item. While the options in the "Main" tab generally rely on information from a household or consumer survey, the information for the "Items" tab comes from studies on the organization of the industry or market under study as well as from firm surveys or analysis on competition conditions from the competition market authorities (CMA).

The user can choose from 1 to 10 items. For each item, the user can indicate:

- The short name of the item or the product.
- The variable name of the expenditures per capita.
- The market structure: The tool needs information on the structure of the supply side of the industry, i.e. how many firms or suppliers are and how do they interact in the market. In addition, each model of market structure requires a different set of parameters that the User requires to feed into the mcwel tool. For instance, while the Monopoly structure only requires information on the elasticity of the demand, the Oligopoly: Nash Equilibrium needs in addition to the demand elasticity, information on the initial number of firms in the market. Following the instructions in the chart Point and click 05, the user can select among three alternative structures and the required industry parameters:

43

a. *Monopoly:* The User only needs to provide the value of the price elasticity of the demand. Notice that this elasticity is typically a negative parameter in the range (-1,0) since by theory the monopolist optimizes by producing in the elastic segment of the demand curve.

b. *Oligopoly-Nash equilibrium*: Under this type of market structure, the User must provide information on the elasticity of demand faced by the firms, as well as on the number of firms in the oligopolistic market.

c. *Partial collusive oligopoly*: In this scenario, the User must provide the value of the price elasticity of demand as well as the observed market share of the oligopolistic group.

- The non-compensated elasticity.
- The number of firms (model: Oligopoly: Nash equilibrium).
- The market size of the oligopoly group (model: PCO).

Point and click 11

User > WELCOM > Market concentration > Market concentration and well-being > Items > Number of firms

MCWEL| Market Concentration and Welfare --> mcwel command

Main | Items | Table Options | Graph Options | if/in

Items info:

Number of items*: 3

	Short names	Varnames*	Structure	Elasticity	Number of firms	Market size
Item_1	Combustible	pcexp_comb	Oligopoly (PCO)	-0.904		0.4231
Item_2	Communicat	pcexp_comu	Oligopoly (Nash)	-0.643	8	
Item_3	Cereals	pcexp_cereal	Oligopoly (PCO)	-.92700186		0.3471

OK   Cancel   Submit

It must be noted that one of the caveats of the analysis currently available in the tool is that the welfare outcomes of the alternative market structures are compared against a perfect competition counterfactual. This implies that the tool assumes, for instance, that after implementing a policy reform aimed at eliminating a monopoly in a market, this market will become perfectly competitive, assumption that might be problematic in some circumstances.

e. The "Table Options" tab

This tab allows the user to select the tables' options. The default option when you do not select the tables and override options is the production of all tables.

- *Tables: Select the tables to be produced*

In case the user wishes to have only a selected number of tables the code of these tables can be indicated in the box. The list of codes with the titles of the tables can be seen by clicking on the question mark button "?". For example, you can type "*11 23*" to produce tables 1.2 and 2.3 only (no commas, one space between numbers).

- *Excel file: Produce an Excel file of results*

This box allows the user to define the Excel file where all tables should be stored. The user can select an existing file to override or create a new file. The user can either specify the name of the file or not. In the case of an existing file, the user should make sure that this file is closed when the program is launched, otherwise an error message will appear.

f. *The "Graph Options" tab*

The tab on the Graph Options allows the User to decide if she wants the tool to produce graphs with the estimated impacts of the analysis of the policy interventions aimed at foster competition, and what are the parameters and characteristics of the graphs. To access the "Graph Options" tab, the User should follow the indications in the **Point and click 10** box. The main three options available allow to select the graphs to be produced, choose the folder to save such graphs and select among alternative graph options.

- *Graphs: Select the graphs to be produced*

This option allows the User to save only selected graphs by indicating the code of each graph. The list of codes with the titles of the graphs can be seen by clicking on the question mark button "?". For example, if the user wishes to produce only Graphs 1, 2 and 4, the user will simply type "1 2 4" (no commas, one space between numbers).

- *Select the folder of graph results*

This option allows the user to select the directory where the saved graphs should be stored. Note that all graph files are saved in three formats: .gph. .pdf and .wmf. will save a folder with the name "Graphs" in the directory selected.

- *Graph options*

For each graph, the user can select options regarding the y-axis scale (min and max) and other two-way graphs options as indicated in the Stata graph help files. For example, users may want to limit the range of the graphs to a specific interval like between 10 and 80. This can be done by indicating min and max values. Or users may want to omit titles of the graphs to add these titles separately in the report. This can be done by adding the Stata graph option "title ("")". Note that each of the displayed graphs is automatically saved in three format in a the previously indicated folder ("Graph"). The three format the saved graphs are: (i) *.gph; (ii) *.wmf; and (iii) *.pdf.

Point and click 13
User > WELCOM > Market concentration > Market concentration and >Graph options

g. *The "if/in" tab*

The "in/in" tab includes a single command box to select a relevant subsample from the database on memory to perform the analysis.

- *Restrict observations*

Note that, as shown by the **Point and click 09** box below, the mcwel tool offers two main ways to restrict the observations to a smaller subsample. The first alternative is to select observations conditional on a specific if expression or criteria. The second alternative implies restricting the analysis to a predetermined range of observations.

Point and click 14
User > WELCOM > Market concentration > Market concentration and well-being>if/in
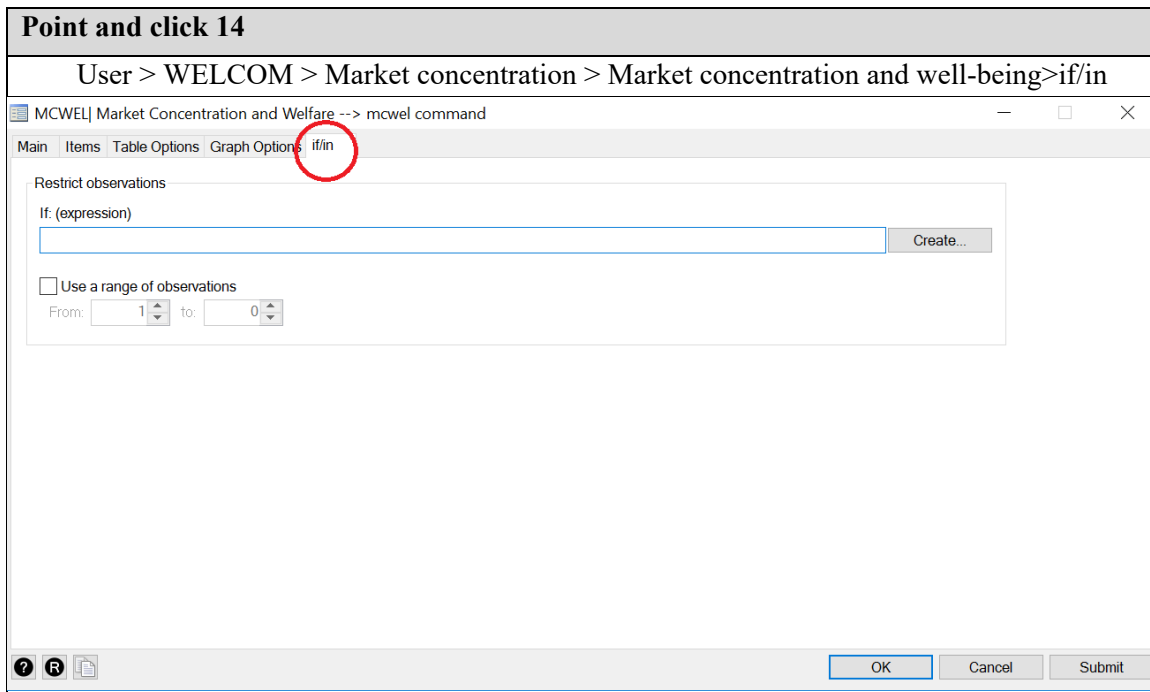
3.3 The mcwel outputs

