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THE TOTAL ECONOMIC IMPACTS OF PHILADELPHIA'S BEVERAGE TAX

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EXECUTIVE SUMMARY

The following report evaluates the total economic repercussions of the City of Philadelphia's Beverage Tax from a macroeconomic perspective. No prior studies have taken on this viewpoint. They, instead, have tended to analyze just part of the overall story, examining (1) how consumers react to a rise in beverage prices, (2) how and which industries will directly suffer as a result, and (3) how the childcare industry is likely to thrive as a result of being subsidized. No prior studies have examined how the introduction of subsidized childcare for low-income households might affect a change in the supply of labor—one of the rationales behind subsidizing child daycare. This analysis incorporates all of the above for a full economic and fiscal evaluation of the Beverage Tax and the programs it supports.

To evaluate the Beverage Tax and the use of its revenues a tailor-made computable general equilibrium (CGE) model for Philadelphia is applied. It retains sectoral detail for beverage distributors, beverage retailers, and childcare as well as four household groups. The household groups are based on income levels, with extra detail for those Philadelphia households that receive less than 200% poverty level based on household size. It also includes three tax categories for City revenues, one features the Beverage Tax the other two are the City's wage and property taxes. These features enable a clear evaluation of critical components of the Beverage Tax as well as the programs it funds.

The analysis examines 2019 Beverage Tax revenues ($76.9 million), which is distributed to childcare (32.5% of revenues) with the remainder going to the City's general fund. This forms Scenario 1 in the analysis, with Philadelphia's economy in 2016 –the year prior to the implementation of the Beverage Tax—as the baseline. This analysis shows, while several industries suffer somewhat, that the overall program's benefits to the City's economy are very close, if not equal, to meeting costs suffered by those industries and workers in them. The new jobs created pay less than those lost; and costs of churning in the labor market are not counted. Fiscally, the City appears, perhaps, to be less well off, but marginally. The benefits appear to accrue to lower-income households, however, which may offset those marginal costs.

Scenarios 2 and 3 invoke conditions of Scenario 1 and add changes to labor supply due to the addition of parents of children in subsidized child daycare. Two scenarios are included since it is not clear how many parents joined the labor market (perhaps both did) nor the number of hours they worked if they joined. The childcare program touts 3,300 seats and through 2019, at least, a maximum or 2,648 had been filled, although spending on that program was higher in 2020. The Scenario 2 examines a low estimate that the City's workforce expands by 0.2% (about 1,750 jobs), and Scenario 3 examines a high figure of 0.5% (about 4,400 jobs).

Scenario 2 displays a clear favorable economic and fiscal balance, with a net of more than 800 jobs, $28 million in labor income, and $50 million in private GDP. Scenario 3, while more unlikely, almost doubling those figures. Fiscally, the City comes well out of the red in both instances as well. It is clear that any small improvement in the City's labor supply enabled via subsidized childcare, even just improved productivity with no rise in jobs, would secure a positive net effect for the City's private industries and the City's tax coffers. Still, beverage distributors and related logistics industries remain affected in a negative manner. Of course, the greater the rise in the labor supply, the more positive is the net balance.

1. Introduction

On January 1, 2017, the City of Philadelphia imposed a tax upon dealers who supply of any sugar-sweetened beverage within the City. The so-called "Philadelphia Beverage Tax" is restricted to the supply, acquisition, delivery or transport of such beverages when they are held out for retail sale within the City.[1] City of Philadelphia officials expected the tax to add about $1 to the cost of a two-liter bottle of soda and to generate about $90 million a year in revenue for the city.

The tax is presently set at 1.5 cents per ounce of beverage. Since its inception and through the first three quarters of 2020, the City has received $247.8 million in constant or real 2020 terms ($244.2 million in nominal terms) in Beverage Tax revenue. In a typical year, it appears that this tax yields about $77 million in tax revenue to the City. Table 1 shows how these funds have been roughly distributed over time. A lion's share of the revenue to date—62.0% or $153.6 million of the $247.8 million—has been retained by the City's General Fund. Another 5.5% has been used to fund community schools, the payroll of the City's Department of Education, and the City's Rebuild Program including debt-related bond obligations associated with this program.[2] The remaining share (about 32.5%) has funded the City's pre-kindergarten program (henceforth PHLpreK), which this report assesses.

Table 1. Expenditure Allocations for the Philadelphia Beverage Tax, 2017-2020

Fiscal Year	Community Schools	Pre-K	Parks and Recreation	Debt Service	Office of Education	General Fund	TOTAL
2017	$1,166,103	$8,368,368	--	--	$563,735	$29,427,176	$39,527,399
2018	$1,668,419	$19,095,412	$507,204	--	$572,402	$55,577,987	$77,423,442
2019	$2,016,967	$22,436,592	$448,324	$1,677,489	$663,957	$49,611,690	$76,857,038
2020*	$1,402,704	$29,794,123	$300,418	$1,986,500	$563,414	$16,314,963	$50,364,142
Nominal Total	$6,254,193	$79,694,495	$1,255,946	$3,663,989	$2,363,509	$150,931,815	$244,172,021
Real Total+	$6,348,769	$80,546,117	$1,267,918	$3,668,825	$2,403,403	$153,598,484	$247,841,730
2017	3.0%	21.2%	0.0%	0.0%	1.4%	74.4%	100.0%
2018	2.2%	24.7%	0.7%	0.0%	0.7%	71.8%	100.0%
2019	2.6%	29.2%	0.6%	2.2%	0.9%	64.6%	100.0%
2020*	2.8%	59.2%	0.6%	3.9%	1.1%	32.4%	100.0%
Real Total	2.5%	32.5%	0.5%	1.5%	1.0%	62.0%	100.0%

Source: The Philadelphia City Controller's Office https://controller.phila.gov/philadelphia-audits/data-release-beverage-tax/ and R/ECON calculations.

Notes: *First three quarters reported only.
+Inflated by the 2017-2019 annual CPI-U index of the US Bureau of Labor Statistics (respectively, 245.120, 251.107, 255.657) and the May 2020 index value 256.394.

As might be clear from Table 1, until the pandemic hit, the revenue stream seemed to have hit its stride rolling in at a clip of about $77 million annually. Its allocation to City expenses,

[1] City of Philadelphia, Bill No. 160176 available online in October 2020 at https://www.phila.gov/services/payments-assistance-taxes/business-taxes/philadelphia-beverage-tax/.

[2] Rebuild was developed to make physical improvements to parks, recreation centers, and libraries. It has an eye toward promoting diversity and economic inclusion. In this vein, Rebuild supports minorities and women who work (or want to work) in the design and construction industries. Further it engages with community members to leverage their knowledge, power, and expertise.

however, did not settle equally into any stable pattern.[3] This is part due to the nascency of PHLpreK. It seems, problematic to ascertain a steady pattern of spending on its aspects pertaining to childcare subsidies (CCS), which have risen monotonically since program's inception. Indeed, despite what looks like a slightly dampened revenue stream for fiscal year 2020—with 67% of 2019 revenues after 75% of the year reported—PHLpre-K secured its largest funding ever from the Beverage Tax revenues at close to $29.9 million so far.

PHLpreK reports that it funds 3,300 seats in 130+ pre-kindergarten (pre-K) locations across Philadelphia. Entry to this program is free to all children who live within the City as long as attendance is limited to a traditional school day (5.5 hours) during the traditional school year. Additional hours and summer school require tuition payments, although a CCS is available to qualifying parents. Eligibility for a CCS are based on family income, family size, child age, and the family's residential location. Guidelines suggest that parents should work 20 or more hours a week, or work 10 hours a week and train 10 hours a week. Exceptions are made for families with parents who have a promise of a job that starts within 30 days of their application for a CCS. Foster parents get some added priority. Teen parents must attend an education program.

The point of this report is to roughly estimate the present economic viability of this program. That is, what follows is a partial assessment of whether the spending on PHLpreK has been beneficial to the City's economy or not. In this vein, we analyze short-run responses of the economy of

- The costs of the tax to beverage distributors and, hence, to consumers who bear any added costs associated with a price rise in sugary beverages due to the tax and
- The economic benefit of the use by the city of its new-found Beverage Tax revenues.

With regard to the benefits, we not only analyze the expansion of Philadelphia's childcare industry, but also the contribution of the rest of the revenues its other purposes, which are largely channeled through the City's General Fund. More uniquely, we also analyze the implications of employing parents who take advantage of a CCS so their children can attend PHLpreK. We do this by examining what happens if labor compensation paid by firms within the City rose by between 0.25% and 0.5% as a result of this program. This means we analyze what happens if the City gained between 2,000 to 4,400 jobs as a result of Beverage Tax funding of this program.[4]

2. Literature Review

The economic rationale behind a tax on sugary beverages is to explicitly include the health costs of the beverages in its price (McGranahan & Schanzenbach, 2011), i.e., an externality-correcting Pigouvian tax (Pigou, 1920). The idea is that the tax raises the price of a good that yield negative externalities, which improves social welfare by reducing the good's consumption. The external cost in this instance are the financial health care costs of obesity. Moreover, the revenues from a Pigouvian tax can be used to compensate those who pay for the good's deleterious costs. This is necessary because research has revealed that some people either over-discount health

[3] This appears to have been due to some conservativism on the part of City leaders as the tax was challenged in the courts. https://www.publichealthlawcenter.org/litigation-tracker/lora-jean-williams-et-al-v-city-philadelphia-et-al-nos-2077-2078-cd-2016-2017.

[4] This is the count of jobs in Philadelphia in 2016 as reported in U.S. Bureau of Economic Analysis CAEMP25 files in October 2020 at www.bea.gov.

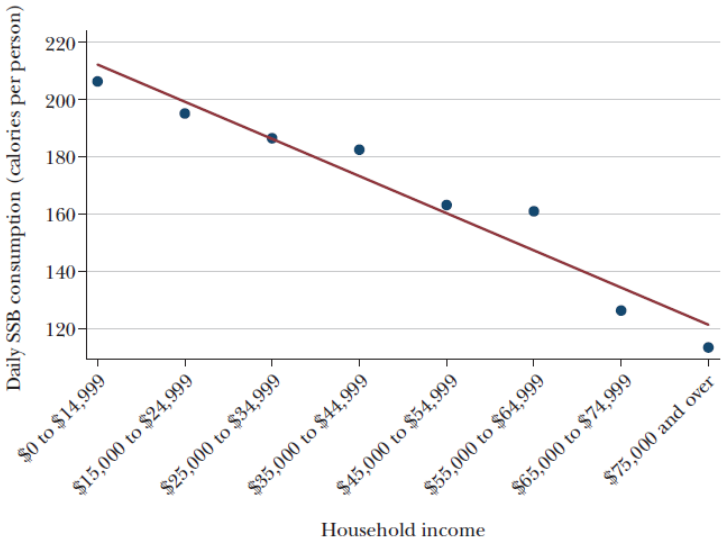
concerns or are misinformed about their health. They accordingly give less value to their lives than do others.

2.1. Price Elasticity of Demand.

A key to any analysis of the effect of price change (or tax rise) on demand is the good's price elasticity of demand. Alcott, Lockwood, and Tabuinsky (2019) note that in reviewing price elasticities of demand for sugary beverages Andryeva, Long and Bromwell (2010) and Powell et al. (2013) found these range from -0.13 to -3.87 with an average centered on something close to -1.0, almost precisely the elasticity estimated by Cawley et al. (2019a) for Philadelphia. That is, sugary-beverage consumption is quite responsive to price changes.

2.2. Tax Pass-Through.

Figure 1. Sugar-sweetened Beverage Consumption by Household Income



Source: Allcott, Lockwood, and Taubinsky (2019).

Philadelphia's Beverage Tax does not affect retail prices directly since it is placed on dealers/distributors rather than at the retail level. So, there is a matter of the degree to which the tax is also passed on to consumers or absorbed by distributors. Broadly speaking, the extent of pass through is uneven for U.S. cities that have applied such a tax and for which studies have been performed (Berkeley, California; Boulder, Colorado; and Philadelphia), ranging from 47% to 97% (Cawley at al., 2019b). This is likely because the consumers' responses vary by city, due to their preferences, income levels, set of available beverage options, the size distribution and nature of local retailers who sell such beverages, nature of advertising by suppliers, strategic responses of local retailers, and the average distance to untaxed stores beyond the city borders, i.e., the municipality's spatial extent. Studies of the Philadelphia beverage tax have used scanner data from large chain retailers (Roberto et al., 2019; Seller, Tuchman, & Yao, 2020), household purchases at a variety of store types (Cawley et al., 2019a), airport retail prices (Cawley, Willage, & Friswold, 2018), household receipts for retail beverage purchases (Cawley et al, 2019b), and self-reports of consumption (Cawley et al., 2019b; Zhong et al., 2020). Two of the above studies (Seiler, Tuchman, & Yao, 2020; Cawley et al, 2019a) identify a nearly complete passed through of the tax from distributors to consumers, corresponding to a 30% to 34% price increase. They report that,

in response to that price rise, demand for sugary beverages in Philadelphia decreased by 31 to 46% with no noticeable changeover to bottled water and modest substitution toward (untaxed) natural juices. These two teams of authors suggest this is largely because many Philadelphia resident opt to buy sugary beverages from retail locations outside of the city. Thus, any switching away from sugary beverages is likely undertaken by lower-income households, which have more trouble overcoming the friction of shopping on the other side of the City's borders. Moreover, members of lower-income households tend to drink more sugary beverages (see Figure 1).

Soda tax opponents typically cite its regressivity as a rationale for disapproval. That is, regressive taxes comprise a larger income share of low-income households than for high-income taxpayers,[5] so they spend more of their income on sugary beverages. Thus, they either pay disproportionally more taxes or are forced to more heavily alter their preferences. The same proponents suggest that soda taxes negatively affect low- to moderate-income households since they are more likely to have their cut by soda producers, distributors, transporters, and retailers. The American Beverage Association (ABA), for example, suggested that Philadelphia's soda tax would cause on the order of 1,200 jobs to be lost within the City and most within that set of industries (Kane, 2017).[6]

2.3. Childcare and Labor Supply

While the literature on the potential negative effects of a sugar tax is rather thick, surprisingly that on the effects of childcare on labor supply of low-income households is somewhat sparser. Heckman (1974) was among the first to address the issue of childcare and female labor-force participation. The author addressed it almost strictly in a microeconomic-theoretic manner, albeit one that holds up today. Kimmel (2006) and Severini et al. (2019) press the issue further noting that if policy makers want to stimulate more-productive employment, they should concentrate on the female labor participation, especially where it is most discouraged. They suggest that promoting female labor participation is important because it: (i) ensures the implementation of the equity principle between men and women; (ii) improves the household well-being; (iii) reduces economic vulnerability of older women; (iv) and contributes to the growth of the economy in which they engage. These are, indeed, many of the principles that City of Philadelphia hoped to apply by promoting public childcare services, particularly targeted to economically disadvantaged families (as well as direct impacts on children's development). While Severini et al. (2019) simulated various scenarios of female employment, they did not examine the influence of childcare.

Parents, particularly mothers, do not make choices about paid and unpaid work in a vacuum; their choices are heavily influenced by the institutional and cultural milieu and the households in which they find themselves. Bassanini, Rasmussen, and Scarpetta (1999) note that the lack of affordable childcare is a likely barrier to employment and, hence, improved economic status for low-income households. That is, to the extent that childcare subsidies make paid work worthwhile for low-income households (reduce a parent's reservation wage), they serve as labor supply subsidies. In a broad review of leave policies, childcare services and cultural norms across 19 countries, Rønsen and Sundström (2002) find that higher levels of publicly supported childcare, particularly for children below three years of age, is associated with higher levels of maternal

[5] "Theme 3: Fairness in Taxes, Lesson 2: Regressive Taxes," *Understanding Taxes Teach*, Internal Revenue Service, accessed October 2020 at https://bit.ly/2Oxtuqv.

[6] This report examined only costs of Philadelphia's Beverage Tax—the reduced bottling activity along with lost trade and transport margins from consumer purchases—and neglected to measure any of its possible benefits.

employment and longer working hours. This is likely because, at least at that juncture, childcare options for younger children were quite limited. They further report that the gap in hours worked by mothers is smallest for countries with the highest levels of enrollment in such programs. Connelly and Kimmel (2003) show that welfare dependency in the United States was reduced by 28 percentage points among those mothers in poor households who had childcare expenses subsidized by 50%. Lewis (2009) notes that this sort relationship between publicly provided childcare with full-time employment is likely even stronger.

As in the case of sugary beverage markets, some macroeconomic analyses have been undertaken analyzing the economic impacts of childcare. Most (e.g., Pratt & Kay, 2006; Bishop-Joseph, Schaefer, & Watson, 2014) focus on the relative importance of the childcare sector in an economy; but they do so without considering the effects of parents becoming engaged in the economy, which is a main part of a government's rationale for providing such a public good. It seems only Graafland (2000) and Rickman and Snead (2007) have taken a broader look by using an applied computable general equilibrium (CGE) model.[7]

Graafland's research focused on the Dutch system, which, as a nation, was much more able than Philadelphia to enroll children in subsidized child daycare—about 75,000 with a waiting list of 30,000 in 1996. Moreover, Graafland modeled the nation's daycare decision and labor supply reaction at large, far beyond the scope of this study's objectives. Rickman and Snead's (2007) work was entire prospective; Oklahoma had no subsidized childcare program, at least not by the date their piece was published. They, therefore, considered three options to pay for the subsidized child daycare: 1) a reduction in other state government spending; 2) an increase in the tax on labor; and 3) an increase in the tax on capital. But they also examined the effects of public childcare provision on labor supply, citing only one other study besides Graafland's on the subject—that by Harrigan, McGregor, and Swales (1996). Rickman and Snead's modeling effort, while similar, had analytical objectives that differed from ours in that (a) PHLpreK has a known source of funding along with a fairly robustly estimated pass-through share and a reasonably well-founded price elasticity of demand (b) our work is strictly limited to publicly provided childcare, and (c) we do not allow in our estimates for higher-income households to enroll in subsidized public childcare. Still, our work on Philadelphia parallels theirs on Oklahoma in most other ways.

