Export constraint and domestic fiscal reform: lessons from 2011 subsidy reform in Iran*

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Abstract

This paper uses the 1987–2011 Household Budget Surveys from the Statistical Center of Iran consisting of 293,953 observations, coupled with the price data from the Central Bank of Iran, to estimate the structure of demand for goods and services in urban areas of Iran. The estimation procedure assumes a Quadratic Almost Ideal Demand System (QUAIDS) introduced by Banks *et al.* (1997). It then uses the estimated demand system to study the implications of the removal of the massive subsidies on energy and basic foodstuff that were in place in Iran at the end of 2010. It examines the changes in the economy's consumption patterns, income distribution, private and social welfare, and the environment. The paper's key contribution is to recognize and study how the results of this domestic reform depended on international trade barriers faced by the country. It shows how a seemingly welfare improving policy in the absence of export restrictions turned out to be quite the opposite—at least for the current generations of Iranians.

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1 Introduction

Economists are, as a rule, against government policies that intervene with the working of competitive price systems. When it comes to redistributive policies, however, some degree of price distortion often becomes necessary. Barring specific preference structures that imply uniform commodity taxes,[1] which are almost always rejected by the data, relative consumer prices of goods differ from relative marginal costs. The exact nature and the rules that govern this differentiation are extensively studied in the literature on optimal taxation. The need for distortionary taxation arises because governments have to raise revenues for financing of their projects, redistributive and otherwise, but lack revenue sources that can be tapped without creating distortions.

To a great extent, energy exporting countries appear to be able to skirt around this revenue raising problem. They have a huge source of revenue in terms of an existing asset to finance their projects and need not resort to distortionary taxation for this purpose—at least not to the extent that other countries do.[2] Yet these countries have managed to distort their prices in another fashion. Typically, they sell energy products at extremely low prices to their citizens with the idea that their poor cannot afford world-market prices. Additionally, at times, they also sell foodstuff at subsidized prices.

One country which has recently tried to break away from this trend and end its price subsidies is Iran. This paper studies the implications of this reform for the Iranian economy with respect to consumption patterns, income distribution, private and social welfare, and the environment. One key contribution of the paper is to recognize and examine how the results of this domestic reform ended up to depend on international trade barriers. In the case of Iran, the problem has been the severe international sanctions on its oil exports.[3] However, the message that trade barriers can have far reaching

[1] In the presence of an optimal general income tax, this requires weak-separability between labor and consumption goods; and in its absence, weak separability plus linear Engel curves.

[2] Of course, other interesting economic questions arise in this context including the questions of the optimal extraction, refining, and investment of the generated revenues versus consumption. Nevertheless one can safely argue that they do not have the same problems as other countries in terms of raising public revenues.

[3] There is also the constraints OPEC imposes through its changing production quotas to limit supply and keep prices high.

consequences for domestic reform is quite a general one. The paper shows how a seemingly welfare improving policy in the absence of export restrictions turned out to be quite the opposite—at least for the current generations of Iranians.

A second and related contribution of the paper, reported in Section 2, is to estimate the demand structure for goods in Iran that underlies the reported welfare calculations. To study this issue, the paper uses the 1987–2011 Household Budget Surveys from the Statistical Center of Iran, coupled with the price data from the Central Bank of Iran, to estimate the structure of demand for goods and services in urban areas of Iran. Lack of price data for rural areas has forced us to exclude these areas from our estimation procedure.[4] The pooled sample consists of 293,953 urban households with a wide range of income variations and other socio-economic characteristics. Price variations, on the other hand, are far more limited because price controls have led to no variations across geographic regions (at least according to the official data). Nevertheless, given the quarterly nature of the data and its availability over many years, we are able to count on 100 price observation.[5]

In light of the subsidy reform emphasis on energy, and some food items, the paper reconfigures the broad categories of expenditures one finds in the Household Budget Surveys. The data contain detailed information on various expenditure items, with uniquely assigned codes, that makes this possible. We thus aggregate consumption expenditures into seven broad categories: (i) energy, (ii) subsidized food, (iii) nonsubsidized food, (iv) energy-consuming goods, (v) non-energy consumer goods, (vi) services, and (vii) housing. Given this reconfiguration, we also have to build a price index for each category. We do so using the detailed monthly price indices of the Central bank

[4] This restricts our ability to arrive at reliable macro numbers for the economy as a whole. However, when needed, we provide a "rough estimate" for the economy-wide numbers by assuming that aggregate changes in urban areas apply to rural areas as well.