After launching the computation, a series of results (tables and figures) are displayed. The main results tables provided are:

a. *The estimated market parameters*

In table 1, the price change, the adjusted elasticity and the rest of used or estimated parameters of the market structure are reported.

b. The descriptive statistics on household expenditures

In table 2, the average per capita to expenditures and that on the product of interest are reported for each population group. Also, it is displayed the expenditure shares.

c. The impact of the market concentration on household well-being

In table 3, the price change implied by the moving from a market without concentration to that with concentration is reported. In addition, table 3 reports the average impact of the price change on household well-being, and this by population groups.

d. The impact of the market concentration on poverty

In table 4, the three popular poverty indices are reported for the cases of with and without market concentration. Also, the impact of the market concentration on poverty is reported.

e. The impact of the market concentration on inequality:

In table 5, four inequality indices are reported for the cases of with and without market concentration. Also, the impact of the market concentration on the inequality is reported. The inequality indices are:

- The Gini index;
- The Atkinson index;
- The generalized entropy index;
- The Quantiles ratio index ($Q(p=0.1)/Q(p=0.9)$).

Note: The full information on the sampling design of the survey is used to assess the standard error of the different statistics.

The Figure results are:

- The expenditures share on the product of interest, per the well-being percentile;
- The per capita impact on well-being according to the well-being percentile;
- The Lorenz curve of well-being and the concentration curve of the product of interest.

3.4   Examples of WELCOM

Example 01:

➢ Step 1: Be sure that you have installed the WELCOM

➢ Step 2: load the zipped folder:
   http://dasp.ecn.ulaval.ca/WELCOM/examples/mcwel_examples.rar

➢ Step 3: Unzip the loaded folder in a given folder location: for instance c:/PDATA/WELCOM2/

➢ Step 4: Open the dialog box (type: db mcwel);

➢ Step 5: Load the file mcwel_example_01.mcw. This step will initialize the information in the
   dialog box

➢ Step 6: Click on the button submit.

In this first example, we would like to produce the tables 1.1 and 1.2, as well as the figure 01. We
have three items of interest, and their three corresponding market structures are already indicated
in the TAB items of the dialog box. As we can remark in the box *estimated impact,* we would like
to estimate the impact of moving from the concentrated market to the competitive market.
Further, we would like to estimate the impacts of a six partial moving toward the competitive
markets.

Table 1.1: Models and parameters

Item: Combustible	Market type : Partial Collusive Oligopoly		
Step	Market size (in%)	Elasticity	Price
Concentrated Market	42.310	-0.9040	1.879809
Step : 1	21.155	-0.6210	1.516716
Step : 2	14.103	-0.5266	1.365767
Step : 3	10.578	-0.4794	1.283072
Step : 4	8.462	-0.4511	1.230875
Step : 5	7.052	-0.4323	1.194930
Step : 6	6.044	-0.4188	1.168670
Competitive Market	0.000	-0.3379	1.000000

Item: Communication	Market type : Oligopoly: Nash Equilibrium		
Step	# of firms	Elasticity	Price
Concentrated Market	8.000	-0.6430	1.162760
Step : 1	12.000	-0.5821	1.125223
Step : 2	16.000	-0.5517	1.101755
Step : 3	24.000	-0.5213	1.074013
Step : 4	32.000	-0.5061	1.058158
Step : 5	40.000	-0.4970	1.047897
Step : 6	48.000	-0.4909	1.040714
Competitive Market	.	-0.4604	1.000000

Item: Cereals	Market type : Partial Collusive Oligopoly		
Step	Market size (in%)	Elasticity	Price
Concentrated Market	34.710	-0.9270	1.598550
Step : 1	17.355	-0.6787	1.343533
Step : 2	11.570	-0.5960	1.240897
Step : 3	8.677	-0.5546	1.185481
Step : 4	6.942	-0.5298	1.150793
Step : 5	5.785	-0.5132	1.127035
Step : 6	4.959	-0.5014	1.109745
Competitive Market	0.000	-0.4305	1.000000

For instance, for the combustible item, we have initially a PCO market structure, and where the market share of the oligopoly firms is 42.31 %. In the first step of the adjustment toward the competitive market, the market share is reduced, by the half, and then by two thirds and so on. Table 01 also shows the corresponding elasticities and prices.

Table 02 gives some descriptive statistics on the population and the expenditures

Table 1.2: Population and expenditures (in currency)

Groups	Population	Number of households	Household size	Total expenditures	Total expenditures per capita	Total expenditures per household
Quintile 1	24009490	4854708	4.95	18849142784	785.07	3882.65
Quintile 2	23958312	5402162	4.43	35458871296	1480.02	6563.83
Quintile 3	23982586	5894251	4.07	52534333440	2190.52	8912.81
Quintile 4	23986720	6734927	3.56	80423206912	3352.82	11941.21
Quintile 5	23969206	8784954	2.73	232294957056	9691.39	26442.37
Total	119906312	31671002	3.79	419560521728	3499.07	13247.47