2.4. Summary

Most assessments of the economic effects of beverage taxes and childcare subsidies have been microeconometric. They tend to confirm the expected changes to labor demand and supply. Such studies capture the direct partial equilibrium effects, but they omit the indirect general equilibrium macroeconomic effects that are required to assess the potential equity-growth tradeoff. A general equilibrium approach captures the direct and indirect effects on all product and factor markets of any increases in participation of low-income households in the labor market. Of the research reviewed herein, only Rickman and Snead (2009) take a perspective and approach similar to that required for the economic problem posed for analysis for Philadelphia's Beverage Tax.

3. Research Approach

The economic problem posed in the Introduction of this section of the report is one in which we want to learn the general equilibrium effects of a tax rise on a particular sector—in this case

[7] Note Ferracuti, Severini, and Socci (2015)—a research team at the University of Macerata in Italy—has also done some similar work on the topic but ask on a draft of their paper that it not be cited. Yet, we dare to mention them here.

one that distributes sugary beverages. This not only includes learning how the price rise might deleteriously affect consumption by Philadelphian's of such beverages but also learning how the allocation of the revenues from this Beverage Tax also is spent to the benefit of City and its citizens. The spending related to this activity recirculates within the City's economy, to some degree, creating multiplier effects that ripple across its industries. It also includes the benefits from a burgeoning PHLpreK program, which in turn frees up parents of attending children to find and secure job. A sizeable share of the Beverage Tax revenues is targeted to benefit the city's poorer families and neighborhoods.

From the perspective of Philadelphia's economy, the size of the beverage distribution industry and the number of seats available through PHLpreK are fairly well known. The magnitude and ultimate receivers of price effects from the tax rise also appear to be fairly well-established. Not as well-known are the effects of PHLpreK parents' entry into the labor market, and the net economic and fiscal benefits of the Beverage Tax and the use of its revenues by the City.

3.1. Why CGE?

Although microeconometric studies can capture the direct partial-equilibrium labor-supply effects of childcare subsidies as well as the direct effect on consumer demand for sugary beverages, they ignore all indirect macroeconomic general-equilibrium consequences. These are required to properly assess any potential equity-growth tradeoff. Obtaining general equilibrium results implies use of either a systems econometric time-series model (SETSM), an input-output (I-O) model or an applied CGE model. SETSMs are best used when forecasting or when the impacts of future policy roll-outs are a focus of analysis. I-O models lack the dynamics availed by SETSM but are far better for eliciting details of interindustry interactions and related multiplier effects. They are also best when results with industry detail are demanded, which is why their multiplier effects are preferred. CGE models, which have an I-O model embedded in them (albeit, typically quite aggregated) are best when the full set of industry and consumer reactions to some new, external influence are not as well known. In this vein, they are often *prospectively* used to investigate the general equilibrium effects of *regulatory policy*, particularly environmental, tax, and trade policy.

As noted in the introduction to this section, although most aspects of the Beverage Tax and the PHLpreK program are known, some aspects must be handled in a somewhat more idiosyncratic manner. This idiosyncrasy calls for CGE modeling. In particular, we do not really know how Philadelphia's labor market has reacted to the entry of PHLpreK-parent labor. And, while we do know how the revenues from the Beverage Tax have been allocated to cover City expenses, we do not have a sense of how that spending has affected Philadelphia's economy. Most of these programs, including the new-found earned income of PHLpreK parents redistributes income downwardly, i.e., they are designed to empower and support low-income households in Philadelphia. That such downward redistribution of income comes at the expense of growth is common coinage (see, e.g., Edwards, 2007), at least in the short-run when political unrest among society's most disadvantaged is not a consideration.

Therefore, we use readily available U.S. data to construct and implement a CGE model to estimate the direct and indirect economic effects of the Philadelphia Beverage Tax, its allocation and redistribution by the City (including subsidizing PHL-pre-K), and the supply of labor released via the provision of subsidized child daycare. The model employs a social accounting matrix (SAM) of Philadelphia, essentially an extended I-O table. The SAM tracks transactions among the various institutions industries; households; City, state, and federal government; and the rest of the

world. Consistent with neoclassical economic theory, but in contrast to other general equilibrium models, the supplies and demands for industry production are regulated by (relative) prices in CGE models. Thus, it also includes the supply of capital and labor (also known as factors of production) by households and the demand for these factors by industries. As with other items, relative prices of the factors facilitate the equilibrium state of their demand and supply. Household receive returns from capital as well and are compensated for their labor services. They either spend or save these funds. Savings are invested as capital goods.

3.2. Components of a CGE

3.2.1. Social Accounting Matrix (SAM)

A SAM is an accounting table for a particular period that describes flows within an economic system as well as that economic system's industrial structure. It includes the economy's I-O table, which contains information on production and income accounts. An I-O table comprehensively depicts the economic cycle of income creation, income-induced demand, and demand-induced production in the economic system. I-O tables are available for most countries of the world since they are recommended by the United Nations (2018) to produce the gross domestic product (GDP) that results from the double-entry accounting system used to create them. This worldwide unified accounting scheme enables GDP to be compared across nations of the world. Under the leadership of Sir Richard Stone (1947, 1956, 1961) the United Nations, World Bank, and vigorous promotion by other international associations, I-O tables have been amplified and expanded into SAMs enabling them to support of Walrasian[8] CGE models.

A few SAMs have been constructed for entire United States to analyze tax policy. But documented local SAMs for a state or city are quite limited. In order to build the CGE model to analyze the economic impacts of Philadelphia's beverage tax, we elaborated a SAM for Philadelphia in 2016 (henceforth SAMPHL-2016—the year before the Philadelphia Beverage Tax was implemented--using publicly available data. The prime sources are latest national benchmark I-O tables from the U.S. Bureau of Economic Analysis (BEA), industry-level GDP for Pennsylvania for 2016 from BEA, county data on jobs and earnings by somewhat aggregated industries from BEA, detailed industry employment data for 2016 from the U.S. Bureau of Labor Statistics (BLS), Public Use Microdata Sample (PUMS) on employment by place of residence by industry from The U.S. Census Bureau, The *U.S. Internal Revenue Service (IRS) 2016 Tax Book,* the 2016 Annual Survey of State & Local Government Finances from the U.S Census Bureau, as well as revenue reports from 2016-2020 from the City of Philadelphia.[9]

SAMPHL-2016 is a 42-by-42 balanced matrix of social accounts for Philadelphia in 2016—the base year of the subsequent analysis. Prices are, by definition, one (unity) in the base year and each value in the SAMPHL-2016 is equal to quantities regardless of what it displays: production, income, investments, or savings (See Appendix A, Table 1). In addition to 22 productive industries, it also contains 8 institutional accounts, including 4 composite household "types" split by household income, 1 corporate sector, 3 types of government (federal, state, and local), and two foreign sectors (Rest of US and Rest of the world). GDP by income (or value added) includes 2 primary productive factors—labor and capital, 5 tax-revenue accounts (one each for state and federal tax revenues, plus three for the City of Philadelphia: the wage tax, property

[8] Léon Walras (1874) is credited with being the father of general equilibrium theory.

[9] Including Annual report, Wage Tax collections by sector and City monthly revenue collections in fiscal year 2016 and 2017.

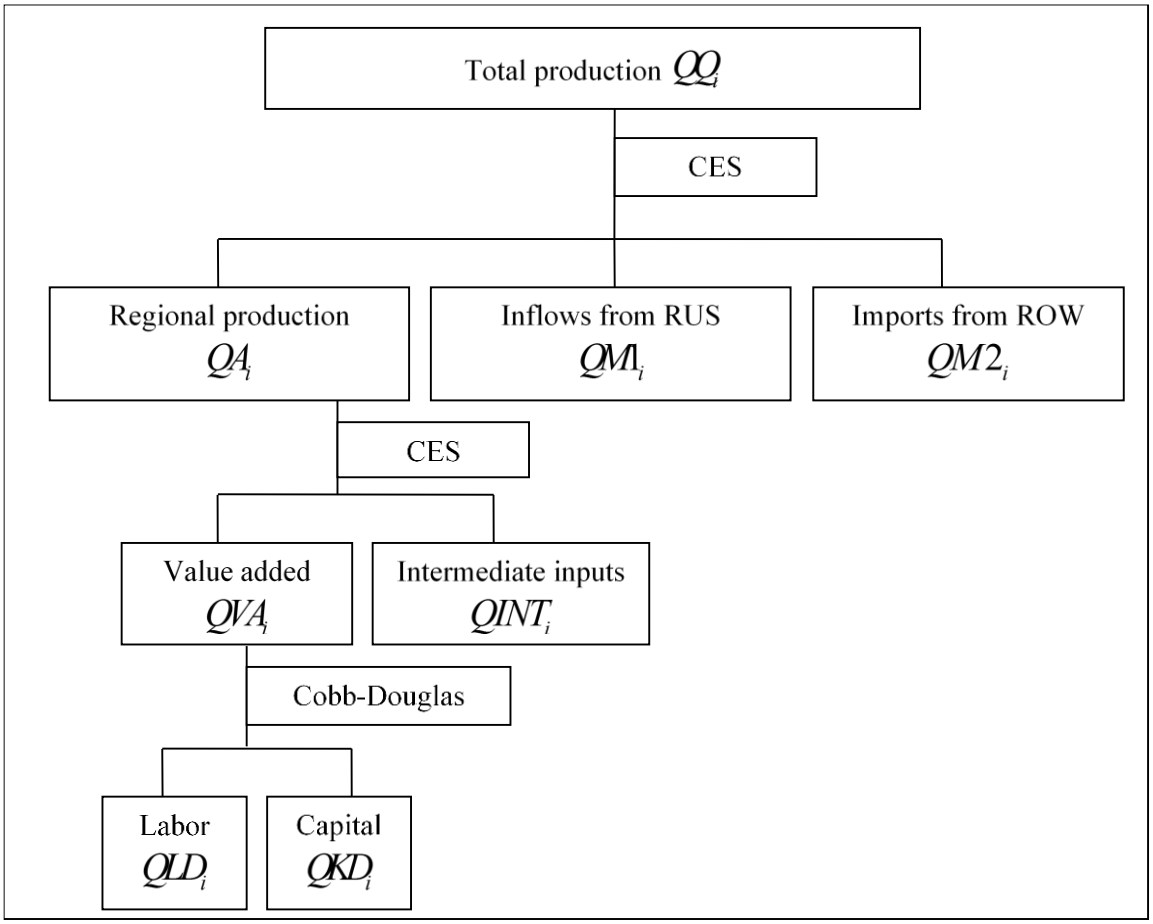
taxes, the Beverage Tax and other local taxes). In addition to household spending by the four household types, GDP by expenditures includes two accounts represent changes in the industry stocks and savings, as well as a single investment account that comprises all investment, both public and private. The basic structure of the SAMPHL-2016 is detailed in Table 2, in which the I-O table, which contains the most information, is merely the upper-right most cell labeled "Intermediate matrix."

Table 2. SAMPHL-2016: Basic Framework

	Productivity Sectors (22)	**Primary Factors (2)**	**Institutions (8)**	**Taxes (5)**	**Gross Capital Formation (1)**	**Change in industry Stocks (1)**	**Savings (1)**	**Foreign Sector (2)**
Productive Sectors	Intermediate matrix		Public and private consumption		Investment and Stocks variation			Exports /Outflow
Primary factors	Labor and capital income							Adjustments for residence
Institutions		Labor and capital income	Transfers among institutions	Redistribution of tax revenues among the institutional Sector s				
Taxes	Taxes on production, wage tax, property tax and beverage tax		Income taxes and subsidies payments					Adjustments for residence
Gross Capital Formation							Redistribution of savings	
Change in industry Stocks							Redistribution of savings	
Savings			Public and private savings					Foreign savings
Foreign Sector	Imports /Inflow						Redistribution of savings	

3.2.2. CGE Modeling Framework

Figure 2. Production Relationships in the Philadelphia CGE



The SAM forms a set of constraints for the CGE model that, in this case at least, optimizes the behavior of the main economic agents within Philadelphia's economy (specifically firms maximize their operating surplus and households maximize their income). Table 3 presents the main equations of our Philadelphia CGE model. The corresponding variable and parameter definitions are displayed in Appendix A, Table 2. The model contains 22 productive industries[10] that minimize their costs subject to a specific level of total production, which is represented by a CES (Constant elasticity of substitution) demand combination of domestic production, international imports and intra-regional inflows (Equation 1). This production is demanded by consumers who maximize their utility through a combination of consumption and savings. The domestic production can also be represented by a CES demand combination of intermediate inputs and value added (Equation 2). Valued added is a Cobb-Douglas function of labor and capital demand (Equation 3), while intermediate inputs are assumed to be fixed output proportions based

[10] We aggregated the full set of 405 industries in R/ECON's 2016 Philadelphia I-O table into just 22 industries for practical reasons related to CGE modeling. Such aggregation is normal practice, as it reduces potential computational conflicts and issues related to calibration of the model's parameters. For more, please see Section 3.3.1.

on the input-output model (Equation 4). The relationship between each production can be shown in Figure 2.

Table 3. Primary CGE Equations

Production functions (for all industry, i)

$$QQ_i = \alpha_i^{qq}\left[\delta_i^{qq} QA_i^{\rho_i^q} + (1-\delta_i^{qq}) QM_i^{\rho_i^q}\right]^{1/\rho_i^q} \quad (1)$$

$$QA_i = \alpha_i^{qa}\left[\delta_i^{qa} QVA_i^{\rho_i} + (1-\delta_i^{qa}) QINTA_i^{\rho_i}\right]^{1/\rho_i} \quad (2)$$

$$QVA_i = \alpha_i^{va}\left[\delta_i^{va} QLD_i^{\rho_i^{va}} + (1-\delta_i^{va}) QKD_i^{\rho_i^{va}}\right]^{1/\rho_i^{va}} \quad (3)$$

$$QINT_{ij} = ica_{ij} \cdot QINTA_j \quad (4)$$

Household revenue and household consumption

$$YH_h = WL \cdot shifhl_h \cdot QLS + Wk \cdot shifhk_h \cdot QkS + \sum_{gov} transfrh_{gov} + transfrent_h \quad (5)$$

$$QH_{ih} = shrh_{ih} \cdot mpc_h \cdot (1 - tifs_h - tiwt_h - tipt_h) \cdot YH_h \quad (6)$$

Corporate revenue and saving

$$YENT = Wk \cdot shifentk \cdot QkS \quad (7)$$

$$ENTSAV = (1 - tifsent - tiloent) \cdot YENT - \sum_h transfrent_h \quad (8)$$

Total demand for goods and services

$$DEM_i = \sum_j QINT_{ij} + \sum_h QH_{ih} + \overline{QINV_i} + \sum_{gov} \overline{QGV_{govi}} + \overline{QSV_i} + \overline{QE_i} \quad (9)$$

Market clearing prices for goods and services

$$QQ_i = DEM_i \quad (10)$$

Primary productive factor demands (for all industry, i)

$$QKD_i = QVA_i \Bigg/ \left\{ \alpha_i^{va} \cdot \left[1 - \delta_i^{va} + \delta_i^{va} \cdot \left(\delta_i^{va} Wk \cdot (1 + tvak_i) / (1 - \delta_i^{va}) WL \right)^{\rho_i^{va}/1-\rho_i^{va}} \right]^{1/\rho_i^{va}} \right\} \quad (11)$$

$$QLD_i = QVA_i \Bigg/ \left\{ \alpha_i^{va} \cdot \left[\delta_i^{va} + \left(1 - \delta_i^{va}\right) \cdot \left((1 - \delta_i^{va}) WL / \delta_i^{va} Wk \cdot (1 + tvak_i) \right)^{\rho_i^{va}/1-\rho_i^{va}} \right]^{1/\rho_i^{va}} \right\} \quad (12)$$

Market clearing factor prices

$$QKS = \sum_i QKD_i \quad (13)$$

$$QLS = \sum_i QLD_i + \overline{QL_{RUS}} \quad (14)$$

Demand for each industry's output derives from several categories of intermediate and final demand. Final demand is composed of household consumption, investment, federal, state and local government consumption, changes in the industry stocks, and exports. Intermediate demand and household consumption are conventionally endogenous to (internally determined in) CGE models. Equation 5 describes how the two primary productive factors as well as government and corporate transfers become household income. All household types mainly spend their after-tax income on a variety of different goods and services. Each household type is taxed at a different tax

rate for each tax account, which is constant over time (Equation 6). The corporate sector, an intermediate institution, receives income from capital (Equation 7) and pays out pre-savings taxes and transfers (Equation 8). In addition to tax revenues, governments collect income via intergovernmental transfers, typically such transfers flow downward only from federal to state and from state to local governments. Federal, state and local governments also purchase locally produced goods and services, which are assumed to be exogenously determined. Investments are purchases of equipment and structures; and changes in the industry stocks changes in inventories that vary by industry. Both investments and stock changes are exogenous to this model. Similarly, international exports and domestic outflows of good and services to other parts of Pennsylvania and to other states are exogenously determined.

Prices adjust to equate total demand with supply for each good and service. According to market-clearing conditions, the economic system balances when total demand (Equation 9) for each good or service equals its available supply (Equation 10). Regarding primary factor demands, businesses produce goods and services in Philadelphia by employing different mixes of labor and capital, which substitute for one another. Firms substitute away from a primary productive factor when its costs become relatively more expensive than those of the alternative. Thus, labor demand declines as wages rise and rises with the so-called "rental rate" of capital (Equations 11 and 12). Consistent with national rate of return to capital, in our model, Philadelphia's rate of return to capital is assumed to adjust to bring capital demand and supply into balance (Equations 13). Similarly, labor supply adjusts to equate with the labor demand, which includes both resident and non-resident workers of Philadelphia-based institutions (Equation 14).