[5] In an earlier attempt, Gahvari and Taheripour (2011) also used Household Budget Surveys data to estimate the consumers' demands in Iran. However, their data covered the period of 1998 to 2001 only for a total of 16 seasons. This limitation on price variations, i.e. availability of only sixteen data points, severely limited the reliability of their price elasticity estimates. Equally important, Gahvari and Taheripour (2011) did not consider the implications of trade barriers for their results. This issue is at the heart of the present study. Nor did they look at the environmental benefits of the reform.

of Iran.[6]

We use Banks *et al.*'s (1997) Quadratic Almost Ideal Demand System (QUAIDS) for our estimation procedure. Demand functions derived from the commonly-specified utility functions, e.g. CES, impose severe a-priori restrictions on demand estimates that are unsupported by the data. The most popular demand system satisfying the axioms of choice in consumer theory without imposing restrictions such as homotheticity is Deaton and Muellbauer's (1980) Almost Ideal Demand System (AIDS).[7] Another advantage of this system is that it allows the estimation of the parameters of an underlying indirect utility function behind the demand system. This is extremely useful in calculating the welfare changes of government's fiscal policies. Nevertheless the AID system has a drawback. It implies, rather implausibly, that all goods have Engel curves that vary *linearly* with the log of expenditures. Empirical Engel curves, on the other hand, often indicate relationships that are nonlinear. QUAIDS generalizes the AID system in that it is also based on the optimization of an underlying indirect utility function but one that allows for nonlinear Engel curves (having AIDS as a special case). We chose QUAIDS because initial non-parametric analyses of consumer expenditures in our data suggest that the Engel curves for many of the goods categories are nonlinear in the logarithmic of expenditures.

The estimation of a demand system is an essential undertaking for the study of the effects, and the design, of government policies. Such an undertaking has never been done for Iran. Yet policy makers in Iran, and other major oil producing countries, are currently grappling with the daunting question of developing a tax-based source of government revenue. For many of these countries, oil revenues constitute their main,

[6]By contrast, Gahvari and Taheripour (2011) used the data's broad categories of: (i) grains/bread/cake, (ii) other food products, (iii) clothing, (iv) housing (rent and imputed rent), (v) utilities (water, electricity, natural gas, phone, etc.), (vi) household items and furnishing , (vii) health, (viii) transportation (including fuel used outside the house), (ix) education, recreation, personal hygiene, (x) durable goods including automobiles (expenditures as opposed to imputed services), and (xi) other non-durable goods and services. This categorization is somewhat problematic for studying the effects of removing price subsidies. Energy appears in a number of these categories particularly utilities and transportation. Similarly, items (i) and (ii) include both subsidized and nonsubsidized food.

[7]Amongst other commonly used specifications, log-linear models do not satisfy theory exactly, linear expenditure system is overly restrictive, and flexible functional forms lead to representations of utility functions only approximately.

if not the sole, source of public funds which will sooner or later be exhausted. It is in this light, that we consider the estimation of the demand system for goods in Iran to be one original and general contribution of our study. Section 3 of the paper contains this material.

More specifically, however, this paper aims to shed light on the welfare implications of the recent elimination of price subsidies on energy and basic foodstuff in Iran and replacing them with cash subsidies.[8] The estimate of the underlying indirect utility function allows us to compute exact welfare measures for *non-marginal* tax/subsidy reforms. This is in contrast to the prevalent use of Ahmad and Stern (1984) approach in the literature for examining marginal commodity tax reforms.[9] In particular, our finding will shed light on the questions of the efficiency and equity gains in switching from price to cash subsidies, the incidence of the reform on different income groups (who gained, who lost, and by how much), and the environmental benefits that come with a reform that cuts energy consumption.

Most interestingly, we will argue that the customary way one goes about the welfare implications of fiscal reforms will give a very distorted picture of what happened in Iran. The reason is that textbook applications of price reforms are predicated upon an implicit assumption that may not always hold. Specifically, one typically assumes that by, say, raising domestic prices and thus cutting domestic consumption of certain goods, one is able to sell the excess on international markets. Now while this is generally true, it was not the case for Iran which was facing severe sanctions at the time of the reform. To study the importance of ignoring this (and similar type of) restriction, we examine the welfare implications of the reform under two scenarios. In one, which is what the policy makers expected to occur when they introduced the reform, there is no export constraint. The reduction in the domestic consumption of energy would be sold

[8] The policy is commonly referred to as "targeting subsidies". This may have been the initial intention of the government; but is a misnomer. The policy that was instituted was neither targeted nor self-targeted. Instead, it was a uniform monthly cash rebate to every person in a household (of about \$44.5 using the official rate of exchange of the time).

[9] The advantage of Ahmad and Stern (1984) first-order approximation approach is that it requires less information. However, the estimation of the indirect utility function gives us the required information. Consequently, we do not need to resort to any approximation.

overseas at the international market prices. We use this scenario as our hypothetical benchmark for the "expected changes," and report the welfare changes that were hoped for in Section 4 of the paper.