Figure 01 gives more refined results similar to those of table 1.1:
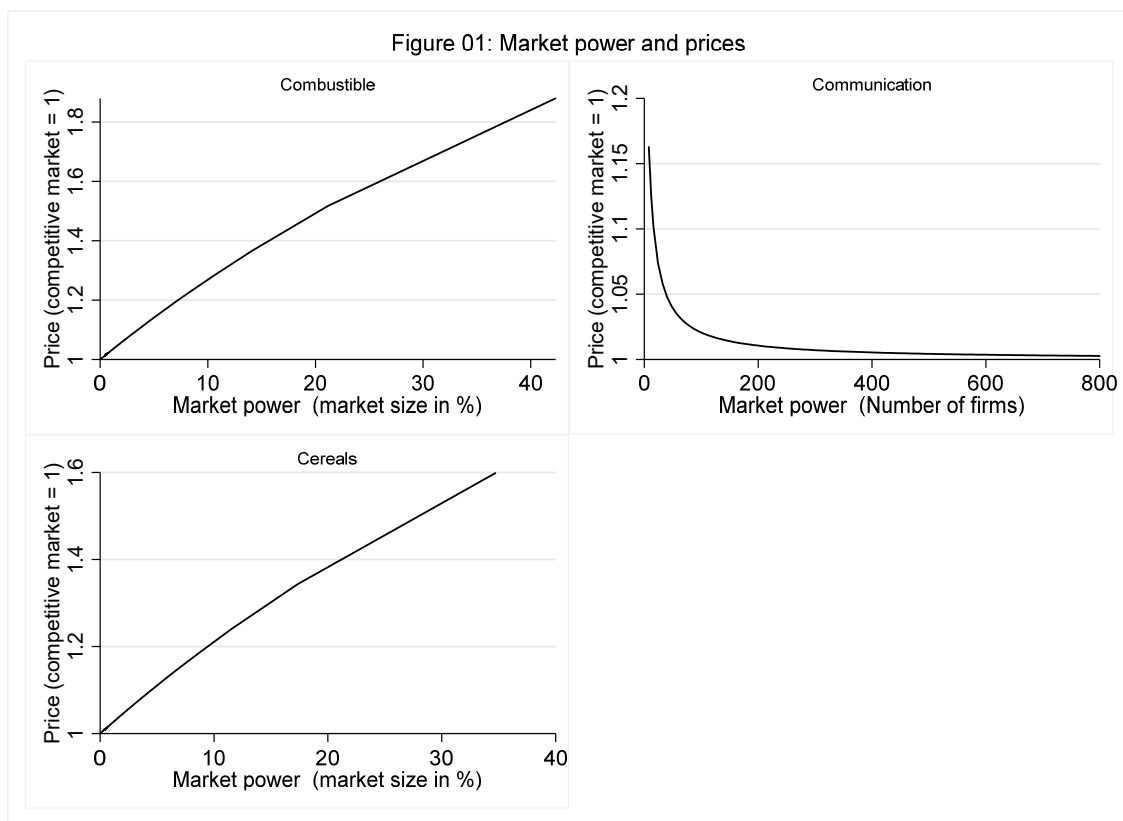
Figure 1: The mcwel table outputs

Example 02:

➢ Step 5: Load the file mcwel_example_02.mcw.

➢ Step 6: Click on the button submit.

This example is similar to the first, but in this case the number of steps of adjustment are two and we produce all of the tables and figures.

```
Table 1.1: Models and parameters

Item: Combustible        │ Market type : Partial Collusive Oligopoly

              Step       │Market size (in%)    Elasticity         Price

Concentrated Market      │      42.310          -0.9040        1.879809
Step : 1                 │      21.155          -0.6210        1.516716
Step : 2                 │      14.103          -0.5266        1.365767
Competitive  Market      │       0.000          -0.3379        1.000000

Item: Communication      │ Market type : Oligopoly: Nash Equilibrium

              Step       │  # of firms      Elasticity         Price

Concentrated Market      │       8.000          -0.6430        1.162760
Step : 1                 │      12.000          -0.5821        1.125223
Step : 2                 │      16.000          -0.5517        1.101755
Competitive  Market      │          .          -0.4604        1.000000

Item: Cereals            │ Market type : Partial Collusive Oligopoly

              Step       │Market size (in%)    Elasticity         Price

Concentrated Market      │      34.710          -0.9270        1.598550
Step : 1                 │      17.355          -0.6787        1.343533
Step : 2                 │      11.570          -0.5960        1.240897
Competitive  Market      │       0.000          -0.4305        1.000000
```

The mcwel module estimates the different statistics for each step of adjustment. For instance, for the impact on the poverty headcount, the first table shows the level of poverty with the concentrated market (53.352%), and then with only the partial adjustment of the combustible market (52.28). The last line shows the impact of the partial adjustment in the three markets (51.43). The table 5.1 is reproduced for each adjustment step.

Table 5.1: The market power and the poverty headcount || Concentrated to competitive: Step 1

Step	Poverty level	The change in poverty	Standard error	P-Value
Concentrated Market	53.352	.	.	.
Combustible	52.280	-1.072	0.101	0.000
Communication	53.263	-0.089	0.027	0.001
Cereals	52.566	-0.786	0.083	0.000
Competitive Market	51.435	-1.917	0.131	0.000

Table 5.1: The market power and the poverty headcount || Concentrated to competitive: Step 2

Step	Poverty level	The change in poverty	Standard error	P-Value
Concentrated Market	53.352	.	.	.
Combustible	51.923	-1.429	0.114	0.000
Communication	53.219	-0.133	0.040	0.001
Cereals	52.273	-1.079	0.097	0.000
Competitive Market	50.725	-2.627	0.156	0.000

Table 5.1: The market power and the poverty headcount || Concentrated to competitive: Full adjustement

Step	Poverty level	The change in poverty	Standard error	P-Value
Concentrated Market	53.352	.	.	.
Combustible	51.041	-2.311	0.147	0.000
Communication	52.895	-0.457	0.073	0.000
Cereals	51.557	-1.795	0.124	0.000
Competitive Market	49.057	-4.295	0.198	0.000

For the poverty and inequality, the Figures 05 and 06 will show the partial impacts in a refined way.

Figure 06: Market power and inequality

Steps and market power

Combustible

Communication

Cereals

All items
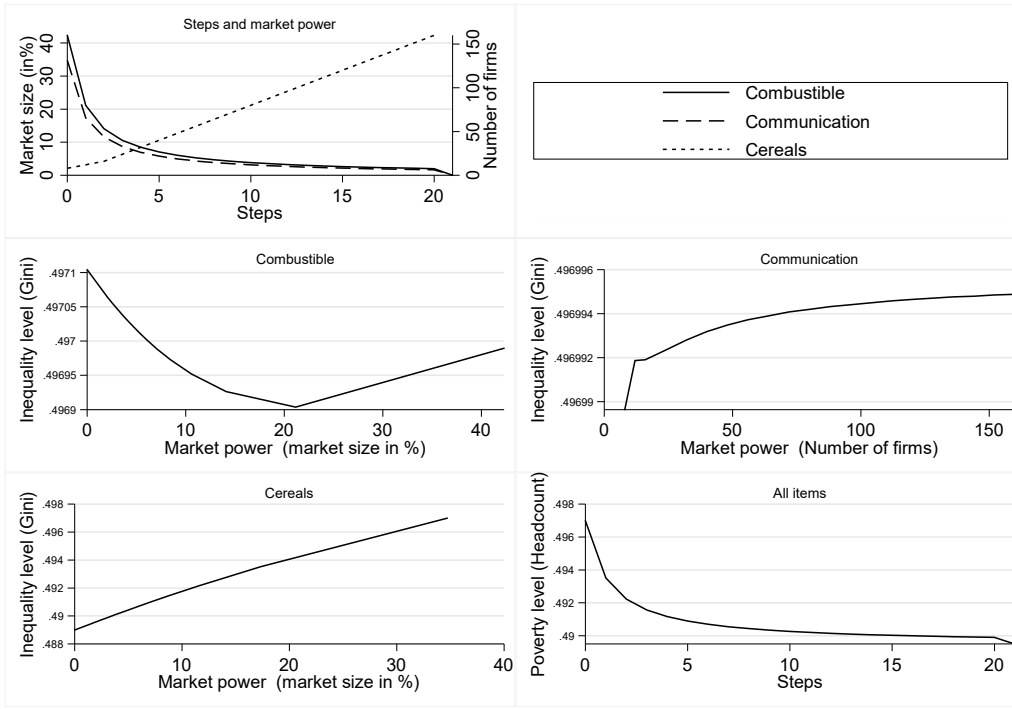
Figure 05: Market power and poverty headcount