3.2.3. Elasticities

The parameters and exogenous variables of CGE models must be numerically defined. Initial values are typically discovered within the SAM. The CGE herein has, indeed, been calibrated using the SAMPHL-2016 described above. However, in order to estimating the CES production functions and do the simulation, getting the reasonable elasticity of substitution is very important. According to the definition, the elasticity of substitution between two factor inputs measures the percentage response of the relative marginal products of the two factors to a percentage change in the ratio of their quantities. In another word, elasticity of substitution represents how many percentage points of the relative proportion of two inputs quantities will increase, while the relative price of two inputs increases by one percentage point, total output remaining the same.

In our model, three sets of substitution elasticities have been derived from the GTAP 9 data base (see Hertel & van der Mensbrugghe, 2016). The first set relates to substitution between imports and domestic production—the so-called Armington elasticity. The elasticity of substitution between locally produced goods and imports is set to 1.9, except for those in agriculture, forestry, fishing, and hunting plus mining industry, utilities industry, durable goods and nondurable goods industry. These we set the elasticity to 3.725, 2.8, 3.75 and 3.127 respectively. A second set relates to the substitution between the composite set of intermediate material and energy inputs and the value added for each industry. And a last set of substitution elasticities relates to the substitution between capital and labor. The second and third sets of the CES elasticities of substitution are set as being the same and are, according to GTAP, equal to 1.26 for most industries.

For calibration purposes, the substitution elasticities from GTAP 9 had to be transformed into constant behavior parameters preferred in the CES functional form of consumer demand. We display the final transformed results of each substitution elasticity in Appendix A, Table 3.

3.2.4. Closure Rule

The closure rule in a CGE model determines the endogenous variables under market-clearing conditions. It is probably the item to which any CGE model is most sensitive. That is, the closure rule selected can create substantial differential effects on the simulation results (Álvarez-Martínez and Polo, 2012). We opted for the neoclassical closure rule. It is consistent with neoclassical economic theory. Prices balance the supply of goods and services by producers with the demand by buyers in the CGE model. No industry is supposed large enough on its own to change industry prices or factor prices. Correspondingly, the equilibrium is a set of prices and quantities whereby total supply equals total demand by industry (Equation 9); labor supply equals effective labor demand (Equation 13), and capital services supply equals demand (Equation 14).

Table 4. Neoclassical Closure Rule in CGE Model

Investment-saving balance condition

$$EINV = \sum_{h}(1-mpc_h)\cdot(1-tifs_h-tiwt_h-tipt_h)\cdot YH_h + \sum_{gov}\overline{SAV_{gov}} + FSAV\cdot EXR - \sum_{i}\overline{QSV_i} \quad (15)$$

Foreign exchange balance condition

$$\sum_{i} pwm_i \cdot QM_i = \sum_{i} pwe_i \cdot \overline{QE_i} + FSAV + \overline{QL_{RUS}} + \overline{Wage_{RUS}} \quad (16)$$

Fixed exchange rates closure rule

$$EXR = \overline{EXR} \quad (17)$$

Neoclassical closure rule

$$QKS = \overline{QKS} \quad (18)$$

$$QLS = \overline{QLS} \quad (19)$$

Table 4 presents the model closure rule in equations. Again, corresponding variable and parameter definitions are displayed in Appendix A, Table 2. Under neoclassical closure, gross capital formation, represents total investment in economy is exogenous, which also equals to domestic and foreign savings less inventory changes (Equation 15). Regarding the foreign Sector s, current foreign exchange balances adjust by fixed exchange rate, while foreign saving is endogenous (Equation 16 and 17). Most importantly, neoclassical closure assumes that all primary productive factor prices and production prices are determined endogenously by the model, while primary factor supplies are always equal to primary factor endowment, indicating full employment (Equation 18 and 19). According to Walras's law, we must set a numeraire price, we chose wages as the benchmark.

3.3. Uniqueness of the Philadelphia SAM

3.3.1. Industry Detail

As mentioned in Section 3.2.1, we compiled SAMPHL-16 by first producing a 405-industry I-O table for Philadelphia using techniques described in Lahr (2001). Generally, analysts prefer maintaining the greatest industry detail when modeling. But doing so for such a particular application is unnecessary. And more importantly, it can unnecessarily introduce computational complexities. Thus, analysts typically maintain detail for industries critical to a specific analysis and aggregate those that are of lesser interest. We therefore follow this rule of thumb. After all, the purpose the SAM is not only get a sense of how the many industries interact, but also to get a sense of the magnitude of the overall general equilibrium effects. So, while we want to be able to achieve a proper answer and, hence, preserve as much information as possible, we also need to keep it manageable or the model will find a solution "infeasible." So, eventually, we aggregated the 405 industries in Philadelphia input-output table into just 22 industries for the SAMPHL-16. A discussion of the industries selected follows.

We maintained detail in (a) grocery and related products wholesalers and (b) child day care services sector for somewhat obvious reasons: The first pays the Beverage Tax to the City and the second receives an important share of those tax revenues from the City. The other 20 sectors are (1) Agriculture, forestry, fishing, and hunting plus mining; (2) Utilities; (3) Construction; (4) Durable goods manufacturing; (5) Nondurable goods manufacturing; (6) Other wholesale trade; (7) Other retail trade; (8) Food and beverage stores; (9) Other transportation services and warehousing; (10) Truck transportation services; (11) Information; (12) Finance, insurance, real estate and rental and leasing; (13) Professional and business services, (14) Educational services; (15) Other health care and social assistance; (16) Arts, entertainment, and recreation; (17) Accommodations, (18) Food services, (19) Other services sector; and (20) government service. The relationships between the 405 industries and the 22 supersectors are depicted in Appendix A, Table 4.

3.3.2. Household Expenditure Detail

For our analysis, we divided the single household group in the benchmark U.S. I-O accounts into four groups using poverty status as a threshold for identifying them. The four groups are: household income lower than 50% of poverty level, household income between 50%-100% poverty level, household income between 100%-200% poverty level, and household income above 200% of poverty level. These levels were as identified by the U.S. Census for 2016. The main break point of interest was 200% of poverty since it was suggested that this group would be have priority for childcare subsidies.

A group's total consumption expenditures are Philadelphia household total expenditures of that group as a share of its aggregate personal income. The BEA reports 2016 overall spending by Philadelphians for about 15 categories of spending, the American Community Survey's (ACS's) Public Use Microdata Set produced by the U.S. Census Bureau enabled the calculation of shares of regional aggregate personal income for the household income groups in the SAM. The distribution of aggregate income across these groups in 2016 was 0.7%, 3.2%, 9.7%, 86.4%. We applied these shares to the 2016 total personal income for Philadelphia reported by BEA. Microdata from the U.S. BLS's Consumer Expenditure Survey enabled us to differentiate the structure of spending by income group, which we made sure tallied to BEA totals mentioned just above.

3.3.3. Taxation Detail

Government revenues are primarily generated via taxes: state and federal tax, wage tax, property tax, beverage tax and other local tax. We split state and federal tax revenues into three parts. The first is a production tax, which we calculated as the "taxes on production and imports less subsidies" in R/ECON's detailed Philadelphia I-O table, which is derived from Pennsylvania GDP reported for about 60 industries by BEA. Shares of such "indirect business taxes" are netted out shares by industry for local property taxes and other local taxes.

The individual income tax was somewhat simpler, as it is merely separated from the aggregate income of the four household types. Naturally, we distinguish between federal and state individual income tax by household type. Federal individual income tax rates are progressive, so we roughly estimate the federal individual income revenues collected from Philadelphians by using the taxable income data by income range to multiply each progressive income rates accordingly. We normalized the outcome to assure it equaled income taxes that the federal government reports it receives from Philadelphians. The state income tax rate is fixed across households, so we adjusted each household group's tax liabilities to their shares of the City's aggregate personal income.

Nest we estimated federal and state corporate income taxes. Here we applied the City's GDP shares of state totals as estimated from R/ECON's City GDP by industry.

The wage tax in SAMPHL-2016 is the combination of the Philadelphia wage tax and earnings tax in 2016 as recorded in city monthly revenue collections. Both the wage and earnings tax are applied to labor compensation by place of work, i.e. the worker's residence does no come into play. Therefore, we further divided the wage tax in SAMPHL-2016 into two parts: resident and nonresident households. First, according to the Philadelphia I-O table, residents and non-residents are compensated, respectively, $55.8 billion and $17.2 billion for their labor services. Using these figures as the tax base and by multiplying them by the tax rate for each group, we can estimate the wage revenues for each group. The estimates of nonresident and resident wage tax revenues are, therefore, $391.9 million and 1,426.9 million.

As for property tax (the real estate tax), we assume that all the property tax accrues to the City of Philadelphia. We assume half is generated from households with incomes more than 200% poverty level, and the rest is paid by the 22 productive sectors. Only grocery and related product wholesalers pay the Beverage Tax. Other local tax is comprised of the all other tax and non-tax categories that listed on the City monthly revenue collections, such as hotel tax, amusement tax, etc. For matching those tax with SAMPHL-2016 productive sectors, we allocate each tax categories into the different industry by using NASIC code. For the tax categories that covers multiple industries, we use their value-added share as a guide for allocation.

3.4. Description of the Simulation

CGE models are designed to simulate the transition of an economy from an initial equilibrium level of economic activity to a new one. The economic impact of a policy change is derived by comparing the two general equilibrium values that result after a policy tool is effected in the model. It is assumed that all else remains unchanged. We use the General Algebraic Modeling System (GAMS) [11] to program the model and use the NLP solver for computation.

[11] For more information on GAMS, see http://www.gams.com/. Code for the model is presented in Appendix B.

The following simulation were made to formulate the policy change within the CGE model. In the initial equilibrium, it is 2016 before the Philadelphia Beverage Tax has been implemented. We then test three scenarios.

In Scenario 1, we assume all total revenue from the Beverage Tax to be those received in fiscal year 2019—the $76.9 million, which is paid by Grocery and related product wholesalers. We use this year since it best represents likely long-run revenues streams, given it was a solid growth year but not as good nationally as 2018. In this scenario, we allocate those revenues as they have been allocated to date, from fiscal year 2017 through the third quarter of fiscal year 2020. We use this because it seems the best way to simulate the long-term expenditure stream for these tax revenues. Thus, we allocated about 35.5% beverage tax revenue spending to PHLpreK, i.e., subsides to daycare services were $27.2 million. The rest of Beverage Tax revenues were simply allocated to local government (the general fund).

In Scenario 2, not only enable the revenue and concordant expenditure stream from the Beverage Tax, but we enhance the labor supply. We increase it by 0.2%. Given about 877,000 exist in Philadelphia according to BEA, this suggests that about 1,750 new jobs are added to payrolls of Philadelphia-based establishments. Scenario 3, is similar to the Scenario 2 but, in this case, we let the labor supply rise by 0.5% or nearly 4,400 jobs. Both Scenarios 2 and 3 represent fully fleshed out policy evaluations. We used both since we were unable to secure precise numbers on the number of parents who worked, let alone how many hours they worked. We did learn that PHLpreK enrollment varied from 2,100 to 2,650 in 2019; Moreover, the City reports the program has space for 3,300 seats. We therefore speculate that Scenario 2 sets a lower bound for the net economic impacts and Scenario 3 a rather loose upper bound.

4. Model Results and Discussion

4.1. General Economic Impacts

Table 5 shows the baseline measures by industries for the City of Philadelphia in 2016, the year prior to the implementation of the City's Beverage Tax. Sectors to be directly affected by the tax are denoted in a combination of upper- and lower-case fonts. Note the City had 877,146 jobs making $55.8 billion for an average annual labor income of $63,627. Firms more than doubled the City's wealth (GDP) gained annually through labor income by paying taxes and accumulating operating surpluses, thus contributing more than $115.9 billion to the nation's GDP in 2016.

Yet, in light of the above, it should be clear that the $76.9 million collected in Beverage Tax revenues in 2019, while a substantial sum, comprises a rather small share of Philadelphia's overall economy. We make this point because we express the three scenarios in terms of their difference (or change) from the baseline in Table 5.

Table 5. Philadelphia's Total GDP, Labor Income and Jobs by Supersector in 2016

Sector #	Description	Baseline GDP ($000)	Baseline Labor Income ($000)	Baseline Jobs
1	AGRICULTURE, FORESTRY, FISHING, AND HUNTING PLUS MINING	$ 12,865	$ 10,999	758
2	UTILITIES	315,658	264,247	1,895
3	CONSTRUCTION	2,306,836	1,128,741	22,182
4	DURABLE GOODS	1,030,057	667,407	9,613
5	NONDURABLE GOODS	3,288,648	991,973	12,561
6	WHOLESALE TRADE	2,284,414	1,115,142	12,854
7	GROCERY AND RELATED PRODUCT WHOLESALERS	437,896	268,193	4,478
8	RETAIL TRADE	1,988,537	1,287,519	42,131
9	FOOD AND BEVERAGE STORES	539,304	394,557	16,030
10	OTHER TRANSPORTATION AND WAREHOUSING	3,092,810	1,860,605	43,070
11	TRUCK TRANSPORTATION	84,000	61,778	2,151
12	INFORMATION	24,201,747	1,460,278	13,732
13	FINANCE, INSURANCE, REAL ESTATE AND RENTAL AND LEASING	23,250,067	5,430,932	75,321
14	PROFESSIONAL AND BUSINESS SERVICES	15,281,454	10,055,325	120,520
15	EDUCATIONAL SERVICES	7,252,391	5,963,009	88,325
16	OTHER HEALTH CARE AND SOCIAL ASSISTANCE	11,157,729	9,861,619	160,458
17	CHILDCARE SERVICES	237,235	169,191	7,694
18	ARTS, ENTERTAINMENT, AND RECREATION	2,177,333	1,070,766	22,639
19	ACCOMMODATION	683,070	382,968	8,099
20	FOOD SERVICES	1,992,531	1,377,817	55,173
21	OTHER SERVICES, EXCEPT GOVERNMENT	1,541,608	1,604,979	48,897
22	GOVERNMENT	12,789,950	10,382,662	108,565
	TOTAL	$115,946,140	$55,810,707	877,146

Source: US BEA and R/ECON™ calculations

4.1.1. Scenario 1, Economic Impacts

Table 6 shows the general equilibrium results of the effect of the Beverage Tax and its redistribution through the City's general fund and through PHLpreK. The burden on Grocery and related product wholesalers not dissimilar to that foretold by the ABA. The industry foregoes more than 200 jobs because it must pay the Beverage Tax which shows as a strong positive in the industry's GDP ledger. Manufacturing, Professional business services, Transportation and Trucking services, Utilities, and Finance industries suffer as that industry swoons.

But the City's spending of those tax revenues appears to offset any losses in labor income paid by organizations within the City, and the job count rises marginally—by 216 jobs. Given the lack of income impact, it is clear that the new jobs pay far less than those lost, however. This is no surprise since most of the added jobs accumulate in the Childcare sector, although Government, Educational, and Social services accumulate some new jobs as well alone with labor income. On

balance, however, it appears that the Scenario 1 yield an almost perfectly neutral outcome with respect to the core measures. It seems likely, however, that lower-income families are likely benefiting from the receipt of the extra services provided the City.

Table 6. Scenario 1, Economic Impacts of the Beverage Tax and Its Redistribution (Only)

		Scenario 1		
Sector #	Description	GDP ($000)	Labor Income ($000)	Jobs
1	AGRICULTURE, FORESTRY, FISHING, AND HUNTING PLUS MINING	5	5	0
2	UTILITIES	(172)	(144)	(1)
3	CONSTRUCTION	283	124	2
4	DURABLE GOODS	923	596	9
5	NONDURABLE GOODS	(1,120)	(330)	(4)
6	WHOLESALE TRADE	(651)	(305)	(4)
7	GROCERY AND RELATED PRODUCT WHOLESALERS	51,685	(13,134)	(219)
8	RETAIL TRADE	98	68	2
9	FOOD AND BEVERAGE STORES	162	121	5
10	OTHER TRANSPORTATION AND WAREHOUSING	(864)	(509)	(12)
11	TRUCK TRANSPORTATION	(93)	(69)	(2)
12	INFORMATION	3,547	201	2
13	FINANCE, INSURANCE, REAL ESTATE AND RENTAL AND LEASING	(422)	(128)	(2)
14	PROFESSIONAL AND BUSINESS SERVICES	(5,605)	(3,713)	(45)
15	EDUCATIONAL SERVICES	2,976	2,448	36
16	OTHER HEALTH CARE AND SOCIAL ASSISTANCE	4,325	3,813	62
17	CHILDCARE SERVICES	9,653	6,886	313
18	ARTS, ENTERTAINMENT, AND RECREATION	175	88	2
19	ACCOMMODATION	264	155	3
20	FOOD SERVICES	896	642	26
21	OTHER SERVICES, EXCEPT GOVERNMENT	397	409	12
22	GOVERNMENT	3,426	2,779	29
	TOTAL	$69,888	-	216

Note further that while GDP appears to have risen overall by $69.9 million in Table 6, that this figure is less than the $76.9 million collected from Grocery and related product wholesalers alone, which is included in the $69.9 million. That is, labor income's contribution to GDP is flat and the tax contribution has risen, which signifies that the operating surplus of private business necessarily has fallen by about $10 million.

Although there is substantial labor market churning (shifts in labor use across sectors), on balance, it appears that the Scenario 1 yields a fairly neutral outcome with respect to the core measures. It is fair to make this statement since the net impact numbers in Table 6 are quite small, even with respect to the size of the policy change effected. Nonetheless, it seems that lower-income families likely benefit from the receipt of the extra services provided the City. In this vein, Scenario

1, the Beverage Tax even excluding any change in labor supply, can be deemed to have achieved its core goals.