Steps and market power

Combustible

Communication

Cereals

All items

Also, all of the tables are stored in an *.xml file that can be edited by Excel.

| | Combustible | | | | Communication | | Cereals | | |
	Market size (in%)	Elasticity	Price	# of firms	Elasticity	Price	Market size (in%)	Elasticity	Price
Concentrated_Market	42.3100	-0.9040	1.8798	8.0000	-0.6430	1.1628	34.7100	-0.9270	1.5985
Step___1	21.1550	-0.6210	1.5167	12.0000	-0.5821	1.1252	17.3550	-0.6787	1.3435
Step___2	14.1033	-0.5266	1.3658	16.0000	-0.5517	1.1018	11.5700	-0.5960	1.2409
Competitive__Market	0.0000	-0.3379	1.0000	.	-0.4604	1.0000	0.0000	-0.4305	1.0000

4. WELCOM and the demands system models

As reported before, the consumer reaction to the change in prices is among the main determinant of the market power. Disposing the information on the price elasticities is thus primordial to study the impacts of the market power on well-being. Depending on, on the specific context of each study, the practitioner can decide to use the available information on the elasticity in the other empirical studied or even estimate the required price elasticities. As an important contribution of the WELCOM package, is to introduce the popular and most updated demand system models and to provide the user-friendly tools for the estimations.

Because of the complex-specific details of each demand system model, it will be helpful to start by introducing in a more concise form each of the models and thus the WELCOM Stata module to estimate it. Thus, our aim is to remember briefly the most popular models and especially to focus on the computational framework, as well as to document or to develop the Stata code for the estimations of price elasticities. During the last decades, there is a significant progress in developing the flexible demand system models, as the AIDS/QUIDS or the EASI models. However, handling the data and estimating the models require some expertise.

4.1 Deaton's (1988) Unit Value Model

The Deaton's theoretical model

Estimating a demand system requires information on the household expenditures at different price levels. The price can vary spatially or temporally. However, accurate price-data are rare. This scarcity of data justifies switching to what we call the *unit value model*. In particular, for the case of large consumption groups with weak separability, Deaton (1988) develops a model to estimate the price and income elasticities, and this, using unit values, and where the model enables to compensate for the quality effect.

As reported by Deaton (1988), we assume that we have a given main set of expenditures, where each of them is composed of a predetermined group of items. Let E_c denotes the household expenditures on the group of items c.

$$E_c = p_c q_c \tag{4.1}$$

where p_c and q_c are vectors denoting the prices and the quantities of the group c. Within the group of commodities c, let λ_c denotes the proxy unique price of the commodities c and v_c the indicator of quality such that:

$$E_c = \lambda_c v_c Q_c \tag{4.2}$$

For the same level of expenditures E_c the aggregated quantity within the group c (Q_c) will depend on the quality of bought goods, v_c. More important, the estimated unit value $V_c = \frac{E_c}{Q_c} = \lambda_c v_c$ will depend on the product of proxy unique price and quality. Based on this model, the price elasticity is defined as follows:

$$e_c = \frac{\partial Q_c}{\partial \lambda_c} = \frac{\partial \ln Q_c}{\partial \ln V_c}\left(1 + \frac{\partial \ln v_c}{\partial \ln \lambda_c}\right) \tag{4.3}$$

Deaton (1988) proposes the adoption of the weak separable utility function with demands:

$$q_c = f_c\left(\frac{E_c}{\lambda_c}, p_c^*\right) \tag{4.4}$$

The consumer selects in the first stage the –normalized- budget $\frac{E_c}{\lambda_c}$ that is allocated to the group c. After that, and depending on the vector of the prevailed prices according to the quality (p_c^*), the consumer will select the levels of expenditures on the different items of the group c. In addition, the assumption of weak separability leads to:

$$\frac{\partial \ln v_c}{\partial \ln \lambda_c} = \frac{\dfrac{\partial \ln v_c}{\partial \ln x}\dfrac{\partial \ln Q_c}{\partial \ln \lambda_c}}{\dfrac{\partial \ln Q_c}{\partial \ln x}} \tag{4.5}$$

The empirical implementation and estimation

We start with the case of the standard unit value model, and where we assume that the quality effect is nil or can be neglected. As suggested by Deaton (1988), the simple model with the weak separability assumption is as follows:

$$w_{c,i} = \alpha_0 + \beta_0 x_i + \gamma_0 z_i + \phi_0 \ln(V_{c,i}) + u_{0,i} \tag{4.6}$$

where

$w_{c,i}$: The budget share of group c.
x_i : The household income.
z_i : Household characteristics
$V_{c,i}$: Unit value of group c.

We have that:

$$\frac{\partial \ln Q_c}{\partial \ln V_c} = \frac{\dfrac{\partial \ln w_c}{\partial \ln V_c}}{w_c} - 1$$

$$e_c = \frac{\partial Q_c}{\partial \lambda_c} = \left(\frac{\dfrac{\partial \ln w_c}{\partial \ln V_c}}{w_c} - 1\right)\left(1 + \frac{\partial \ln v_c}{\partial \ln \lambda_c}\right) \tag{4.7}$$

For the standard unit value model and by assuming that the quality is uncorrelated with the price changes (i.e. $\frac{\partial \ln v_c}{\partial \ln \lambda_c} = 0$), we have that:

$$\hat{e}_c = \left(\frac{\hat{\phi}_0}{\overline{w}_c} - 1 \right) \tag{4.8}$$

The case where $\frac{\partial \ln v_c}{\partial \ln \lambda_c}$ is not nil and with the assumption of weak separability, we have that:

$$e_c = \frac{\partial Q_c}{\partial \lambda_c} = \left(\frac{\frac{\partial \ln w_c}{\partial \ln V_c}}{w_c} - 1 \right) \left(1 + \frac{\frac{\partial \ln v_c}{\partial \ln x} \frac{\partial \ln Q_c}{\partial \ln \lambda_c}}{\frac{\partial \ln Q_c}{\partial \ln x}} \right) \tag{4.9}$$

Deaton recommends three steps to estimate the parameters and the elasticities:

Step 1: using the simultaneous equations, we estimate the components $\frac{\partial \ln v_c}{\partial \ln x}$ and $\frac{\partial \ln Q_c}{\partial \ln x}$,

$$w_{c,i} = \alpha_1 + \beta_1 x_i + \gamma_1 z_i + f_c + u_{1,i} \tag{4.10}$$

$$\ln(V_{c,i}) = \alpha_2 + \beta_2 x_i + \gamma_2 z_i + f_c + u_{2,i} \tag{4.11}$$

Where f_c is the fixed effect of the group c.

Step 2: estimating the component $\frac{\partial \ln w_c}{\partial \ln V_c}$ using the average predicted values of $w_{c,i}$ and $V_{c,i}$ at the cluster level and this using the following model.

$$\tilde{w}_c = \alpha_3 + \phi_3 \ln(\tilde{V}_{c,i}) + u_3 \tag{4.12}$$

It can be noted here that the estimation at this second stage is not ordinary least squares. Indeed, Deaton (1988) uses the correlation between the first stage residuals to estimate the severity of the measurement error. This is used to adjust the estimates and to correct for the structural correlation between quantity and unit value.

Step 3: Solving the equation (09) for the argument $\frac{\partial Q_c}{\partial \lambda_c}$.

The DUVM Stata module

The Deaton (1997) book's includes a set of the Stata do files, which were updated in the WELCOM package to perform the estimation of unit value models. Our main contribution was to update the Stata code to produce a concise Stata ado file, which will be easier for the practitioner. Among the improvements, we find:

1. The possibility of using the sampling weight to consider the level of representativeness of each observation;
2. The possibility of tacking into account for the nil expenditures using the Heckman approach, or in short, the IMR component in the estimation;
3. Producing the elasticities different population groups;
4. The use of dialog box, saving the information of the dialog box;
5. Saving results in the Excel format;
6. Etc.

As we can show with some examples, these aspects can largely influence the estimated elasticities. The name of the new Stata command is **duvm**.

Figure 4.2 : The DUVM dialog box

The basic syntax of the DUVM module is as follows:

duvm **namelist , [options]**

The **namelist** should contain the names of items of expenditures. Note that the data must contain two variables for each item in the **namelist**. The name of the first variable is composed of the letter **w** followed by the name of the item. The name of second variable is composed of the word **luv** and the name of the item. For instance, if the name is of the item is *flour*, we must have the two variables: *wflour* and *luvflour*, which refers to the expenditure share and the log of the unit value of the flour item respectively. The options of the **duvm** command are (required in bold):

inisave   To save the duvm dialog box information. Mainly, all-important information in the dialog box will be saved in this file. In another session, the user can open the project using the command duvm_db_ini followed by the name.

hhsize   The household size.

expend   The household expenditures.

hgroup   Variable that captures a socio-demographic group. For example, this variable could equal 1 for rural households and 2 for urban ones.

indcat   The list of the independent variables that are categorical.

indcon   The list of the independent variables in continues form.

cluster   The cluster is required in an intermediate step to estimate the derivative of the log(exp_share) with regards to the log(unit value).

region   The region area.

subround   The round of the surveyed household.

csb   Correction of Selection Bias. In the case of csb(1), for each item, the routine estimates the beforehand IML ratio based on the binary model (Consumption is not nil), and then, it uses the IMR variable in models of the first stage.

hweight   The sampling weight of the variable.

boot   boot(number of replications) : to estimate the standard errors of the price elasticities.

xfil   To indicate the name of Excel file, which will be used to save the results (*.xml format).

dec   To indicate number of decimals of the displayed results.

sname   To indicate the short names of items.

dregres   To display the regression results.

The data

For the ENIGH Mexican data of 2014, we have four groups of expenditures on the ***cereal products***: *corn, wheat, rice and other_cereals*. The size of the full dataset is 19477 observations/households. By using the extended data on expenditures and quantities, we can remark that:

- The household may or may not consume a part of the sub items, or even the item/group c;
- Each group (or item) c can be composed of a set of sub items (c, j);

CORN
A001 Grain corn
A002 Maize flour
A003 Mass of corn
A004 Corn tortilla
A005 Toast
A006 Other maize products

WHEAT
A007 Wheat flour
A008 Flour tortilla
A009 Pasta for soup
A010 Sweet cookies
A011 Crackers
A012 White bread: bolillo, telera, baguette, etc.
A013 Sweet bread in pieces
A014 Sweet bread packaged
A015 Bread for sandwich, hamburger, hot-dog and toasted
A016 Cakes and pastries in pieces or in bulk
A017 Packaged cakes and pastries
A018 Other Wheat Products

RICE
A019 Rice grain
A020 Other rice products

OTHER CEREALS
A021 Corn, wheat, rice, oat, granola, etc. cereal
A022 Botanas: fritters, popcorn, Cheetos, Doritos et cetera (except potatoes)
A023 Instant soups
A024 other cereals

For each group c, we need two information (for each household), which are the unit value and the expenditure share. The household expenditure share is easy to be computed, and it ranges between 0 and 1. For the unit value, the Laspyers index is usually used.

$$V_{c,i} = \sum_{i=1}^{Jc} w_{c,j,i} V_{c,j,i} \qquad (4.13)$$

In the case where the household does not consume any item of the group, we can attribute to this household the average unit value of the group *c* at the level of his cluster. This can be justified by the fact that the household will have the same consumption habits and prices of the other households living in the same cluster. As another step in this example is that we exclude some observations wit where the expenditure share (relative to the current income) exceeds the 95%.   After finishing the treatment, the data file (15866 observations) will contain among others the following variables:

The variable	The definition
cluster	Primary sampling unit
hh_current_inc	Current income of the household
hhsize	Household size
sweight	sampling weight
sex	Sex of household head
age	Age of household head
psu	Primary sampling unit
education	Diploma of the household head
wcorn	expenditures share of corn
wwheat	expenditures share of wheat
wrice	expenditures share of rice
wother	expenditures share of the rest of cereals
luvcorn	log of the unit val of flour
luvwheat	log of the unit val of semolina
luvrice	log of the unit val of couscous
luvother	log of the unit val of pasta

For more information on the treatment of data, type the following Stata command:

view http://dasp.ecn.ulaval.ca/welcom/examples/ds/example_cereals_data.do

Example I-1

```
#delimit ;
use http://dasp.ecn.ulaval.ca/welcom/examples/ds/Mexico_2014_Cereals.dta , replace;
duvm corn wheat rice other,  hhsize(hhsize) expend(hh_current_inc) hweight(sweight) cluster(psu) region(rururb)
 inisave(ex1_duvm_db) indcat(sex educ)  indcon(age)   xfil(myfile) dregres(1) hgroup(decile) boot(50) ;
```

After executing the line command, a series of results are displayed.