4.1.2. Scenarios 2 and 3, Economic Impacts

Table 7. Scenario 2, The Beverage Tax plus a Labor Supply Rise of 0.2%

Sector #	Description	Scenario 2 GDP ($000)	Scenario 2 Labor Income ($000)	Scenario 2 Jobs
1	AGRICULTURE, FORESTRY, FISHING, AND HUNTING PLUS MINING	10	8	1
2	UTILITIES	37	36	0
3	CONSTRUCTION	1,059	693	14
4	DURABLE GOODS	1,451	967	14
5	NONDURABLE GOODS	462	209	3
6	WHOLESALE TRADE	490	308	4
7	GROCERY AND RELATED PRODUCT WHOLESALERS	51,948	(12,986)	(217)
8	RETAIL TRADE	1,824	1,228	40
9	FOOD AND BEVERAGE STORES	593	447	18
10	OTHER TRANSPORTATION AND WAREHOUSING	303	391	9
11	TRUCK TRANSPORTATION	(37)	(22)	(1)
12	INFORMATION	14,507	1,035	10
13	FINANCE, INSURANCE, REAL ESTATE AND RENTAL AND LEASING	16,455	4,318	60
14	PROFESSIONAL AND BUSINESS SERVICES	(548)	15	0
15	EDUCATIONAL SERVICES	5,242	4,434	66
16	OTHER HEALTH CARE AND SOCIAL ASSISTANCE	7,490	6,752	110
17	CHILDCARE SERVICES	15,409	10,996	500
18	ARTS, ENTERTAINMENT, AND RECREATION	899	501	11
19	ACCOMMODATION	487	295	6
20	FOOD SERVICES	2,244	1,616	65
21	OTHER SERVICES, EXCEPT GOVERNMENT	1,046	1,084	33
22	GOVERNMENT	6,886	5,806	61
	TOTAL	128,256	28,134	805

Given the net apparent outcome (economic neutrality) of Scenario 1, any additional benefits elicited as a result of the Beverage Tax should cause benefits to exceed costs. This is the case as shown in Table 7. The 0.2% rise in the labor supply (a count of 1,754 new jobs) due to the release into the labor force of parents of children in subsidized childcare coupled with the Beverage Tax enables a total GDP change ($128.2 million) substantially exceeds direct Beverage Tax collections ($76.8 million) by roughly $51.4 million. Only labor income and jobs in Grocery and related product wholesalers and Trucking services sectors fall. Labor market churning is clearly less of an issue. Philadelphia's count of jobs rises by 805 (overall by nearly 0.1%) and its labor income by $28.1 million (a 0.5% rise), suggesting most of the rise is in lower wage jobs, as also

noted in Scenario 1. Sectors that are prime recipients of the boost are Child daycare, Other healthcare and social services, Government, Educational services, and Financial and real estate services.

Table 8. Scenario 3, The Beverage Tax plus a Labor Supply Rise of 0.5%

Sector #	Description	Scenario 3 GDP ($000)	Scenario 3 Labor Income ($000)	Scenario 3 Jobs
1	AGRICULTURE, FORESTRY, FISHING, AND HUNTING PLUS MINING	15	12	1
2	UTILITIES	301	263	2
3	CONSTRUCTION	2,039	1,412	28
4	DURABLE GOODS	2,104	1,426	21
5	NONDURABLE GOODS	2,454	887	11
6	WHOLESALE TRADE	2,030	1,132	13
7	GROCERY AND RELATED PRODUCT WHOLESALERS	52,277	(12,800)	(214)
8	RETAIL TRADE	4,322	2,901	95
9	FOOD AND BEVERAGE STORES	1,214	914	37
10	OTHER TRANSPORTATION AND WAREHOUSING	1,793	1,536	36
11	TRUCK TRANSPORTATION	39	40	1
12	INFORMATION	28,473	2,096	20
13	FINANCE, INSURANCE, REAL ESTATE AND RENTAL AND LEASING	39,297	10,289	143
14	PROFESSIONAL AND BUSINESS SERVICES	5,931	4,783	57
15	EDUCATIONAL SERVICES	8,280	7,085	105
16	OTHER HEALTH CARE AND SOCIAL ASSISTANCE	11,610	10,571	172
17	CHILDCARE SERVICES	15,652	11,177	508
18	ARTS, ENTERTAINMENT, AND RECREATION	1,842	1,037	22
19	ACCOMMODATION	769	473	10
20	FOOD SERVICES	4,110	2,959	118
21	OTHER SERVICES, EXCEPT GOVERNMENT	1,892	1,963	60
22	GOVERNMENT	11,353	9,706	101
	TOTAL	197,797	59,862	1,347

Naturally, if even more parents take advantage of the opportunity to join the labor force with the advent of PHLpreK, the balance weighs even more in favor of the plan behind the Beverage Tax being a success. Table 8 shows what happens when labor supply rises instead by 0.5% (4,386 jobs). Private GDP rises by about $120 million ($197.8 million-$76.8 million), labor income rises by $59.9 million, and about 1,350 new jobs are created. Only the beverage wholesalers take on jobs and income losses.

4.2. Net Fiscal Impacts to the City of Philadelphia

It is clear from the above that the Beverage Tax likely nets out to be a positive for the economy at large, even if the labor supply effects were smaller than we tested. But it is also fair to

ask whether the same can be said for the City's tax coffers. In this vein, we examine how the City's wage, property, and other tax revenues are altered across the three scenarios. As before, it is important to understand the starting point; see Table 9.

Table 9. City of Philadelphia Tax Revenues, 2016 ($1,000s)

Other Local Tax	Wage Tax	Property Tax
$ 1,402,100	$ 1,840,807	$ 571,485

4.2.1. Scenario 1, Net Fiscal Impacts

Table 10. City of Philadelphia Tax Revenues, Scenario 1 ($1,000s)

Other Local Tax	Wage Tax	Property Tax
($733)	($5)	($7)

Scenario 1, which introduces the Beverage Tax and allocates its expenditure by the City's "long-run" pattern (from 2017 to the third quarter of 2020), proves to yield a net loss to the City's coffers in general equilibrium (see Table 9). Most of the loss is apparently in the form of indirect taxes paid by businesses. It is likely the industries that reduce their tax payments are those that reduced their labor income most in Scenario 1 as discussed in Section 4.1.1. Indeed, these Other local tax revenue losses exceed by just more than $0.7 million those $76.8 million that the City gains from the Beverage Tax. The wage and property tax streams change, but imperceptibly.

4.2.2. Scenario 2 and 3, Net Fiscal Impacts

Table 11. City of Philadelphia Tax Revenues, Scenario 2 ($1,000s)

Other Local Tax	Wage Tax	Property Tax
($17)	$2,177	$595

A 0.2% rise in the labor supply clear appears to do more than just balance the ledgers (see Table 10). Returns via the City's wage tax and its property tax outweigh the almost negligible loss in "Other local tax" revenues, which includes the Beverage Tax. The net balance to Philadelphia's tax coffers is estimated to be a positive $2.75 million.

Table 12. City of Philadelphia Tax Revenues, Scenario 3 ($1,000s)

Other Local Tax	Wage Tax	Property Tax
917	5,436	1,454

A 0.5% rise in the labor supply only further fortifies the City's ledgers (see Table 12). The 250% change (from 0.2% to 0.5%) in the labor-supply rise induces almost a similar net effect on wage and property tax revenues. We estimate the net balance to Philadelphia's tax coffers for Scenario 3 to be positive in the amount of $7.81 million.

5. Conclusions

Much of the existing literature on Philadelphia's Beverage Tax, to date, paints a rather bitter picture. One in which the beverage industry will suffer an economic storm and in which the City's poor will suffer the brunt of storm's surge. But, as we point out, all of these analyses examine just a portion of what has happened. That is, while they likely accurately depict what they examine, they do not account for all of what transpires in an economy after a new tax is introduced and allocated to a jurisdiction's expenditure stream. In particular, none examined the new tax in light of likely a change in the labor supply, which is the purpose of providing a childcare subsidy. Indeed, analyses of similar (albeit larger) programs in Oklahoma and The Netherlands suggests that such programs are tax neutral, at least economywide.

We develop a 2016 social accounting matrix (SAM) for Philadelphia and insert it into a computable general equilibrium (CGE) model that attempts to maximize household incomes and industry surplus after introducing the Beverage Tax. The SAM, essentially a picture of the economy's structure and interindustry interactions at a point in time, constrains the economy's ability to optimize. We submitted the 2019 revenues from the Beverage Tax and let it be submitted across City functions via its historic 2017 to third quarter 2020 allocation shares. We next sequentially add a labor supply rise by 0.2% or by about 1,750 jobs. We then test instead a 0.5% rise in Philadelphia's labor supply (4,386 jobs) on top of the Beverage Tax and its revenue reallocation.

We find that Philadelphia's Beverage Tax alone does appears to negatively affect private concerns as well as the City's fiscal condition. But, on balance, net changes to the aggregate labor income and total jobs in the City are negligible; and the wage and property tax streams are not affected much. Moreover, sectors that grow appear to be those with lower wages and that supply services to the underprivileged, including childcare. That is, City reallocations appear to have met their mark.

Any additional stimulus of a small change in the City's labor supply enabled by the provision of subsidized childcare services is sufficient to secure a positive net effect on the City's private industries and the City's tax coffers. Still, beverage distributors and related logistics industries remain affected in a negative manner. Of course, the greater the rise in the labor supply the more positive is the net balance.

In summary, Philadelphia's Beverage Tax has solid fiscal and economic footing. This is without valuing changes in the health of citizens of Philadelphia, a prime issue when the ordinance

was being formulated. It is especially a concern for members of the City's poorer households who tend to consume more sugary beverages.

Needless to say, the research reported here can be improved upon. Perhaps foremost is that we did not break down employment by industry into the same household types that we characterized in the SAM for Philadelphia. Doing so would permit changes in the distribution of any lost or added labor income across household types. That is, household-type shares remained fixed in our work, despite changes in labor income that likely favored lower-income households, the spending of which the SAM characterized in detail.

Further, in its basic, unaltered state, the CGE model did not apply a price elasticity of demand of -1 to Grocery and beverage wholesalers. It was, instead, about -0.90. We deemed this "close enough" not to require a change; that is, -0.90 is likely not different from -1.0 in a statistically significant manner. Moreover, changing it would have required undue time and effort. Still, it is imperfect. A greater issue with the modeling effort is that we could not assure a 97% pass-through of tax's incidence to consumers. This is because we assume what is called fixed "Leontief technology" and consumer preferences. That is, it is difficult to model substitution within a household's consumption basket or in a firm's production processes. It can be done, however. But this too might not be a problem given the 22-sector aggregation scheme that we deployed in the SAM. This is because any substitution likely takes place within rather than across the sectors that the SAM articulates. Still, some changes in the use of commodities likely take place in the wake of a new tax. Fortunately, those changes would likely be very small, given the size of the tax change compared to the size of the City's overall revenue stream.

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7. Appendix A: Additional Tables Cited in the Text

Appendix A Table 1. SAMPHL-2016 Table

	SEC1	SEC2	SEC3	SEC4	SEC5	SEC6	SEC7	SEC8	SEC9	SEC10	SEC11	SEC12	SEC13	SEC14	SEC15	SEC16	SEC17	SEC18	SEC19	SEC20	SEC21	SEC22
SEC1	1293.6	258.3	10320.2	1130.8	149.6	0.5	0.1	4.8	1.5	886	1.8	198.6	8.7	523.7	3.6	21.8	1.9	1.2	0.3	39.6	15.8	3034.2
SEC2	2098.9	91549.8	5493.8	14752.1	99298.1	31122.1	11479.2	63030.9	36454.2	49046.4	742.6	103244.7	257841.1	89782.5	159690.5	134513.4	1913.9	13110.5	27635.4	66314.3	23392.5	29323.9
SEC3	996.4	21813.7	181.6	1421.5	37429	2167.4	481.1	4119.8	1064.4	20718.8	100.9	17933.3	284295.8	6438.8	12392.3	7214.8	201.6	1646.5	1843.5	2910.9	16207.3	235723
SEC4	89.7	532.9	38775.5	56103.6	14669.1	2859.2	1255.6	4668.8	867.4	13003.9	269.4	26406.8	5236.9	16957	4614.8	25076.8	516.9	1336.6	1300.9	4103.5	9760.7	20621.9
SEC5	1403.3	39743.3	22909.9	20191.1	347166.6	20455.3	5201.6	16342.9	5467	196310.4	10280.9	95653	63464.8	65931.6	59644.7	121947.2	2797.3	12162.2	11582	41136.1	31012.1	436682.8
SEC6	1337.4	11144.2	67960.5	93787.9	200517.7	78859.8	14861.5	38389.5	7073.9	40563.3	1722.6	224257.9	45351.8	98123.3	58429	324670.8	1443.4	12634.7	12307.6	42423.6	44470.8	127185.8
SEC7	8.7	222.6	319.4	708.7	86828.4	7212.2	977.2	2469.6	2377.8	1156.4	14.3	2235.4	1149.7	2926.1	28293	25116.5	1710.3	2360.8	3264	19177.4	3536.4	20626.4
SEC8	241.2	8457.6	93557.9	5111.1	29394.5	11854.2	3411.9	17096.2	4608.2	35511.6	9080.2	33976.9	55468.5	34822.1	11584.5	39430.6	179.9	5028.5	6883.7	21304.8	20774.4	26088.7
SEC9	1	398.2	275.3	116.7	509.9	268.9	66.7	363.1	282.5	1265.5	379.1	474.2	3290.3	2136.2	6537.7	3124.8	171.5	427	812.3	5614.7	853.1	2499.3
SEC10	4910	114183.6	6747.9	16970	166984.8	167591.5	40625.5	169954.4	50378.7	459865	24112.4	124757.6	129764.7	154609.2	54625.4	119702.6	1045.8	26690.2	8099.5	18315	30444.1	160278.1
SEC11	134.1	4568.6	5429.6	5268.4	36625	2534.3	735.1	5586.7	1777.8	10028.3	854.5	8055.3	2209.9	5260	2340.6	7887.2	138.4	1140.7	608.1	1830.7	2472.9	10587.4
SEC12	497.3	20973.3	13329.2	15239.2	24872.7	108206.8	14734.9	135407.4	21836.2	41182.4	1067.8	4058838.5	376081.2	546175.1	147930.4	223811.1	1963.2	43526.8	43211.8	74851.2	130826.2	264233.2
SEC13	2808.6	66717.8	51496.5	41165.1	64740.7	226730.2	46218.4	366920.8	74845.4	385251.1	12749.6	538623.8	7325779.1	1015247.7	1181329	1673564.7	39730.6	122858.4	49031.9	210841.4	539544.6	616566
SEC14	9754.5	118972.4	96332.3	112200.1	263769.9	469635.9	107906.5	354206.1	53165.4	219854.6	10722.7	1608180	1738884.5	1815137.2	393449.8	1671157.1	8124	160330.5	170763	376743.8	291373.7	723844.6
SEC15	10.9	2576	289.2	680.8	1917.3	5129.7	513.3	7870.6	3737.4	10054	23.7	176244.7	21194.9	23742.1	126311.3	15221.4	169.9	43685.5	2465.5	1604.7	39526.4	44534.1
SEC16	6.7	35.6	1396.1	57.3	484.7	174.5	75.3	142.1	32.6	1309.8	45.6	1210.3	1191.5	1455.8	835.1	268564.1	6.9	966.4	54.5	202.6	1128.6	21039.4
SEC17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2864.7
SEC18	172.4	1755.3	955.4	5648.2	9853.6	11780.6	2708.2	9426.5	4018.4	7629.7	219.9	317055.6	33737.9	96626	34584.5	11743.3	221.6	98656.5	3467	13357.8	17991.5	8456.9
SEC19	32	3002.1	589.3	1965.9	3988.8	3215.2	622.3	1882.4	666.3	18477.6	37.4	17639.1	54599.7	54986.4	25355.3	45866.4	486.7	3965.8	6128.2	5364.7	10557.1	15566.3
SEC20	39.4	11781.1	965.1	3725.9	9132.1	10952.2	2526.4	10923.6	3493.4	81755.6	222.4	25660.5	202229.8	152299.8	61914.5	260374.9	2991.6	14670.9	24703.9	13079.5	20546.9	40393.4
SEC21	74.5	2823.5	4983.8	3157	9667	21143	6513.3	20578	5426.3	15811	3485.1	72144.8	126740.4	73373.2	43491.5	127503.4	1541.5	7981.2	5576.6	17338	61223.9	36340.5
SEC22	428.1	79403.3	2709.6	5251	36837.4	51381.9	11868.7	26060.9	6706.3	53964.3	2789.8	110111.4	232070.9	83601.4	150826.3	154421.3	2890.8	20972.9	15071.2	27165.6	30038.2	116160.8
L	10999	264247	1128741	667407	991973	1115142	268193	1287519	394557	1860605	61778	1460278	5430932	10055325	5963009	9861619.4	169190.6	1070766	382968	1377817	1604979	10382662
K	2097.8	42169.4	1150870.1	340991.1	2157836.6	711149.8	137667.6	416048.5	85814.1	820115.5	20662.4	21567042.6	15083548.4	4525797.4	1113626.9	1223727.7	51218.7	768483.2	161448.9	403402.2	5812.7	1992730.4
H1																						
H2																						
H3																						
H4																						
CORP																						
FGV																						
SGV																						
LGV																						
FSTX	-275.8	8164.1	19350.6	18142.9	127612.8	375215.5	16143.5	212063	39339.2	401532.5	1272.7	1091815.2	2413666	558232.2	150999.4	-10980	16016.2	310116.2	79467	204432	-170902.4	319493
LOTX	12.2	299.6	2189.2	977.5	3120.9	77276.6	14813.1	68005.6	18264.7	2935.1	79.7	22967.4	264622.1	104439.1	6882.5	55864	225.1	22601.7	57502.4	1969.6	97919.4	63544.5
WAGETX																						
PROTX	31.7	777.9	5685.1	2538.5	8104.7	5629.8	1079.2	4900.6	1329.1	7622.1	207	59643.8	57298.5	37660.3	17873.1	27497.6	584.7	5365.9	1683.4	4910.5	3799.2	31520.1
SUGTX							0															
INV																						
SV																						
SA																						
RUS	16376.5	524277.6	599587.1	808831.2	4578062.1	572911.9	131133.7	564702	142015.8	1093743	49075.6	5102731.2	5126033.8	2403180.4	1315800.3	3244146	42158	251155.2	179829.5	517716.6	824852	2598009.4
ROW	2348.2	110010.2	116209.6	294585.3	1729091.2	75349.7	15917.9	83110.8	17977.7	356807.5	6921.7	1042845.6	380816.8	381108.6	133652.9	541342.9	3988.4	29500.8	30231.3	69840.8	169421.8	412093.1