Part_1: Estimations of the first stage.

```
. #delimit ;
delimiter now ;
. use http://dasp.ecn.ulaval.ca/welcom/examples/ds/Mexico_2014_Cereals.dta , replace;

.  duvm corn wheat rice other,  hhsize(hhsize) expend(hh_current_inc) hweight(sweight) cluster(psu) region(rururk
> inisave(ex1_duvm_db) indcat(sex educ) indcon(age)   xfil(myfile) dregres(1) hgroup(decile) boot(50) ;
(note: file ex1_duvm_db.duvm not found)
The cluster fixed effect regression(s)
```

	(1) luvcorn	(2) luvwheat	(3) luvrice	(4) luvother
Log of expenditures	0.0138***	0.00629**	-0.000234	0.0108***
Log of hhsize	-0.0637***	-0.0122***	-0.00508	-0.00581*
Age of head of hou~d	-0.000402***	-0.000169	-0.000333**	-0.0000884
sex==1	0.00646	-0.00431	0.00826*	-0.00239
educ==2	-0.0632	-0.000972	-0.0269	0.00988
educ==3	0.00283	0.00512	0.00733	-0.00158
educ==4	0.00459	-0.00343	0.00848	-0.00106
educ==5	0.000119	-0.0112	-0.0182	-0.00520
educ==6	0.0105	0.00276	-0.00335	-0.00702
educ==7	0.0208**	0.0113*	0.00496	-0.00373
Constant	2.725***	3.792***	2.725***	3.897***
Observations	15375	15340	13172	12166
R-squared	0.911	0.928	0.797	0.958

* p<0.05, ** p<0.01, *** p<0.001

```
The budget shares regression(s)
```

	(1) wcorn	(2) wwheat	(3) wrice	(4) wother
Log of expenditures	-0.0171***	-0.00797***	-0.000674***	0.000189***
Log of hhsize	0.0126***	0.00526***	0.000866***	0.000145**
Age of head of hou~d	0.0000642***	-0.0000181	0.00000121	-0.00000966***
sex==1	-0.000223	-0.000653*	-0.0000224	-0.0000792
educ==2	0.0149***	0.00905**	0.00106	-0.000679
educ==3	0.00259***	0.00246***	0.000190	0.0000395
educ==4	0.00203**	0.00379***	0.000228*	0.000242*
educ==5	0.00111	0.00443***	0.000561***	0.000227
educ==6	0.00239**	0.00480***	0.000144	0.000195
educ==7	-0.0000400	0.00407***	0.0000706	0.000262*
Constant	0.162***	0.0800***	0.00654***	-0.000619
Observations	15866	15866	15866	15866
R-squared	0.503	0.336	0.274	0.224

* p<0.05, ** p<0.01, *** p<0.001

Part_2: Average expenditure shares, income and quality elasticities.

Table 01: Average expenditures shares (in %)

	corn	wheat	rice	other
AV_share	2.317	1.497	0.153	0.100

Table 02: Expenditure elasticities

	corn	wheat	rice	other
Elasti~y	0.250	0.461	0.560	1.178

Table 03: Quality elasticities

	corn	wheat	rice	other
Elasti~y	0.014	0.006	-0.000	0.011

In this first example, the elasticity of quality is very low. This is explained by the nature of goods. For instance, the quality of the flour group cannot vary largely.

Part_3: Price elasticities.

Table 04: Price elasticities: without quality correction | without symmetry restricted estimators

	corn	wheat	rice	other
corn	-0.877	0.059	-0.019	-0.010
wheat	0.075	-0.813	0.178	0.016
rice	-0.111	0.089	-1.108	-0.095
other	0.110	0.126	-0.039	-0.720

Table 05: Price elasticities: without quality correction | with symmetry restricted estimators

	corn	wheat	rice	other
corn	-0.877	0.056	-0.013	-0.004
wheat	0.081	-0.809	0.069	0.014
rice	-0.203	0.676	-1.152	-0.101
other	-0.107	0.192	-0.156	-0.710

Table 06: Price elasticities: with quality correction | without symmetry restricted estimators

	corn	wheat	rice	other
corn	-0.869	0.059	-0.019	-0.010
wheat	0.073	-0.800	0.175	0.016
rice	-0.111	0.089	-1.108	-0.095
other	0.110	0.126	-0.039	-0.720

Table 07: Price elasticities: with quality correction | with symmetry restricted estimators

	corn	wheat	rice	other
corn	-0.869	0.055	-0.013	-0.004
wheat	0.080	-0.796	0.068	0.013
rice	-0.203	0.676	-1.152	-0.101
other	-0.107	0.192	-0.156	-0.710

Table 08: Standard errors: with the bootstrap method

	corn	wheat	rice	other
corn	0.003	0.003	0.020	0.048
wheat	0.002	0.004	0.021	0.034
rice	0.001	0.002	0.008	0.007
other	0.002	0.002	0.005	0.010

Treatment of hgroups : 1:2:3:4:5:6:7:8:9:10:

Table 09: Own Price Elasiticies by hgroups

	corn	STE	wheat	STE	rice	STE	other	STE
Decile_1	-0.708	0.012	-1.060	0.014	-1.830	0.054	-1.261	0.049
Decile_2	-0.953	0.007	-0.982	0.009	-1.351	0.029	-1.512	0.064
Decile_3	-0.882	0.007	-1.087	0.010	-1.131	0.026	-0.633	0.049
Decile_4	-0.987	0.007	-0.890	0.012	-1.076	0.034	-0.925	0.047
Decile_5	-1.040	0.006	-0.887	0.012	-1.317	0.024	-0.863	0.034
Decile_6	-0.936	0.006	-0.937	0.010	-1.384	0.027	-0.780	0.031
Decile_7	-0.984	0.006	-0.803	0.009	-1.163	0.029	-0.841	0.024
Decile_8	-0.964	0.006	-0.794	0.013	-0.866	0.029	-0.623	0.029
Decile_9	-1.016	0.006	-0.671	0.012	-1.409	0.032	-0.553	0.015
Decil-10	-0.751	0.009	-0.407	0.011	-0.756	0.040	-0.231	0.021

The price elasticity may vary largely across deciles. It is important to consider this aspect to assess accurately the impact of price changes on the poor group.

4.2 AIDS & QUAIDS Demand System Models

The Almost Ideal Demand System theoretical model (AIDS)

To present the AIDS model, we start by defining the PIGLOG model. This model can be represented via an expenditure function $c(\mathbf{P}, U)$ that defines the minimum level of expenditure to reach a predetermined level of utility given prevailing prices:

$$\log(c(p, U)) = (1 - U)\log(a(p)) + U\log(b(p)) \tag{4.14}$$

where U is the utility located between 0, the level of subsistence, and 1, the level of beatitude. The function $a(p)$ is found through the TRANSLOG form:

$$\log(a(p)) = \alpha_0 + \sum_{i=1}^{K} \alpha_i \log(p_i) + \sum_{i=1}^{K} \sum_{j=1}^{K} \gamma_{i,j}^* \log(p_i)\log(p_j) \tag{4.15}$$

The component $b(p)$ is defined as :

$$\log(b(p)) = \log(a(p)) + \beta_0 \prod_{i=1}^{K} p_i^{\beta_i} \tag{4.16}$$

Thus, we find that:

$$\log(c(p, u)) = \alpha_0 + \sum_{i=1}^{K} \alpha_i \log(p_i) + \sum_{i=1}^{K} \sum_{j=1}^{K} \gamma_{i,j}^* \log(p_i)\log(p_j) + u\beta_0 \prod_{i=1}^{K} p_i^{\beta_i}. \tag{4.17}$$

Using Shephard's Lemma $(\partial c(p, u)/\partial p_k = x_k)$, the expenditure share on good i becomes:

$$w_i = \alpha_i + \sum_{i=1}^{K} \sum_{j=1}^{K} \gamma_{i,j} \log(p_j) + \beta_i u\beta_0 \prod_{i=1}^{K} p_i^{\beta_i} \tag{4.18}$$

and

$$\gamma_{i,j} = \frac{1}{2}\left(\gamma_{i,j}^* + \gamma_{j,i}^*\right) \tag{4.19}$$

Expenditure shares also simplify as:

$$w_i = \alpha_i + \sum_{j=1}^{K} \gamma_{i,j} \log(p_j) + \beta_i \log(m/a(p)) \tag{4.20}$$

where $a(p)$ can be perceived as a price index equalling:

$$\log(a(p)) = \alpha_0 + \sum_{i=1}^{K} \alpha_i \log(p_i) + \sum_{i=1}^{K} \sum_{j=1}^{K} \gamma_{i,j}^* \log(p_i)\log(p_j) \tag{4.21}$$

The additional conditions of the model are:

$$
\begin{array}{lll}
I: & \sum_{i=1}^{K} \alpha_k = 1 & \textit{Sum of expenditures shares is 1} \\
II: & \sum_{i=1}^{K} \gamma_{i,j} = 0 \;\; \forall j \;\; \text{and} \;\; \sum_{i=1}^{K} \beta_i = 0 & \textit{Homogeneity of degree 0 of demand functions} \\
III: & \gamma_{i,j} = \gamma_{j,i} & \textit{Symmetry of the Slutsky matrix}
\end{array} \tag{4.22}
$$

The Quadratic Almost Ideal System theoretical model (QUAIDS)

Banks Blundell and Lewbel (1997) have proposed the Quadratic Almost Ideal System (QUAIDS) model that adds the quadratic logarithmic income term to the AIDS specification of Deaton and Muellbauer (1980). This was proposed in order to take into account the potential quadratic form of the Engel curve behaviour for some durable and luxury goods. The specification is as follows:

$$w_i = \alpha_i + \sum_{j=1}^{K} \gamma_{i,j} \log(p_j) + \beta_i \log(m/a(p)) + \frac{\lambda_i}{b(p)} \log(m/a(p))^2 \quad (4.23)$$

The price index is given by:

$$\log(a(p)) = \alpha_0 + \sum_{i=1}^{K} \alpha_i \log(p_i) + \sum_{i=1}^{K} \sum_{j=1}^{K} \gamma_{i,j}^* \log(p_i) \log(p_j) \quad (4.24)$$

The price aggregator is given by:

$$b(p) = \prod_{i=1}^{K} p_i^{\beta_i} \quad (4.25)$$

The income and demand elasticities are defined as follows:

$$
\begin{aligned}
I: & \quad e_i = \mu_i/w_i - 1 & & Income \ elasticity \\
II: & \quad e_{i,j}^{nc} = \mu_{i,j}/w_i - \delta_{i,j} & & Non \ compensated \ elasticity \\
III: & \quad e_{i,j}^{c} = \mu_{i,j}/w_i - e_i w_i & & Compensated \ elasticity
\end{aligned}
\quad (4.26)
$$

where

$$\mu_i = \frac{\partial w_i}{\partial \log(m)} = \beta_i + 2\lambda_i \log\left(\frac{m}{a(p)}\right)$$

$$\mu_{i,j} = \frac{\partial w_i}{\partial \log(p_j)} = \gamma_{i,j} + \mu_i\left(\alpha_j + \sum_{k=1}^{K} \gamma_{k,j} \log(p_k)\right) - \frac{\lambda_i \beta_j}{b(p)}\left\{\log\left(\frac{m}{a(p)}\right)\right\}^2$$

Remark:

The Stata module for the estimation of the AIDS and the QAIDS models is already available and well developed by Brian Poi (2012).

- *Poi, Brian P., (2012), Easy demand-system estimation with quaids, Stata Journal, 12, issue 3, p. 433-446*

The module **wquaids** uses implicitly the Brian Poi quaids Stata command (or its updated version wquaids). The improvements are:
1. The possibility of using the sampling weight to consider the level of representativeness of each observation;
2. The use of dialog box, saving the information of the dialog box;
3. Saving results in the Excel format;
4. Etc.

Figure 4.3: the dialog box of the AIDS/QUAIDS models

Practical exercise: The QUAIDS model

The data

We use the same data of the DUVM example (see the subsection 4.1). For simplicity, we consider unit values as the observed prices.

/* The Stata code */

```
#delimit ;
use http://dasp.ecn.ulaval.ca/welcom/examples/ds/Mexico_2014_Cereals.dta , replace;
 wquaids wcorn wwheat wrice wother wcomp,
anot(9.5)
prices(pcorn pwheat price pother pcomp)
snames(Corn Wheat Rice Other_cereal Rest)
expend(hh_current_inc)
hweight(sweight)
model(1)
 inisave(ex1_quaids_db)
demographics(sex educa2- educa7 age)
dregres(1) dislas(0) xfil(myfil);
```

Remarks:
- The command *wquaids* is followed by the expenditure share variables. The variables *wcomp* is the expenditure share on the rest of items (outside the cereal products). The sum of the expenditure shares must be equal to one.
- The option anot() is the initial level of the parameter alpha_0 of the AIDS/QUAIDS model. It can be approximated to the log of the min(household income).
- The option model(1) is for the QUAIDS model. (2) is for the AIDS model.
- The option dislas(0) indicates that the results of the last item (complement or rest of items) will not be displayed.