Appendix A Table 1. SAMPHL-2016 Table (Continued)

	L	K	H1	H2	H3	H4	CORP	FGV	SGV	LGV	FSTX	LOTX	WAGETX	PROTX	SUGTX	INV	SV	SA	RUS	ROW
SEC1			1.7	27.1	24	118.1										14881.3	106.2		24302.9	570.6
SEC2			2491.4	5908.5	10338.1	38075.4										3827.3	6.5		169892.5	8488.3
SEC3			103	484.4	467	1404.7				35.5						2588698.2	-41		172026.1	7170.4
SEC4			529.8	1366.4	3196.1	23085										94928.3	8527.7		1687457	470007.1
SEC5			25359	57537.4	103461.2	452322.7										29201.8	85909.2		7213938	1445422
SEC6			29976.4	55872.6	106310.2	494021.5										502265	8361		952962.7	468664.5
SEC7			6971.2	13035.3	24454.9	112389										745.9	1421.6		432246.9	53774.7
SEC8			82266.2	162013.6	307731.9	1481642										288299.9	6.7		1094593	1375
SEC9			19884.6	38518.3	71903.2	344076.2										883.6	119.7		476907.1	1418.2
SEC10			4070.5	9378.4	10306.9	75753.8										44489.2	7748		3046120	958484.3
SEC11			1217.1	2455.2	7015	35582.4										22669.3	367.2		9737.5	23802.6
SEC12			35612.4	64471.6	161608.5	767954.5										666494.5	-35880.4		28827702	1113467
SEC13			257139.8	517537.2	1334753.4	7762209				241.6						791950.7	-357.9		13582803	818471.4
SEC14			3967.9	66121.4	73844.9	278060.2										1602408.8	-44.7		8648708	958322.7
SEC15			2310.2	76205.4	118428.6	734353.9										83210.8	0		9621796	102219.6
SEC16			20841.6	20951.2	166777.7	731752.9										37325.3	0		18906322	19765.7
SEC17			1593.1	4932.7	21284.4	107259.7									0	28.8	0		213666	0
SEC18			1131	2583.7	12015.1	111832										19656	0		1753898	460960.2
SEC19			1016.6	1698.6	4117.9	31594.3										2792.9	0		971017.9	708.3
SEC20			32297.2	45932.3	117743.5	887694.9										267.4	162.4		1496350	8978.1
SEC21			7756.6	27653.7	51878.9	258075.2										308186.7	1.4		2527441	13668.1
SEC22			39774.5	81520.3	151542	601003.4		2646644	3305903	3259807						302156.8	2118.5		4607760	2543743
L																			17209150	
K																				
H1	132170.7	90550.6					42939.6	155161.6	467505	34607.8										
H2	711800.8	268939					49390	746012.1	2247750	166393.2										
H3	3456847.8	727203.9					90152.9	2257013	6800427											
H4	68719037.8	7155830					1459964	6841439	162454.1											
CORP		4822516																		
FGV											1.2E+07									
SGV		39670310									3443557									
LGV		46914						71293.1	436915.8	450655.3		1402099.8	1840807.2	571485.4	0					
FSTX			22961.8	92359.4	356954.6	6504142	2664482													
LOTX							515587.7													
WAGETX			9657.1	46431.2	140474.7	1247610													396634.6	
PROTX						285742.7														
SUGTX																				
INV																		7405368		
SV																		78532.3		
SA			314004.7	2795289	9975012	60970970		-339304	29692911	908430										-3476309
RUS																		93357102		
ROW																				

Appendix A Table 2. Variable and Parameter Definitions

Variables

QQ -- Total amount of production supply

QA -- Total amount of domestic production supply

QVA -- Total amount of value-added factor

QM -- Total imports and inflows

$QINT$ -- Intermediate demand

$QINTA$ -- Total Intermediate demand

QLD -- Total labor demand

QKD -- Total capital demand

QLS -- Total labor supply

QLS -- Total labor supply

QH -- Household consumption

$EINV$ -- Total investment

$ENTSAV$ -- Corporate saving

$FSAV$ -- Foreign saving

WL -- Labor prices/ wage rate

WK -- Rate of return to capital

$YENT$ -- Corporate revenue

YH -- Household revenue

Subscripts

i -- Industry category

j -- Intermediate demand category

h -- Household category

gov -- Government category (Federal, state, local)

Calibrated parameters

α^{qq} -- CES shift parameter, total production

δ^{qq} -- CES share parameter, total production

α^{qa} -- CES shift parameter, domestic production

δ^{qa} -- CES share parameter, domestic production

α^{va} -- CES shift parameter, value-added

δ^{va} -- CES share parameter, value-added

ica -- Fixed input-output coefficient

mpc -- Household marginal propensity to spend

$shifhl$ --Household labor endowment share

$shifhk$ -- Household capital endowment share

$shrh$ -- Consumption share of disposable income

$shifentk$ -- Corporate capital endowment share

$tifs$ -- Federal and state tax rate for household

$tiwt$ -- Wage tax rate

$tipt$ -- Property tax rate

$tvak$ -- Value-added tax rate for capital

$tifsent$ -- Federal and state tax rate for corporate

$tiloent$ -- Other local tax rate for corporate

Exogenous parameters

$\overline{QE}$ -- Total exports and outflows

$\overline{QINV}$ -- Investment demand

$\overline{QGV}$ -- Government consumption

$\overline{QSV}$ -- Inventory variance

$\overline{QL_{RUS}}$ -- Labor supply from non-resident

$\overline{Wage_{RUS}}$ -- Total Wage tax amount from non-resident

$\overline{SAV}$ -- Government saving

$\overline{EXR}$ -- Fixed exchange rate

$transfrh$ -- Government transfer to household

$transfrent$ -- Corporate transfer to household

ρ^{q} -- Converted substitution elasticity between domestic and imported goods in the Arimington /behavior parameter

ρ^{va} -- Converted substitution elasticity between labor and capital /behavior parameter

ρ -- Converted substitution elasticity between composite intermediate inputs and value added /behavior parameter

Appendix A Table 3. Behavior Parameter in CGE Model

Industry Index	Domestic/Imported	Value-added/ Intermediate inputs	Labor/capital
II01	0.732	-3.405	-3.405
II02	0.643	0.206	0.206
II03	0.474	0.405	0.405
II04	0.733	0.206	0.206
II05	0.680	0.156	0.156
II06	0.474	0.206	0.206
II07	0.474	0.206	0.206
II08	0.474	0.206	0.206
II09	0.474	0.206	0.206
II10	0.474	0.405	0.405
II11	0.474	0.405	0.405
II12	0.474	0.206	0.206
II13	0.474	0.206	0.206
II14	0.474	0.206	0.206
II15	0.474	0.206	0.206
II16	0.474	0.206	0.206
II17	0.474	0.206	0.206
II18	0.474	0.206	0.206
II19	0.474	0.206	0.206
II20	0.474	0.206	0.206
II21	0.474	0.206	0.206
II22	0.474	0.206	0.206

NAICS code	US BEA I-O Industry	SAM Industry	Industry Index
1111A0	Oilseed farming	AGRICULTURE, FORESTRY, FISHING, AND HUNTING PLUS MINING	II01
1111B0	Grain farming		
111200	Vegetable and melon farming		
111300	Fruit and tree nut farming		
111400	Greenhouse, nursery, and floriculture production		
111900	Other crop farming		
112120	Dairy cattle and milk production		
1121A0	Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming		
112300	Poultry and egg production		
112A00	Animal production, except cattle and poultry and eggs		
113000	Forestry and logging		
114000	Fishing, hunting and trapping		
115000	Support activities for agriculture and forestry		
211000	Oil and gas extraction		
212100	Coal mining		
212230	Copper, nickel, lead, and zinc mining		
2122A0	Iron, gold, silver, and other metal ore mining		
212310	Stone mining and quarrying		
2123A0	Other nonmetallic mineral mining and quarrying		
213111	Drilling oil and gas wells		
21311A	Other support activities for mining		
221100	Electric power generation, transmission, and distribution	UTILITIES	II02
221200	Natural gas distribution		
221300	Water, sewage and other systems		
233210	Health care structures	CONSTRUCTION	II03
233262	Educational and vocational structures		
230301	Nonresidential maintenance and repair		
230302	Residential maintenance and repair		
2332A0	Office and commercial structures		
233412	Multifamily residential structures		
2334A0	Other residential structures		
233230	Manufacturing structures		
2332D0	Other nonresidential structures		
233240	Power and communication structures		
233411	Single-family residential structures		
2332C0	Transportation structures and highways and streets		

321100	Sawmills and wood preservation		
321200	Veneer, plywood, and engineered wood product manufacturing		
321910	Millwork		
3219A0	All other wood product manufacturing		
327100	Clay product and refractory manufacturing		
327200	Glass and glass product manufacturing		
327310	Cement manufacturing		
327320	Ready-mix concrete manufacturing		
327330	Concrete pipe, brick, and block manufacturing		
327390	Other concrete product manufacturing		
327400	Lime and gypsum product manufacturing		
327910	Abrasive product manufacturing		
327991	Cut stone and stone product manufacturing		
327992	Ground or treated mineral and earth manufacturing		
327993	Mineral wool manufacturing		
327999	Miscellaneous nonmetallic mineral products		
331110	Iron and steel mills and ferroalloy manufacturing	DURABLE GOODS	II04
331200	Steel product manufacturing from purchased steel		
331314	Secondary smelting and alloying of aluminum		
331313	Alumina refining and primary aluminum production		
33131B	Aluminum product manufacturing from purchased aluminum		
331410	Nonferrous Metal (except Aluminum) Smelting and Refining		
331420	Copper rolling, drawing, extruding and alloying		
331490	Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying		
331510	Ferrous metal foundries		
331520	Nonferrous metal foundries		
332114	Custom roll forming		
33211A	All other forging, stamping, and sintering		
332119	Metal crown, closure, and other metal stamping (except automotive)		
332200	Cutlery and handtool manufacturing		
332310	Plate work and fabricated structural product manufacturing		

332320	Ornamental and architectural metal products manufacturing
332410	Power boiler and heat exchanger manufacturing
332420	Metal tank (heavy gauge) manufacturing
332430	Metal can, box, and other metal container (light gauge) manufacturing
332500	Hardware manufacturing
332600	Spring and wire product manufacturing
332710	Machine shops
332720	Turned product and screw, nut, and bolt manufacturing
332800	Coating, engraving, heat treating and allied activities
332913	Plumbing fixture fitting and trim manufacturing
33291A	Valve and fittings other than plumbing
332991	Ball and roller bearing manufacturing
332996	Fabricated pipe and pipe fitting manufacturing
33299A	Ammunition, arms, ordnance, and accessories manufacturing
332999	Other fabricated metal manufacturing
333111	Farm machinery and equipment manufacturing
333112	Lawn and garden equipment manufacturing
333120	Construction machinery manufacturing
333130	Mining and oil and gas field machinery manufacturing
333242	Semiconductor machinery manufacturing
33329A	Other industrial machinery manufacturing
333314	Optical instrument and lens manufacturing
333316	Photographic and photocopying equipment manufacturing
333318	Other commercial and service industry machinery manufacturing
333414	Heating equipment (except warm air furnaces) manufacturing
333415	Air conditioning, refrigeration, and warm air heating equipment manufacturing
333413	Industrial and commercial fan and blower and air purification equipment manufacturing
333511	Industrial mold manufacturing
333514	Special tool, die, jig, and fixture manufacturing
333517	Machine tool manufacturing

33351B	Cutting and machine tool accessory, rolling mill, and other metalworking machinery manufacturing
333611	Turbine and turbine generator set units manufacturing
333612	Speed changer, industrial high-speed drive, and gear manufacturing
333613	Mechanical power transmission equipment manufacturing
333618	Other engine equipment manufacturing
333912	Air and gas compressor manufacturing
33391A	Pump and pumping equipment manufacturing
333920	Material handling equipment manufacturing
333991	Power-driven handtool manufacturing
333993	Packaging machinery manufacturing
333994	Industrial process furnace and oven manufacturing
33399A	Other general purpose machinery manufacturing
33399B	Fluid power process machinery
334111	Electronic computer manufacturing
334112	Computer storage device manufacturing
334118	Computer terminals and other computer peripheral equipment manufacturing
334210	Telephone apparatus manufacturing
334220	Broadcast and wireless communications equipment
334290	Other communications equipment manufacturing
334413	Semiconductor and related device manufacturing
334418	Printed circuit assembly (electronic assembly) manufacturing
33441A	Other electronic component manufacturing
334510	Electromedical and electrotherapeutic apparatus manufacturing
334511	Search, detection, and navigation instruments manufacturing
334512	Automatic environmental control manufacturing
334513	Industrial process variable instruments manufacturing
334514	Totalizing fluid meter and counting device manufacturing
334515	Electricity and signal testing instruments manufacturing
334516	Analytical laboratory instrument manufacturing
334517	Irradiation apparatus manufacturing

33451A	Watch, clock, and other measuring and controlling device manufacturing
334300	Audio and video equipment manufacturing
334610	Manufacturing and reproducing magnetic and optical media
335110	Electric lamp bulb and part manufacturing
335120	Lighting fixture manufacturing
335210	Small electrical appliance manufacturing
335221	Household cooking appliance manufacturing
335222	Household refrigerator and home freezer manufacturing
335224	Household laundry equipment manufacturing
335228	Other major household appliance manufacturing
335311	Power, distribution, and specialty transformer manufacturing
335312	Motor and generator manufacturing
335313	Switchgear and switchboard apparatus manufacturing
335314	Relay and industrial control manufacturing
335911	Storage battery manufacturing
335912	Primary battery manufacturing
335920	Communication and energy wire and cable manufacturing
335930	Wiring device manufacturing
335991	Carbon and graphite product manufacturing
335999	All other miscellaneous electrical equipment and component manufacturing
336111	Automobile manufacturing
336112	Light truck and utility vehicle manufacturing
336120	Heavy duty truck manufacturing
336211	Motor vehicle body manufacturing
336212	Truck trailer manufacturing
336213	Motor home manufacturing
336214	Travel trailer and camper manufacturing
336310	Motor vehicle gasoline engine and engine parts manufacturing
336320	Motor vehicle electrical and electronic equipment manufacturing
336350	Motor vehicle transmission and power train parts manufacturing

336360	Motor vehicle seating and interior trim manufacturing
336370	Motor vehicle metal stamping
336390	Other Motor Vehicle Parts Manufacturing
3363A0	Motor vehicle steering, suspension component (except spring), and brake systems manufacturing
336411	Aircraft manufacturing
336412	Aircraft engine and engine parts manufacturing
336413	Other aircraft parts and auxiliary equipment manufacturing
336414	Guided missile and space vehicle manufacturing
33641A	Propulsion units and parts for space vehicles and guided missiles
336500	Railroad rolling stock manufacturing
336611	Ship building and repairing
336612	Boat building
336991	Motorcycle, bicycle, and parts manufacturing
336992	Military armored vehicle, tank, and tank component manufacturing
336999	All other transportation equipment manufacturing
337110	Wood kitchen cabinet and countertop manufacturing
337121	Upholstered household furniture manufacturing
337122	Nonupholstered wood household furniture manufacturing
337127	Institutional furniture manufacturing
33712N	Other household nonupholstered furniture
337215	Showcase, partition, shelving, and locker manufacturing
33721A	Office furniture and custom architectural woodwork and millwork manufacturing
337900	Other furniture related product manufacturing
339112	Surgical and medical instrument manufacturing
339113	Surgical appliance and supplies manufacturing
339114	Dental equipment and supplies manufacturing
339115	Ophthalmic goods manufacturing
339116	Dental laboratories
339910	Jewelry and silverware manufacturing
339920	Sporting and athletic goods manufacturing
339930	Doll, toy, and game manufacturing

339940	Office supplies (except paper) manufacturing		
339950	Sign manufacturing		
339990	All other miscellaneous manufacturing		
311111	Dog and cat food manufacturing		
311119	Other animal food manufacturing		
311210	Flour milling and malt manufacturing		
311221	Wet corn milling		
311225	Fats and oils refining and blending		
311224	Soybean and other oilseed processing		
311230	Breakfast cereal manufacturing		
311300	Sugar and confectionery product manufacturing		
311410	Frozen food manufacturing		
311420	Fruit and vegetable canning, pickling, and drying		
311513	Cheese manufacturing		
311514	Dry, condensed, and evaporated dairy product manufacturing		
31151A	Fluid milk and butter manufacturing		
311520	Ice cream and frozen dessert manufacturing		
311615	Poultry processing		
31161A	Animal (except poultry) slaughtering, rendering, and processing	NONDURABLE GOODS	II05
311700	Seafood product preparation and packaging		
311810	Bread and bakery product manufacturing		
3118A0	Cookie, cracker, pasta, and tortilla manufacturing		
311910	Snack food manufacturing		
311920	Coffee and tea manufacturing		
311930	Flavoring syrup and concentrate manufacturing		
311940	Seasoning and dressing manufacturing		
311990	All other food manufacturing		
312110	Soft drink and ice manufacturing		
312120	Breweries		
312130	Wineries		
312140	Distilleries		
312200	Tobacco product manufacturing		
313100	Fiber, yarn, and thread mills		
313200	Fabric mills		