The results:

QUAIDS MODEL	Standard DUV MODEL

Income elasticities

	Corn	Wheat	Rice	Other_ce~l
Elasticity	0.4455	0.6109	0.7575	1.4826

	corn	wheat	rice	other
Elasti~y	0.2405	0.4569	0.5480	1.1811

Uncompensated price elasticities

	Corn	Wheat	Rice	Other_ce~l
Corn	-0.9771	0.0451	-0.0136	-0.0022
Wheat	0.0682	-0.8793	0.0119	0.0010
Rice	-0.2254	0.1139	-1.2268	-0.1680
Other_cereal	-0.0803	-0.0023	-0.2364	-0.7818

	corn	wheat	rice	other
corn	-0.8699	0.0558	-0.0114	-0.0007
wheat	0.0810	-0.7955	0.0682	0.0123
rice	-0.1788	0.6667	-1.1300	-0.1058
other	-0.0390	0.1756	-0.1648	-0.7132

As we can remark, the two-demand system models give close estimates of the price elasticities.

4.3 Exact Affine Stone Index (EASI)

The EASI theoretical model?

To deal with the empirical nonlinear form of the Engel curve and to propose a more flexible model, Lewbel and Pendakur (2009) use the Shephard's lemma to approximate real income. This linear approximation implies the use of the Stone price index (SPI), as in the case of the Linear Approximate Almost Ideal Demand System (LA/AIDS). Even with this restriction, among the advantages of the EASI model is the possibility of using a higher order of the polynomial real income, which enables to better fit the Engel function. Formally, the approximated EASI model can be defined through the implicit marshallian budget share as follow:

$$w_i = \sum_{r=1}^{o} b_r \tilde{y}^r + \sum_{j=1}^{K} a_k \log(p_k) + \sum_{k=1}^{K} b_k \log(p_k) \tilde{y} + \tilde{\varepsilon}$$

$$= \sum_{r=1}^{o} b_r \tilde{y}^r + Ap + Bp\tilde{y} + \tilde{\varepsilon} \tag{4.27}$$

where $\tilde{y}$ denotes here the log of the approximated real income: $y \approx \tilde{y} = log(m) - \sum_{k=1}^{K} w_k \log(p_k)$. The parameter o is the polynomial order of the real income and the parameter $\tilde{\varepsilon}$ is simply the error term of the estimation. For simplicity and compared to the Lewbel and Pendakur (2009) presentation of the model, we omit the household characteristic determinants. Based on the Shephard's lemma and the cost function, Arthur and Pendakur (2009) show that the exact real income is equal to:

$$y = \frac{m - p\prime w + p\prime Ap}{1 - 0.5 * p\prime Bp} \tag{4.28}$$

Thus, the exact EASI model can be defined as follows:

$$w_i = \sum_{r=1}^{o} b_r \left(\frac{m - p\prime w + p\prime Ap}{1 - 0.5 * p\prime Bp} \right)^r + Ap + Bp \left(\frac{m - p\prime w + p\prime Ap}{1 - 0.5 * p\prime Bp} \right) + \varepsilon \tag{4.29}$$

As was the case for the AIDS or the QAIDS models, additional conditions are imposed:

$$
\begin{array}{lll}
I: & \sum_{i=1}^{K} a_{i,j} = 0 \ \forall j \ \text{and} \ \sum_{i=1}^{K} b_i = 0 & \textit{Homogeneity of degree 0 of demand functions} \\
II: & a_{i,j} = a_{j,i} & \textit{Symmetry of the Slutsky matrix}
\end{array} \tag{4.30}
$$

Among the recommended econometric methods to estimate the model is the nonlinear three stages least squares (3SLS). Let p_c denotes the vector of the log of prices after the change.

Computational tools to estimate the EASI model

In what follow, we introduce briefly the different tools, which can be used to estimate the EASI model and the elasticities. Mainly, we suggest three tools:

1- *A set of Stata do files*: **EASI demand system with no interactions** and **EASI demand system with interactions** (Lewbel, A. (2009)).
2- *Estimating EASI in R* (by Stephane Hoareau, Guy Lacroix, Mirella Hoareau, Luca Tiberti (2012)) easi-r.
3- *Estimating EASI in R with Stata*: the **sr_easi** Stata module (Araar, A. (2018)).

The first two tools may require more skill in Stata and R. The third, enables to estimate the EASI model in an easy way, but it uses intermediately the easi R package.

Figure 4.3: The dialog box of the sr_easi module

Practical exercise: The EASI model
The data

We use the same data of the DUVM example (see the subsection 2.4). For simplicity, we consider unit values as the observed prices. For this practical example, I simply use a random subsample of 8000 observations of *the Mexican national household survey of 2014* (INEGI-2014) to estimate the elasticities of the he cereal products (corn, wheat, rice and other cereals). Thus, we have four cereals variable shares in addition to the complement share of expenditures on the rest of goods. Further, for the comparison purpose, we will estimate the income and price elasticities using the DUVM and the QUAIDS models.

The Stata code

```
/****** THE DATA*****************/
#delimit ;
use http://dasp.ecn.ulaval.ca/welcom/examples/ds/Mexico_2014_Cereals.dta , replace;
set seed 4321;
bsample 8000;

/****** THE DUVM MODEL****************/
duvm corn wheat rice other , hhsize(hhsize) expend(hh_current_inc)
cluster(psu) indcon(age isMale educa1-educa10 nocup1-nocup4)
csb(0) boot(0)  xfil(myres1);

/****** THE QUAIDS MODEL****************/
wquaids wcorn wwheat wrice wother wcomp, anot(6)
prices(pcorn pwheat price pother pcomp)
expenditure(hh_current_inc)
demographics(hhsize age isMale educa1-educa10 nocup1-nocup4)
snames(corn wheat rice other complement) dislas(0)  xfil(myres2) ;

/****** THE EASI MODEL****************/
sr_easi wcorn wwheat wrice wother wcomp,  prices(pcorn pwheat price pother pcomp)
snames(corn wheat rice other comp)
expenditure(hh_current_inc)
demographics(hhsize age isMale educa1-educa10 nocup1-nocup4)   dec(4) dregres(1) dislas(0)
inpy(0) inpz(0)   inzy(0)  power(5) xfil(myres3);
```

The results:

Income elasticities

	corn	wheat	rice	other
EASI	0.4375	0.5654	0.6920	1.2910
QUAIDS	0.3702	0.5042	0.6769	1.3472
DUVM	0.2763	0.4789	0.5607	1.2162

Price elasticities

	EASI			
	corn	wheat	rice	other
corn	-0.8993	0.0910	-0.1513	0.0199
wheat	0.0611	-0.9290	0.1263	0.0249
rice	-0.0041	0.0176	-1.2443	-0.1754
other	0.0078	0.0065	-0.1332	-0.7849
	QUAIDS			
	corn	wheat	rice	other
corn	-0.923	0.105	-0.009	0.029
wheat	0.166	-0.982	0.047	-0.028
rice	-0.155	0.464	-1.310	-0.152
other	0.606	-0.395	-0.213	-0.865
	DUVM			
	corn	wheat	rice	other
corn	-0.781	0.068	0.004	-0.001
wheat	0.106	-0.819	0.085	0.033
rice	0.055	0.844	-1.223	-0.147
other	-0.054	0.450	-0.206	-0.647

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