313300	Textile and fabric finishing and fabric coating mills
314110	Carpet and rug mills
314120	Curtain and linen mills
314900	Other textile product mills
315000	Apparel manufacturing
316000	Leather and allied product manufacturing
322110	Pulp mills
322120	Paper mills
322130	Paperboard mills
322210	Paperboard container manufacturing
322220	Paper Bag and Coated and Treated Paper Manufacturing
322230	Stationery product manufacturing
322291	Sanitary paper product manufacturing
322299	All other converted paper product manufacturing
323110	Printing
323120	Support activities for printing
324110	Petroleum refineries
324121	Asphalt paving mixture and block manufacturing
324122	Asphalt shingle and coating materials manufacturing
324190	Other petroleum and coal products manufacturing
325110	Petrochemical manufacturing
325120	Industrial gas manufacturing
325130	Synthetic dye and pigment manufacturing
325180	Other Basic Inorganic Chemical Manufacturing
325190	Other basic organic chemical manufacturing
325211	Plastics material and resin manufacturing
3252A0	Synthetic rubber and artificial and synthetic fibers and filaments manufacturing
325411	Medicinal and botanical manufacturing
325412	Pharmaceutical preparation manufacturing
325413	In-vitro diagnostic substance manufacturing
325414	Biological product (except diagnostic) manufacturing
325310	Fertilizer manufacturing
325320	Pesticide and other agricultural chemical manufacturing
325510	Paint and coating manufacturing

325520	Adhesive manufacturing		
325610	Soap and cleaning compound manufacturing		
325620	Toilet preparation manufacturing		
325910	Printing ink manufacturing		
3259A0	All other chemical product and preparation manufacturing		
326110	Plastics packaging materials and unlaminated film and sheet manufacturing		
326120	Plastics pipe, pipe fitting, and unlaminated profile shape manufacturing		
326130	Laminated plastics plate, sheet (except packaging), and shape manufacturing		
326140	Polystyrene foam product manufacturing		
326150	Urethane and other foam product (except polystyrene) manufacturing		
326160	Plastics bottle manufacturing		
326190	Other plastics product manufacturing		
326210	Tire manufacturing		
326220	Rubber and plastics hoses and belting manufacturing		
326290	Other rubber product manufacturing		
423100	Motor vehicle and motor vehicle parts and supplies		
423400	Professional and commercial equipment and supplies		
423600	Household appliances and electrical and electronic goods		
423800	Machinery, equipment, and supplies		
423A00	Other durable goods merchant wholesalers	WHOLESALE TRADE	II06
424200	Drugs and druggists' sundries		
424700	Petroleum and petroleum products		
424A00	Other nondurable goods merchant wholesalers		
425000	Wholesale electronic markets and agents and brokers		
4200ID	Customs duties		
424400	Grocery and related product wholesalers	GROCERY AND RELATED PRODUCT WHOLESALERS	II07
441000	Motor vehicle and parts dealers		
452000	General merchandise stores	RETAIL TRADE	II08
444000	Building material and garden equipment and supplies dealers		
446000	Health and personal care stores		

447000	Gasoline stations		
448000	Clothing and clothing accessories stores		
454000	Nonstore retailers		
4B0000	All other retail		
445000	Food and beverage stores	FOOD AND BEVERAGE STORES	II09
481000	Air transportation	OTHER TRANSPORTATION AND WAREHOUSING	II10
482000	Rail transportation		
483000	Water transportation		
485000	Transit and ground passenger transportation		
486000	Pipeline transportation		
48A000	Scenic and sightseeing transportation and support activities for transportation		
492000	Couriers and messengers		
493000	Warehousing and storage		
484000	Truck transportation	TRUCK TRANSPORTATION	II11
511110	Newspaper publishers	INFORMATION	II12
511120	Periodical Publishers		
511130	Book publishers		
5111A0	Directory, mailing list, and other publishers		
511200	Software publishers		
512100	Motion picture and video industries		
512200	Sound recording industries		
515100	Radio and television broadcasting		
515200	Cable and other subscription programming		
517110	Wired telecommunications carriers		
517210	Wireless telecommunications carriers (except satellite)		
517A00	Satellite, telecommunications resellers, and all other telecommunications		
518200	Data processing, hosting, and related services		
519130	Internet publishing and broadcasting and Web search portals		
5191A0	News syndicates, libraries, archives and all other information services		
522A00	Nondepository credit intermediation and related activities	FINANCE, INSURANCE, REAL ESTATE AND RENTAL AND LEASING	
52A000	Monetary authorities and depository credit intermediation		

523900	Other financial investment activities		
523A00	Securities and commodity contracts intermediation and brokerage		
524113	Direct life insurance carriers		
5241XX	Insurance carriers, except direct life		
524200	Insurance agencies, brokerages, and related activities		
525000	Funds, trusts, and other financial vehicles		
531HSO	Owner-occupied housing		
531HST	Tenant-occupied housing		
531ORE	Other real estate		II13
532100	Automotive equipment rental and leasing		
532400	Commercial and industrial machinery and equipment rental and leasing		
532A00	General and consumer goods rental		
533000	Lessors of nonfinancial intangible assets		
541100	Legal services		
541511	Custom computer programming services		
541512	Computer systems design services		
54151A	Other computer related services, including facilities management		
541200	Accounting, tax preparation, bookkeeping, and payroll services		
541300	Architectural, engineering, and related services		
541610	Management consulting services		
5416A0	Environmental and other technical consulting services		
541700	Scientific research and development services	PROFESSIONAL	
541800	Advertising, public relations, and related services	AND	II14
541400	Specialized design services	BUSINESS SERVICES	
541920	Photographic services		
541940	Veterinary services		
5419A0	All other miscellaneous professional, scientific, and technical services		
550000	Management of companies and enterprises		
561300	Employment services		
561700	Services to buildings and dwellings		
561100	Office administrative services		
561200	Facilities support services		

561400	Business support services		
561500	Travel arrangement and reservation services		
561600	Investigation and security services		
561900	Other support services		
562000	Waste management and remediation services		
611100	Elementary and secondary schools		
611A00	Junior colleges, colleges, universities, and professional schools	EDUCATIONAL SERVICES	II15
611B00	Other educational services		
621100	Offices of physicians		
621200	Offices of dentists		
621300	Offices of other health practitioners		
621400	Outpatient care centers		
621500	Medical and diagnostic laboratories	OTHER	
621600	Home health care services	HEALTH CARE	
621900	Other ambulatory health care services	AND	II16
622000	Hospitals	SOCIAL	
623A00	Nursing and community care facilities	ASSISTANCE	
623B00	Residential mental health, substance abuse, and other residential care facilities		
624100	Individual and family services		
624A00	Community food, housing, and other relief services, including rehabilitation services		
624400	Child day care services	CHILD DAY CARE SERVICES	II17
711100	Performing arts companies		
711200	Spectator sports		
711500	Independent artists, writers, and performers		
711A00	Promoters of performing arts and sports and agents for public figures	ARTS, ENTERTAINMENT, AND RECREATION	II18
712000	Museums, historical sites, zoos, and parks		
713100	Amusement parks and arcades		
713200	Gambling industries (except casino hotels)		
713900	Other amusement and recreation industries		
721000	Accommodation	ACCOMMODATION	II19
722110	Full-service restaurants	FOOD	II20
722211	Limited-service restaurants	SERVICES	

722A00	All other food and drinking places		
811100	Automotive repair and maintenance		
811200	Electronic and precision equipment repair and maintenance		
811300	Commercial and industrial machinery and equipment repair and maintenance		
811400	Personal and household goods repair and maintenance		
812100	Personal care services	OTHER SERVICES,	
812200	Death care services	EXCEPT	II21
812300	Dry-cleaning and laundry services	GOVERNMENT	
812900	Other personal services		
813100	Religious organizations		
813A00	Grantmaking, giving, and social advocacy organizations		
813B00	Civic, social, professional, and similar organizations		
814000	Private households		
S00500	Federal general government (defense)		
S00600	Federal general government (nondefense)		
491000	Postal service		
S00102	Other federal government enterprises		
GSLGE	State and local government educational services		
GSLGH	State and local government hospitals and health services	GOVERNMENT	
GSLGO	State and local government other services	SERVICE	II22
S00201	State and local government passenger transit		
S00203	Other state and local government enterprises		

Appendix A Table 4. Industry Aggregation Bridge

8. Appendix B: GAMS Code for the Philadelphia CGE Model

```
$TITLE PHILLY CGE MODEL

OPTION solprint = off;

**********************************

* THE SOCIAL ACCOUNTING MATRIX FOR PHILLY IN 2016

**********************************

*=== All account

SET ac
/SEC1,SEC2,SEC3,SEC4,SEC5,SEC6,SEC7,SEC8,SEC9,SEC10,SEC11,SEC12,SEC13,SEC14,SEC15,SEC16,SEC17,SEC18,SEC19,SEC20,SEC21,SEC22,L,K,H1,H2,H3,H4,CORP,FGV,SGV,LGV,FSTX,LOTX,WAGETX,PROTX,SUGTX,INV,SV,SA,RUS,ROW,TOTAL/;

*=== Production activity account

SET a(ac)
/SEC1,SEC2,SEC3,SEC4,SEC5,SEC6,SEC7,SEC8,SEC9,SEC10,SEC11,SEC12,SEC13,SEC14,SEC15,SEC16,SEC17,SEC18,SEC19,SEC20,SEC21,SEC22/;

*=== Labor account and capital account

SET f(ac) /L,K/;

*=== Household account

SET h(ac) /H1,H2,H3,H4/;

*=== All account except total

SET acnt(ac)

/SEC1,SEC2,SEC3,SEC4,SEC5,SEC6,SEC7,SEC8,SEC9,SEC10,SEC11,SEC12,SEC13,SEC14,SEC15,SEC16,SEC17,SEC18,SEC19,SEC20,SEC21,SEC22,L,K,H1,H2,H3,H4,CORP,FGV,SGV,LGV,FSTX,LOTX,WAGETX,PROTX,SUGTX,INV,SV,SA,RUS,ROW /;


acnt(ac)=Yes;

acnt('TOTAL')=NO;

alias(ac,acp);

alias(a,ap);

alias(f,fp);

alias(h,hp);

alias(acnt,acntp);


*=== Import from Excel using GDX utilities

*=== First unload to GDX file (occurs during compilation phase)

$CALL GDXXRW.EXE Philly2016.xlsx PAR=SAM RNG=PHILLY!A1:AR44

*=== Now import data from GDX
```

```
PARAMETER SAM(ac,acp);
$GDXIN Philly2016.GDX
$LOAD SAM
$GDXIN
DISPLAY SAM;

**********************************
********** Balance Check **********
**********************************
PARAMETERS
SAMCHK(ac);
SAMCHK(acp)=sum(ac,SAM(acp,ac))-SUM(ac,SAM(ac,acp));
DISPLAY SAMCHK;

************************************
***** SUBSTITUTION ELASTICITIES ***
************************************
*==== Detail calculation in Excel file : Elasticity-from GRAP 9 (GTAP 2016 VERSION)
PARAMETER
*==== Substitution Elasticity between intermediate inputs and value added = 1/(1-rhoAa(a))
rhoAa(a) /SEC1=-3.405, SEC2=0.206, SEC3=0.405, SEC4=0.206, SEC5=0.156, SEC6=0.206,
      SEC7=0.206, SEC8=0.206, SEC9=0.206, SEC10=0.405, SEC11=0.405, SEC12=0.206,
      SEC13=0.206, SEC14=0.206, SEC15=0.206, SEC16=0.206, SEC17=0.206,SEC18=0.206,
      SEC19=0.206, SEC20=0.206, SEC21=0.206, SEC22=0.206/
*====  Substitution Elasticity between primary factors = 1/(1-rhoVA(a))
rhoVA(a) /SEC1=-3.405, SEC2=0.206, SEC3=0.405, SEC4=0.206, SEC5=0.156, SEC6=0.206,
      SEC7=0.206, SEC8=0.206, SEC9=0.206, SEC10=0.405, SEC11=0.405, SEC12=0.206,
      SEC13=0.206, SEC14=0.206, SEC15=0.206, SEC16=0.206, SEC17=0.206,SEC18=0.206,
      SEC19=0.206, SEC20=0.206, SEC21=0.206, SEC22=0.206/
*====  Substitution Elasticity between domestic and imported goods in the Arimington
*====  = 1/(1-rhoQq(c))
rhoQq(a) /SEC1=0.732, SEC2=0.643, SEC3=0.474, SEC4=0.733, SEC5=0.68, SEC6=0.474,
      SEC7=0.474, SEC8=0.474,SEC9=0.474, SEC10=0.474, SEC11=0.474, SEC12=0.474,
      SEC13=0.474, SEC14=0.474, SEC15=0.474, SEC16=0.474, SEC17=0.474,
      SEC18=0.474, SEC19=0.474, SEC20=0.474, SEC21=0.474, SEC22=0.474/;
```

```
*************************************************************************
********************** PARAMETER CALIBRATION ***************************
*************************************************************************

************************************
******* PRODUCTION   ACCOUNT *****
************************************
PARAMETERS
PA0(a)      TOTAL PRODUCTION PRICE OF DOMESTIC PRODUCTION ACTIVITY A
QA0(a)      TOTAL PRODUCTION AMOUNT OF DOMESTIC PRODUCTION ACTIVITY A
PVA0(a)     TOTAL VALUE ADDED PRICE OF PRODUCTION ACTIVITY A
QVA0(a)     TOTAL VALUE ADDED AMOUNT OF PRODUCTION ACTIVITY A
WL0         LABOR PRICE
WK0         CAPITAL PRICE
QLD0(a)     LABOR DEMAND OF SECTOR A
QKD0(a)     CAPITAL DEMAND OF SECTOR A
PM0(a)      IMPORTED PRODUCTION ACTIVITY A PRICE (FROM ROW AND RUS)
QM0(a)      IMPORTED PRODUCTION ACTIVITY A AMOUNT (FROM ROW AND RUS)
PQ0(a)      TOTAL PRODUCTION PRICE
QQ0(a)      TOTAL PRODUCTION AMOUNT
PINTA0(a)   TOTAL INTERMEDIATE INPUT PRICE OF PRODUCTION ACTIVITY A
QINT0(a,ap) INTERMEDIATE INPUT AMOUNT
QINTA0(a)   TOTAL INTERMEDIATE INPUT AMOUNT OF PRODUCTION ACTIVITY A
EXR0        EXCHANGE RATE
pwm(a)      INTERNATIONAL PRICE OF COMMODITY C
pwe(a)      INTERNATIONAL PRICE OF PRODUCTION ACTIVITY A
PE0(a)      EXPORT PRICE OF PRODUCTION ACTIVITY A
QE0(a)      EXPORT AMOUNT OF PRODUCTION ACTIVITY A
;
PA0(a)=1;
QA0(a)=(sam('TOTAL',a)-sam('ROW',a)-sam('RUS',a))/PA0(a);
PVA0(a)=1;
QVA0(a)=(sum(f,sam(f,a))+sam('PROTX',a))/PVA0(a);
WL0=1;
WK0=1;
QLD0(a)=sam('L',a)/WL0;
```

```
QKD0(a)=sam('K',a)/WK0;
PM0(a)=1;
QM0(a)=(sam('ROW',a)+sam('RUS',a))/PM0(a);
PQ0(a)=1;
QQ0(a)=QM0(a)+QA0(a);
PINTA0(a)=1;
QINT0(a,ap)=sam(a,ap)/PQ0(a);
QINTA0(ap)=sum(a,QINT0(a,ap));
PE0(a)=1;
QE0(a)=(sam(a,'ROW')+sam(a,'RUS'))/PE0(a);
EXR0=1;
pwm(a)=PM0(a)/EXR0;
pwe(a)=PE0(a)/EXR0;

************************************
******** DIFFERENT TAX RATES ******
************************************
PARAMETERS
tFSTX(a)    FEDERAL AND STATE TAX RATE FOR PRODUCTION ACTIVITY A
tLOTX(a)    LOCAL TAX RATE FOR PRODUCTION ACTIVITY A
tvak(a)     PROPERTY TAX FOR CAPITAL
SUGTX0(a)    SUGAR TAX FOR PRODUCTION ACTIVITY A
tSUGTX0(a)   SUGAR TAX RATE FOR PRODUCTION ACTIVITY A
;
tFSTX(ap)=sam('FSTX',ap)/(sum(a,sam(a,ap))+sum(f,sam(f,ap))+sam('PROTX',ap));
tLOTX(ap)=sam('LOTX',ap)/(sum(a,sam(a,ap))+sum(f,sam(f,ap))+sam('PROTX',ap));
tvak(a)=sam('PROTX',a)/sam('K',a);
SUGTX0(ap)=sam('SUGTX',ap);
tSUGTX0(ap)=SUGTX0(ap)/(sum(a,sam(a,ap))+sum(f,sam(f,ap))+sam('PROTX',ap));

************************************
**** PRIMARY FACTOR ACCOUNT  ****
************************************
PARAMETERS
QLRUS0   LABOR SUPPLY FROM OUTSIDE OF PHILLY (RUS)
QLS0     TOTAL LABOR SUPPLY
```

```
QKS0     TOTAL CAPITAL SUPPLY
;
QLRUS0=sam('L','RUS')/WL0;
QLS0=sam('TOTAL','L')/WL0;
QKS0=sam('TOTAL','K')/WK0;

****************************************
** PRODUCTION FUNCTION PARAMETER **
****************************************
PARAMETERS
deltaAa(a)   SHARE IN CES FUNCTION OF QA
scaleAa(a)   SCALE IN CES FUNCTION OF QA (TOTAL DOMESTIC PRODUCTION INCLUDING VALUE ADDED AND INTERMEDIATE PRODUCTION)
deltaVA(a)   SHARE IN CES FUNCTION OF VA
scaleVA(a)   SCALE IN CES FUNCTION OF VA (TOTAL VALUE ADDED INCLUDING LABOR AND CAPITAL)
deltaQQ(a)   SHARE IN ARMINTON FUNCTION OF QQ
scaleQQ(a)   SCALE IN ARMINTON FUNCTION OF QQ (TOTAL COMMODITY INCLUDING IMPORTS AND SELF PRODUCE AND SOLD )
ica(a,ap)    I-O COEFFICIENT FOR INTERMEDIATE INPUT
;
*==== CES FUNCTION CALIBRATION BETWEEN VALUE ADDED AND INTERMEDIATE INPUT
deltaAa(a)=PVA0(a)*QVA0(a)**(1-rhoAa(a))/(PVA0(a)*QVA0(a)**(1-rhoAa(a))+PINTA0(a)*QINTA0(a)**(1-rhoAa(a)));
scaleAa(a)=QA0(a)/(deltaAa(a)*QVA0(a)**rhoAa(a)+(1-deltaAa(a))*QINTA0(a)**rhoAa(a))**(1/rhoAa(a));
*==== CES FUNCTION CALIBRATION BETWEEN LABOR AND CAPITAL
deltaVA(a)=WL0*QLD0(a)**(1-rhoVA(a))/(WL0*QLD0(a)**(1-rhoVA(a))+((1+tvak(a))*WK0)*QKD0(a)**(1-rhoVA(a)));
scaleVA(a)=QVA0(a)/(deltaVA(a)*QLD0(a)**rhoVA(a)+(1-deltaVA(a))*QKD0(a)**rhoVA(a))**(1/rhoVA(a));
*==== ARMINTON FUNCTION CALIBRATION BETWEEN DOMESTIC COMMODITY AND IMPORT COMMODITY
deltaQQ(a)=PA0(a)*QA0(a)**(1-rhoQq(a))/(PA0(a)*QA0(a)**(1-rhoQq(a))+PM0(a)*QM0(a)**(1-rhoQq(a)));
scaleQQ(a)=QQ0(a)/(deltaQQ(a)*QA0(a)**rhoQq(a)+(1-deltaQQ(a))*QM0(a)**rhoQq(a))**(1/rhoQq(a));
ica(a,ap)=QINT0(a,ap)/QINTA0(ap);

****************************************
*** GOVERNMENT TRANSFER PARAMETER ***
****************************************
PARAMETERS
transfrHFGV0(h)  HOUSEHOLD H REVENUE FROM FEDERAL TRANSFER
```

```
transfrHSGV0(h)  HOUSEHOLD H REVENUE FROM STATE TRANSFER
transfrHLGV0(h)  HOUSEHOLD H REVENUE FROM LOCAL TRANSFER
transfrHENT0(h)  HOUSEHOLD H REVENUE FROM CORPORATE TRANSFER
transfrLGVFGV0   LOCAL GOVERNMENT REVENUE FROM FEDERAL TRANSFER
transfrLGVSGV0   LOCAL GOVERNMENT REVENUE FROM STATE TRANSFER
transfrLGVLGV0   LOCAL GOVERNMENT REVENUE FROM OTHER LOCAL GOVERNMENT TRANSFER
;
transfrHFGV0(h)=sam(h,'FGV');
transfrHSGV0(h)=sam(h,'SGV');
transfrHLGV0(h)=sam(h,'LGV');
transfrHENT0(h)=sam(h,'CORP');
transfrLGVFGV0=sam('LGV','FGV');
transfrLGVSGV0=sam('LGV','SGV');
transfrLGVLGV0=sam('LGV','LGV');

****************************************
******* PRIMARY FACTOR SHARE  *******
****************************************
PARAMETERS
shifhl(h)  HOUSEHOLD H SHARE IN LABOR ENDOWMENT
shifhk(h)  HOUSEHOLD H SHARE IN CAPITAL ENDOWMENT
shifentk   CORPORATE REVENUE SHARE IN CAPITAL ENDOWMENT
shifsgvk   STATE GOVERNMENT REVENUE SHARE IN CAPITAL ENDOWMENT
shiflgvk   LOCAL GOVERNMENT REVENUE SHARE IN CAPITAL ENDOWMENT
;
shifhl(h)=(sam(h,'L')/WL0)/QLS0;
shifhk(h)=(sam(h,'K')/WK0)/QKS0;
shifentk=(sam('CORP','K')/WK0)/QKS0;
shifsgvk=(sam('SGV','K')/WK0)/QKS0;
shiflgvk=(sam('LGV','K')/WK0)/QKS0;

****************************************
**** FEDERAL AND STATE TAX SHARE ****
****************************************
PARAMETERS
shiffgvFSTX    FEDERAL GOVERNMENT SHARE IN FSTX (FEDERAL AND STATE TAX)
```

```
shifsgvFSTX    STATE GOVERNMENT SHARE IN FSTX (FEDERAL AND STATE TAX)
;
shiffgvFSTX=sam('FGV','FSTX')/sam('TOTAL','FSTX');
shifsgvFSTX=sam('SGV','FSTX')/sam('TOTAL','FSTX');

****************************************
********* HOUSEHOLD ACCOUNT *********
****************************************
PARAMETERS
YH0(h)   HOUSEHOLD H REVENUE
YHAGG0   TOTAL HOUSEHOLD REVENUE
tiFSTX(h)   FEDERAL AND STATE TAX RATE FOR HOUSEHOLD H
tiWAGETX(h) WAGE TAX RATE FOR HOUSEHOLD H
tiPROTX(h)  PROPERTY TAX RATE FOR HOUSEHOLD H
mpc(h)   COMMODITY CONSUMPTION SHARE IN HOUSEHOLD H DISPOSABLE INCOME
EH0(h)   TOTAL HOUSEHOLD H CONSUMPTION
QH0(a,h) HOUSEHOLD H DEMAND(CONSUMPTION) OF PRODUCTION ACTIVITY A
;
YH0(h)=shifhl(h)*WL0*QLS0+shifhk(h)*WK0*QKS0+transfrHFGV0(h)+transfrHSGV0(h)+transfrHLGV0(h)+t
ransfrHENT0(h);
YHAGG0=sum(h,YH0(h));
tiFSTX(h)=sam('FSTX',h)/YH0(h);
tiWAGETX(h)=sam('WAGETX',h)/YH0(h);
tiPROTX(h)=sam('PROTX',h)/YH0(h);
mpc(h)=sum(a,sam(a,h))/((1-tiFSTX(h)-tiWAGETX(h)-tiPROTX(h))*YH0(h));
EH0(h)=mpc(h)*(1-tiFSTX(h)-tiWAGETX(h)-tiPROTX(h))*YH0(h);
QH0(a,h)=sam(a,h)/PQ0(a);

*********************************************
** COMMODITY CONSUMPTION PARAMETER **
*********************************************
PARAMETER
shrh(a,h)   SHARE OF PRODUCTION ACTIVITY A CONSUMPTION IN HOUSEHOLD H REVENUE
;
shrh(a,h)=(QH0(a,h)*PQ0(a))/EH0(h);

****************************************
```

```
********* CORPORATE ACCOUNT *********
****************************************
PARAMETERS
YENT0    CORPORATE REVENUE
tiFSTXENT   FEDERAL AND STATE TAX RATE FOR CORPORATE
tiLOTXENT   LOCAL TAX RATE FOR CORPORATE
ENTSAV0  CORPORATE SAVING
;
YENT0=shifentk*WK0*QKS0;
tiFSTXENT=sam('FSTX','CORP')/YENT0;
tiLOTXENT=sam('LOTX','CORP')/YENT0;
ENTSAV0=(1-tiFSTXENT-tiLOTXENT)*YENT0-sum(h,transfrHENT0(h));

****************************************
******** GOVERNMENT ACCOUNT *********
****************************************
PARAMETERS
WAGERUS0   WAGE TAX FROM PEOPLE WORK IN PHL BUT LIVE OUTSIDE OF PHL (RUS)
YFGV0     FEDERAL GOVERNMENT REVENUE
YSGV0     STATE GOVERNMENT REVENUE
YLGV0     LOCAL GOVERNMENT REVENUE
EFGV0     FEDERAL GOVERNMENT EXPENDITURE
ESGV0     STATE GOVERNMENT EXPENDITURE
ELGV0     LOCAL GOVERNMENT EXPENDITURE
FGVSAV0    FEDERAL GOVERNMENT SAVING
SGVSAV0    STATE GOVERNMENT SAVING
LGVSAV0    LOCAL GOVERNMENT SAVING
QFGV0(a)   FEDERAL GOVERNMENT DEMAND(CONSUMPTION) OF COMMODITY C
QSGV0(a)   STATE GOVERNMENT DEMAND(CONSUMPTION) OF COMMODITY C
QLGV0(a)   LOCAL GOVERNMENT DEMAND(CONSUMPTION) OF COMMODITY C
;
WAGERUS0=sam('WAGETX','RUS');
YFGV0=shiffgvFSTX*(sum(h,tiFSTX(h)*YH0(h))+tiFSTXENT*YENT0+sum(a,sam('FSTX',a)));
YSGV0=shifsgvFSTX*(sum(h,tiFSTX(h)*YH0(h))+tiFSTXENT*YENT0+sum(a,sam('FSTX',a)))+shifsgvk*WK0*Q
KS0;
```

```
YLGV0=tiLOTXENT*YENT0+sum(a,sam('LOTX',a))+shiflgvk*WK0*QKS0+transfrLGVFGV0+transfrLGVSGV0+t
ransfrLGVLGV0+sum(h,(tiPROTX(h)+tiWAGETX(h))*YH0(h))+sum(a,tvak(a)*WK0*QKD0(a))+WAGERUS0+s
um(a,sam('SUGTX',a)*0.674);

FGVSAV0=sam('SA','FGV');

SGVSAV0=sam('SA','SGV');

LGVSAV0=sam('SA','LGV');

EFGV0=YFGV0-FGVSAV0;

ESGV0=YSGV0-SGVSAV0;

ELGV0=YLGV0-LGVSAV0;

QFGV0(a)=sam(a,'FGV')/PQ0(a);

QSGV0(a)=sam(a,'SGV')/PQ0(a);

QLGV0(a)=sam(a,'LGV')/PQ0(a);


****************************************

******* SAVING AND INVESTMENT *******

****************************************

PARAMETERS

QSV0(a)    STOCK VARIARTION OF COMMODITY C

QINV0(a)   INVESTMENT OF COMMODITY C IN FINAL DEMAND

QSUG0(a)    SUGAR TAX DISTRIBUTION

EINV0      TOTAL INVESTMENT

FSAV0      FOREGIN SAVING

;

QSV0(a)=sam(a,'SV')/PQ0(a);

QINV0(a)=sam(a,'INV')/PQ0(a);

EINV0=sum(a,QINV0(a)*PQ0(a));

QSUG0(a)=sam(a,'SUGTX')/PQ0(a);

FSAV0=sam('RUS','SA')-sam('SA','ROW');


************************************

********** GDP PRICE INDEX **********

************************************

PARAMETERS

GDP0      REAL GDP

PGDP0     GDP PRICE INDEX

;
```

```
GDP0=sum(a,sum(h,QH0(a,h))+QINV0(a)+QSV0(a)+QFGV0(a)+QSGV0(a)+QLGV0(a)+QSUG0(a)-
QM0(a))+sum(a,QE0(a));

PGDP0=(sum(a,PQ0(a)*(sum(h,QH0(a,h))+QINV0(a)+QSV0(a)+QFGV0(a)+QSGV0(a)+QLGV0(a)+QSUG0(a))-
PM0(a)*QM0(a))+sum(a,PE0(a)*QE0(a)))/GDP0;


****************************************

******* OTHER MODEL CHECKING  *******

****************************************

PARAMETERS

EFGV0chk   CHECKING FEDERAL GOVERNMENT EXPENDITURE (Should equal to 0 if correct)

ESGV0chk   CHECKING STATE GOVERNMENT EXPENDITURE (Should equal to 0 if correct)

ELGV0chk   CHECKING LOCAL GOVERNMENT EXPENDITURE (Should equal to 0 if correct)

vadded0    TOTAL VALUE ADDED

GDP0chk    CHECKING WHETHER TOTAL VALUE ADDED EQUAL TO REAL GDP

;

EFGV0chk=sum(a,sam(a,'FGV'))+transfrLGVFGV0+sum(h,transfrHFGV0(h))-EFGV0;

ESGV0chk=sum(a,sam(a,'SGV'))+transfrLGVSGV0+sum(h,transfrHSGV0(h))-ESGV0;

ELGV0chk=sum(a,sam(a,'LGV'))+transfrLGVLGV0+sum(h,transfrHLGV0(h))-ELGV0;

vadded0=sum(a,WL0*QLD0(a)+(1+tvak(a))*WK0*QKD0(a))+sum(a,(tFSTX(a)+tLOTX(a))*(PINTA0(a)*QINT
A0(a)+PVA0(a)*QVA0(a)));

GDP0chk=vadded0-PGDP0*GDP0;


****************************************

********* VARIABLE DEFINITION *********

****************************************

POSITIVE VARIABLE

PA(a)      TOTAL PRODUCTION PRICE OF DOMESTIC PRODUCTION ACTIVITY A

QA(a)      TOTAL PRODUCTION AMOUNT OF DOMESTIC PRODUCTION ACTIVITY A

PVA(a)     TOTAL VALUE ADDED PRICE OF PRODUCTION ACTIVITY A

QVA(a)     TOTAL VALUE ADDED AMOUNT OF PRODUCTION ACTIVITY A

WL         LABOR PRICE

WK         CAPITAL PRICE

QLD(a)     LABOR DEMAND OF SECTOR A

QKD(a)     CAPITAL DEMAND OF SECTOR A

PE(a)      EXPORT PRICE OF PRODUCTION ACTIVITY A

QE(a)      EXPORT AMOUNT OF PRODUCTION ACTIVITY A

PM(a)      IMPORTED PRODUCTION ACTIVITY A  PRICE (FROM ROW AND RUS)
```

QM(a) IMPORTED PRODUCTION ACTIVITY A AMOUNT (FROM ROW AND RUS)
PQ(a) TOTAL PRODUCTION PRICE
QQ(a) TOTAL PRODUCTION AMOUNT
PINTA(a) TOTAL INTERMEDIATE INPUT PRICE OF PRODUCTION ACTIVITY A
QINT(a,ap) INTERMEDIATE INPUT AMOUNT OF PRODUCTION ACTIVITY A FOR EACH COMMODITY C
QINTA(a) TOTAL INTERMEDIATE INPUT AMOUNT OF PRODUCTION ACTIVITY A
EXR EXCHANGE RATE
QLS TOTAL LABOR SUPPLY
QKS TOTAL CAPITAL SUPPLY
;

VARIABLE
YH(h) HOUSEHOLD H REVENUE
QH(a,h) HOUSEHOLD H DEMAND(CONSUMPTION) OF PRODUCTION ACTIVITY A
YENT CORPORATE REVENUE
ENTSAV CORPORATE SAVING
YFGV FEDERAL GOVERNMENT REVENUE
YSGV STATE GOVERNMENT REVENUE
YLGV LOCAL GOVERNMENT REVENUE
EFGV FEDERAL GOVERNMENT EXPENDITURE
ESGV STATE GOVERNMENT EXPENDITURE
ELGV LOCAL GOVERNMENT EXPENDITURE
FGVSAV FEDERAL GOVERNMENT SAVING
SGVSAV STATE GOVERNMENT SAVING
LGVSAV LOCAL GOVERNMENT SAVING
EINV TOTAL INVESTMENT
FSAV FOREIGN SAVING
VBIS VIRTUAL VARIABLE SHOULD BE 0 FOR CHECKING SAVING AND INVESTMENT
GDP REAL GDP
PGDP GDP PRICE INDEX
tSUGTX(a) SUGAR TAX RATE
QSUG(a) SUGAR TAX DISTRIBUTION
;

****

********* EQUATION DEFINITION *********

****

EQUATION

QAfn(a) QA CES FUNCTION

QAFOC(a) QA CES FIRST ORDER CONDITION

PAeq(a) CES PA EQUATION

QVAfn(a) QVA CES FUNCTION

QVAFOC(a) QVA CES FIRST ORDER CONDITION DELTAVA NOT EQUAL TO ONE

QVAFOCDELAT1(a) QVA CES FIRST ORDER CONDITION DELTAVA EQUAL TO ONE

PVAeq(a) CES PVA EQUATION

QINTfn(a,ap) QINT LENOTIF FUNCTION

PINTAeq(a) PINT EQUATION

PEeq(a) PE EQUATION

QQfn(a) QQ CES FUNCTION

QQFOC(a) QQ CES FIRST ORDER CONDITION

PQeq(a) CES PQ EQUATION

PMeq(a) PM EQUATION

YHeq(h) HOUSEHOLD H REVENUE EQUATION

QHeq(a,h) HOUSEHOLD H DEMAND FUNCTION OF COMMODITY C

YENTeq CORPORATE REVENUE EQUATION

ENTSAVeq CORPORATE SAVING EQUATION

EINVeq TOTAL INVESTMENT EQUATION

YFGVeq FEDERAL GOVERNMENT REVENUE EQUATION

YSGVeq STATE GOVERNMENT REVENUE EQUATION

YLGVeq LOCAL GOVERNMENT REVENUE EQUATION

EFGVeq FEDERAL GOVERNMENT EXPENDITURE EQUATION

ESGVeq STATE GOVERNMENT EXPENDITURE EQUATION

ELGVeq LOCAL GOVERNMENT EXPENDITURE EQUATION

FGVSAVeq FEDERAL GOVERNMENT SAVING EQUATION

SGVSAVeq STATE GOVERNMENT SAVING EQUATION

LGVSAVeq LOCAL GOVERNMENT SAVING EQUATION

ComEqui(a) DOMESTIC COMMODITY SUPPLY EQUAL TO DOMESTIC COMMODITY DEMAND (SYSTEM BALANCE CONDITION)

Leq LABOR MARKET EQUATION (LABOR DEMAND EQUAL TO LABOR SUPPLY)

Keq CAPITAL MARKET EQUATION (CAPITAL DEMAND EQUAL TO CAPITAL SUPPLY)

FEXeq IMPORT AND EXPORT BALANCE EQUATION

FSAVdet FOREIGN SAVING EQUATION

ISeq OTHER WAY TO CALCULATE TOTAL INVESTMENT

```
GDPeq      GDP EQUATION
PGDPeq     PRICE OF GDP EQUATION
;
QAfn(a)..
QA(a)=e=scaleAa(a)*(deltaAa(a)*QVA(a)**rhoAa(a)+(1-deltaAa(a))*QINTA(a)**rhoAa(a))**(1/rhoAa(a));

QAFOC(a)..
PVA(a)/PINTA(a)=e=(deltaAa(a)/(1-deltaAa(a)))*(QINTA(a)/QVA(a))**(1-rhoAa(a));

PAeq(a)..
PA(a)*QA(a)=e=(1+tFSTX(a)+tLOTX(a)+tSUGTX(a))*(PINTA(a)*QINTA(a)+PVA(a)*QVA(a));

QVAfn(a)..
QVA(a)=e=scaleVA(a)*(deltaVA(a)*QLD(a)**rhoVA(a)+(1-deltaVA(a))*QKD(a)**rhoVA(a))**(1/rhoVA(a));

QVAFOC(a)$(deltaVA(a) NE 1)..
WL/((1+tvak(a))*WK)=e=(deltaVA(a)/(1-deltaVA(a)))*(QKD(a)/QLD(a))**(1-rhoVA(a));

QVAFOCDELAT1(a)$(deltaVA(a)=1)..
WL/((1+tvak(a))*WK)=e=(QKD(a)/QLD(a))**(1-rhoVA(a));

PVAeq(a)..
PVA(a)*QVA(a)=e=WL*QLD(a)+(1+tvak(a))*WK*QKD(a);

QINTfn(a,ap)..
QINT(a,ap)=e=ica(a,ap)*QINTA(ap);

PINTAeq(ap)..
PINTA(ap)=e=sum(a,ica(a,ap)*PQ(a));

QQfn(a)..
QQ(a)=e=scaleQQ(a)*(deltaQQ(a)*QA(a)**rhoQq(a)+(1-deltaQQ(a))*QM(a)**rhoQq(a))**(1/rhoQq(a));

QQFOC(a)..
PA(a)/PM(a)=e=(deltaQQ(a)/(1-deltaQQ(a)))*(QM(a)/QA(a))**(1-rhoQq(a));
```

PQeq(a)..

PQ(a)*QQ(a)=e=PA(a)*QA(a)+PM(a)*QM(a);

PMeq(a)..

PM(a)=e=pwm(a)*EXR;

PEeq(a)..

PE(a)=e=pwe(a)*EXR;

YHeq(h)..

YH(h)=e=shifhl(h)*WL*QLS+shifhk(h)*WK*QKS+transfrHFGV0(h)+transfrHSGV0(h)+transfrHLGV0(h)+transfrHENT0(h);

QHeq(a,h)..

QH(a,h)*PQ(a)=e=shrh(a,h)*mpc(h)*(1-tiFSTX(h)-tiWAGETX(h)-tiPROTX(h))*YH(h);

YENTeq..

YENT=e=shifentk*WK*QKS;

ENTSAVeq..

ENTSAV=e=(1-tiFSTXENT-tiLOTXENT)*YENT-sum(h,transfrHENT0(h));

EINVeq..

EINV=e=sum(a,QINV0(a)*PQ(a));

YFGVeq..

YFGV=e=shiffgvFSTX*(sum(h,tiFSTX(h)*YH(h))+tiFSTXENT*YENT+sum(a,tFSTX(a)*(PINTA(a)*QINTA(a)+PVA(a)*QVA(a))));

YSGVeq..

YSGV=e=shifsgvFSTX*(sum(h,tiFSTX(h)*YH(h))+tiFSTXENT*YENT+sum(a,tFSTX(a)*(PINTA(a)*QINTA(a)+PVA(a)*QVA(a))))+shifsgvk*WK*QKS;

YLGVeq..

YLGV=e=tiLOTXENT*YENT+sum(a,tLOTX(a)*(PINTA(a)*QINTA(a)+PVA(a)*QVA(a)))+shiflgvk*WK*QKS+transfrLGVFGV0+transfrLGVSGV0+transfrLGVLGV0+sum(h,(tiPROTX(h)+tiWAGETX(h))*YH(h))+sum(a,tvak(a)*WK*QKD(a))+WAGERUS0+sum(a,tSUGTX(a)*(PINTA(a)*QINTA(a)+PVA(a)*QVA(a)))*0.674;

EFGVeq..

EFGV=e=sum(a,QFGV0(a)*PQ(a))+transfrLGVFGV0+sum(h,transfrHFGV0(h));

ESGVeq..

ESGV=e=sum(a,QSGV0(a)*PQ(a))+transfrLGVSGV0+sum(h,transfrHSGV0(h));

ELGVeq..

ELGV=e=sum(a,QLGV0(a)*PQ(a))+transfrLGVLGV0+sum(h,transfrHLGV0(h));

FGVSAVeq..

FGVSAV=e=YFGV-EFGV;

SGVSAVeq..

SGVSAV=e=YSGV-ESGV;

LGVSAVeq..

LGVSAV=e=YLGV-ELGV;

ComEqui(a)..

QQ(a)=e=sum(ap,QINT(a,ap))+sum(h,QH(a,h))+QINV0(a)+QSV0(a)+QFGV0(a)+QSGV0(a)+QLGV0(a)+QSUG(a)+QE(a);

Leq..

sum(a,QLD(a))+QLRUS0=e=QLS;

Keq..

sum(a,QKD(a))=e=QKS;

FSAVdet..

FSAV=e=FSAV0;

FEXeq..

sum(a,pwm(a)*QM(a))=e=sum(a,pwe(a)*QE0(a))-FSAV+WAGERUS0+QLRUS0;

ISeq..

EINV=e=sum(h,(1-mpc(h))*(1-tiFSTX(h)-tiWAGETX(h)-tiPROTX(h))*YH(h))+FGVSAV+SGVSAV+LGVSAV-FSAV*EXR-sum(a,QSV0(a))+VBIS;

```
GDPeq..
GDP=e=sum(a,sum(h,QH(a,h))+QINV0(a)+QSV0(a)+QFGV0(a)+QSGV0(a)+QLGV0(a)+QSUG(a)-
QM(a))+sum(a,QE(a));


PGDPeq..
PGDP*GDP=e=sum(a,PQ(a)*(sum(h,QH(a,h))+QINV0(a)+QSV0(a)+QFGV0(a)+QSGV0(a)+QLGV0(a)+QSUG(a))
-PM(a)*QM(a))+sum(a,PE(a)*QE(a));


****************************************
****** VARIABLE BOUND SETTING *******
****************************************
QA.lo(a)=0.0001;
PA.lo(a)=0.0001;
QA.lo(a)=0.0001;
PVA.lo(a)=0.0001;
QVA.lo(a)=0.0001;
PINTA.lo(a)=0.0001;
QINTA.lo(a)=0.0001;
QLD.lo(a)=0.0001;
QKD.lo(a)=0.0001;
PE.lo(a)=0.0001;
QE.lo(a)=0.0001;
PM.lo(a)=0.0001;
QM.lo(a)=0.0001;
PQ.lo(a)=0.0001;
QQ.lo(a)=0.0001;


****************************************
******* PRIMARY VALUE ASSIGN ********
****************************************
PA.l(a)=PA0(a);
QA.l(a)=QA0(a);
PVA.l(a)=PVA0(a);
QVA.l(a)=QVA0(a);
PINTA.l(a)=PINTA0(a);
QINTA.l(a)=QINTA0(a);
```

```
QINT.l(a,ap)=QINT0(a,ap);
QLD.l(a)=QLD0(a);
QKD.l(a)=QKD0(a);
WL.l=1;
WK.l=1;
PE.l(a)=1;
QE.fx(a)=QE0(a);
PM.l(a)=1;
QM.l(a)=QM0(a);
PQ.l(a)=1;
QQ.l(a)=QQ0(a);
EXR.l=1;
YH.l(h)=YH0(h);
QH.l(a,h)=QH0(a,h);
YENT.l=YENT0;
ENTSAV.l=ENTSAV0;
EINV.l=EINV0;
YFGV.l=YFGV0;
YSGV.l=YSGV0;
YLGV.l=YLGV0;
EFGV.l=EFGV0;
ESGV.l=ESGV0;
ELGV.l=ELGV0;
FGVSAV.l=FGVSAV0;
SGVSAV.l=SGVSAV0;
LGVSAV.l=LGVSAV0;
FSAV.l=FSAV0;
VBIS.l=0;
GDP.l=GDP0;
PGDP.l=PGDP0;

****************************************
*** NEO CLASSIC CLOSURE CONDITION ***
****************************************
QLS.fx=QLS0;
QKS.fx=QKS0;
```

```
WL.fx=1;
tSUGTX.fx(a)=tSUGTX0(a);
QSUG.fx(a)=QSUG0(a);

MODEL Philly ABOVE MODEL /all/;
SOLVE Philly using nlp minimizing VBIS;

*****************************************
**** ADDING SUGAR TAX INTO MODEL ****
*****************************************
PARAMETER

GDPOLD     TOTAL ORIGINAL GDP
ld         LABOR DEMAND
va(a)      VALUE ADDED FOR EACH SECTOR
localtx    OTHER LOCAL TAX REVENUE
wagetx     WAGE TAX REVENUE
protx      PROPERTY TAX REVENUE
hc         QUANTALITY OF HOUSEHOLD CONSUMPTION
priceq     PRICE OF GOOD
;
GDPOLD=GDP.l;
ld(a)=QLD.l(a);
va(a)=WL.l*QLD.l(a)+(1+tvak(a))*WK.l*QKD.l(a)+(tFSTX(a)+tLOTX(a)+tSUGTX.l(a))*(PINTA.l(a)*QINTA.l(a)
+PVA.l(a)*QVA.l(a));
localtx=tiLOTXENT*YENT.l+sum(a,tLOTX(a)*(PINTA.l(a)*QINTA.l(a)+PVA.l(a)*QVA.l(a)));
wagetx=sum(h,tiWAGETX(h)*YH.l(h))+WAGERUS0;
protx=sum(h,tiPROTX(h)*YH.l(h))+sum(a,tvak(a)*WK.l*QKD.l(a));
hc(a,h)=QH.l(a,h);
priceq(a)=PQ.l(a);

**79600/679722= 0.113134
tSUGTX.fx('SEC7')=tSUGTX0('SEC7')+0.113134;
**22400 is the day care funding transfered from sugar tax
QSUG.fx('SEC17')= QSUG0('SEC17')+22400;

MODEL SIM1 SIMULATION FOR ADD SUGAR TAX /all/;
```

```
SOLVE SIM1 using nlp minimizing VBIS;
*****************************************
**** ADD 0.2% of LABOR SUPPLY INCREASE****
*****************************************
PARAMETER
GDPOLD1     TOTAL GDP
ld1         LABOR DEMAND
va1(a)      VALUE ADDED FOR EACH SECTOR
localtx1    OTHER LOCAL TAX REVENUE
wagetx1     WAGE TAX REVENUE
protx1      PROPERTY TAX REVENUE
hc1         QUANTALITY OF HOUSEHOLD CONSUMPTION
priceq1     PRICE OF GOOD
;
GDPOLD1=GDP.l;
ld1(a)=QLD.l(a);
va1(a)=WL.l*QLD.l(a)+(1+tvak(a))*WK.l*QKD.l(a)+(tFSTX(a)+tLOTX(a)+tSUGTX.l(a))*(PINTA.l(a)*QINTA.l(a
)+PVA.l(a)*QVA.l(a));
localtx1=tiLOTXENT*YENT.l+sum(a,tLOTX(a)*(PINTA.l(a)*QINTA.l(a)+PVA.l(a)*QVA.l(a)));
wagetx1=sum(h,tiWAGETX(h)*YH.l(h))+WAGERUS0;
protx1=sum(h,tiPROTX(h)*YH.l(h))+sum(a,tvak(a)*WK.l*QKD.l(a));
hc1(a,h)=QH.l(a,h);
priceq1(a)=PQ.l(a);
QLS.fx=QLS0*1.002;

MODEL SIM2 SIMULATION FOR ADD 0.2% Labor Supply /all/;
SOLVE SIM2 using nlp minimizing VBIS;
*****************************************
**** ADD 0.5% of LABOR SUPPLY INCREASE****
*****************************************
PARAMETER
GDPOLD2     TOTAL GDP
ld2         LABOR DEMAND
va2(a)      VALUE ADDED FOR EACH SECTOR
localtx2    OTHER LOCAL TAX REVENUE
wagetx2     WAGE TAX REVENUE
protx2      PROPERTY TAX REVENUE
```

```
hc2        QUANTALITY OF HOUSEHOLD CONSUMPTION
priceq2    PRICE OF GOOD
;
GDPOLD2=GDP.l;
ld2(a)=QLD.l(a);
va2(a)=WL.l*QLD.l(a)+(1+tvak(a))*WK.l*QKD.l(a)+(tFSTX(a)+tLOTX(a)+tSUGTX.l(a))*(PINTA.l(a)*QINTA.l(a
)+PVA.l(a)*QVA.l(a));
localtx2=tiLOTXENT*YENT.l+sum(a,tLOTX(a)*(PINTA.l(a)*QINTA.l(a)+PVA.l(a)*QVA.l(a)));
wagetx2=sum(h,tiWAGETX(h)*YH.l(h))+WAGERUS0;
protx2=sum(h,tiPROTX(h)*YH.l(h))+sum(a,tvak(a)*WK.l*QKD.l(a));
hc2(a,h)=QH.l(a,h);
priceq2(a)=PQ.l(a);
QLS.fx=QLS0*1.005;

MODEL SIM3 SIMULATION FOR ADD 0.5% Labor Supply /all/;
SOLVE SIM3 using nlp minimizing VBIS;

PARAMETER
GDPOLD3    TOTAL GDP
ld3        LABOR DEMAND
va3(a)     VALUE ADDED FOR EACH SECTOR
localtx3   OTHER LOCAL TAX REVENUE
wagetx3    WAGE TAX REVENUE
protx3     PROPERTY TAX REVENUE
hc3        QUANTALITY OF HOUSEHOLD CONSUMPTION
priceq3    PRICE OF GOOD
;

GDPOLD3=GDP.l;
ld3(a)=QLD.l(a);
va3(a)=WL.l*QLD.l(a)+(1+tvak(a))*WK.l*QKD.l(a)+(tFSTX(a)+tLOTX(a)+tSUGTX.l(a))*(PINTA.l(a)*QINTA.l(a
)+PVA.l(a)*QVA.l(a));
localtx3=tiLOTXENT*YENT.l+sum(a,tLOTX(a)*(PINTA.l(a)*QINTA.l(a)+PVA.l(a)*QVA.l(a)));
wagetx3=sum(h,tiWAGETX(h)*YH.l(h))+WAGERUS0;
protx3=sum(h,tiPROTX(h)*YH.l(h))+sum(a,tvak(a)*WK.l*QKD.l(a));
hc3(a,h)=QH.l(a,h);
priceq3(a)=PQ.l(a);
```

```
Execute_Unload 'result.gdx'

Execute 'Gdxxrw  result.gdx O = result.xls par = GDPOLD Rng =Sheet1!a1';
Execute 'Gdxxrw  result.gdx O = result.xls par = GDPOLD1 Rng =Sheet1!a2';
Execute 'Gdxxrw  result.gdx O = result.xls par = GDPOLD2 Rng =Sheet1!a3';
Execute 'Gdxxrw  result.gdx O = result.xls par = GDPOLD3 Rng =Sheet1!a4';
Execute 'Gdxxrw  result.gdx O = result.xls par = ld Rng = Sheet2!a1:z1';
Execute 'Gdxxrw  result.gdx O = result.xls par = ld1 Rng = Sheet3!a2:z2';
Execute 'Gdxxrw  result.gdx O = result.xls par = ld2 Rng = Sheet4!a3:z3';
Execute 'Gdxxrw  result.gdx O = result.xls par = ld3 Rng = Sheet5!a4:z4';
Execute 'Gdxxrw  result.gdx O = result.xls par = va Rng = Sheet6!a1:z1';
Execute 'Gdxxrw  result.gdx O = result.xls par = va1 Rng = Sheet7!a2:z2';
Execute 'Gdxxrw  result.gdx O = result.xls par = va2 Rng = Sheet8!a3:z3';
Execute 'Gdxxrw  result.gdx O = result.xls par = va3 Rng = Sheet9!a4:z4';
Execute 'Gdxxrw  result.gdx O = result.xls par = localtx Rng =Sheet10!a1';
Execute 'Gdxxrw  result.gdx O = result.xls par = localtx1 Rng =Sheet10!a2';
Execute 'Gdxxrw  result.gdx O = result.xls par = localtx2 Rng =Sheet10!a3';
Execute 'Gdxxrw  result.gdx O = result.xls par = localtx3 Rng =Sheet10!a4';
Execute 'Gdxxrw  result.gdx O = result.xls par = wagetx Rng =Sheet11!a1';
Execute 'Gdxxrw  result.gdx O = result.xls par = wagetx1 Rng =Sheet11!a2';
Execute 'Gdxxrw  result.gdx O = result.xls par = wagetx2 Rng =Sheet11!a3';
Execute 'Gdxxrw  result.gdx O = result.xls par = wagetx3 Rng =Sheet11!a4';
Execute 'Gdxxrw  result.gdx O = result.xls par = protx Rng =Sheet12!a1';
Execute 'Gdxxrw  result.gdx O = result.xls par = protx1 Rng =Sheet12!a2';
Execute 'Gdxxrw  result.gdx O = result.xls par = protx2 Rng =Sheet12!a3';
Execute 'Gdxxrw  result.gdx O = result.xls par = protx3 Rng =Sheet12!a4';
Execute 'Gdxxrw  result.gdx O = result.xls par = hc Rng =Sheet13!a1:z23';
Execute 'Gdxxrw  result.gdx O = result.xls par = hc1 Rng =Sheet14!a1:z23';
Execute 'Gdxxrw  result.gdx O = result.xls par = hc2 Rng =Sheet15!a1:z23';
Execute 'Gdxxrw  result.gdx O = result.xls par = hc3 Rng =Sheet16!a1:z23';
Execute 'Gdxxrw  result.gdx O = result.xls par = priceq Rng = Sheet17!a1:z1';
Execute 'Gdxxrw  result.gdx O = result.xls par = priceq1 Rng = Sheet18!a1:z1';
Execute 'Gdxxrw  result.gdx O = result.xls par = priceq2 Rng = Sheet19!a1:z1';
Execute 'Gdxxrw  result.gdx O = result.xls par = priceq3 Rng = Sheet20!a1:z1';
```