In our second scenario, which is what actually happened and reported in Section 5 of the paper, we recognize that the country faced an export constraint. As a result, what was not consumed domestically could not be sold overseas to benefit the current generations of Iranian. We show that this changed the welfare calculus of the reform, from its expected benchmark, in a dramatic way. Highlighting these differences illustrates the central message of our paper, namely, in analyzing the consequences of domestic reform one should pay great attention to the international constraints the country faces. Quantifying these differences emphasizes how drastic the impact of these constraints have been for Iran. A seemingly welfare improving policy may turn out to be quite the opposite—at least for current generations.

We start our inquiry by calculating the size of price subsidies in Iran prior to the reform. Given that there are no official statistics on the size of subsidies in Iran, this constitutes the third contribution of the paper.[10] These calculations are not based on our estimated demand system and form the starting point for our study.

2 Pre-reform price subsidies

Two categories of goods have been traditionally subsidized in Iran: Energy and basic foodstuff. Energy prices have been kept low for many decades. That Iran is an oil-producing country with a nationalized oil industry has enabled and facilitated this process by allowing it to simply sell its oil products domestically at extremely low prices. In 2010, the year before the reform, Iran ranked behind only Venezuela for having the lowest gasoline and diesel oil pump prices (among 168 countries reported). In that year, a liter of gasoline in Iran sold for \$0.097 about 1/13 of the average world price of \$1.234 (1/11 of the average price in Iran's neighboring countries). Diesel, or

[10] In the case of energy, the 2009 Iran Energy Balance Report (IEBR) reports computations that indicate total subsidies to "energy carriers" in all sectors of the economy amounted to 442,033 billion Rials (which translates into approximately 44.2 billion US dollar using the market exchange rate in 2009). It also reports separate calculations for households; but they do not include subsidies on gasoline.

gas oil, was even cheaper. It sold at 1/68 of the average world price and 1/55 of the average price in the neighboring countries.[11] As to the basic foodstuff—bread, egg, oil, and sugar—they too have been heavily subsidized over the past three decades or so.

2.1 Subsidy rates

In order to come up with precise calculations for the "dollar amount" of subsidies, one requires data on the consumption and the "subsidy rate," where the subsidy rate is the difference between the item's domestic pre-reform price and its "global" producer prices (reflecting its opportunity cost). For consumption data, we use the Household's Income and Expenditure Surveys (HIES) of the Statistical Center of Iran (SCI). These are collected from a cross section of urban and rural households on a quarterly basis. We use the figures for 2010, the year before the price reform, to represent consumption levels in our calculations of the size of the subsidies. For prices, we use different sources from Iran and international organizations (the Central Bank of Iran, the Bureau of Subsidy Targeting, the Ministry of Energy, and National Iranian Oil Refining and Distribution Company). In some cases, and more importantly, later on for estimation of the demand system, our sole source for consumer prices is the data published by the Central Bank of Iran (CBI). Unfortunately, the CBI price indices cover only urban areas which forces us to exclude the HIES data on rural households' expenditures in our estimation procedure. Because of this we focus on the estimates for urban households who constitute about 73% of total households in Iran.[12]

In the case of "energy," the consumer budget surveys include information on ten energy items: (i) Natural gas, piped (for residential cooking, heating, and lighting), (ii) gasoline, (iii) electricity, (iv) kerosene, (v) liquefied natural gas, LNG (for residential cooking), (vi) gas oil for residential heating, (vii) gas oil for transportation, (viii) fuel oil (for residential heating), (ix) compressed natural gas, CNG (as fuel for automobile), and (x) motor oil and the like (break-oil, grease, and fuel supplements). However, lack

[11] Gasoline and diesel oil pump prices, expressed in terms of US dollar per liter, are found at http://databank.worldbank.org/ddp/.

[12] According to the Statistical Center of Iran, 21,185,647 households lived in Iran in 2010; 15,427,848 of whom lived in urban areas and 5,757,799 in rural areas.

of information on the domestic prices for items (vii)–(ix) has forced us to exclude them from our list of energy goods. Yet this should not be a problem as the expenditures on these items are quite small amounting to just about 1% of total expenditures on all the cited items. The CBI data provide information on the domestic prices of the other seven items. Turning to "global prices," for items (ii), (iv)–(vi), we have relied on international market prices (for computing a global producer price that leads to a subsidy rate).[13] There remains items (i), (iii), and (x). For the first two, natural gas and electricity, there are no integrated international markets and prices differ considerably around the world. For the global price of natural gas, we used its average export price to the neighboring countries plus a 30% distribution cost; for electricity we used its domestic production cost.[14] For item (x), motor oil, we calculated its subsidy rate by the percentage increase in its price index after the reform (as reported by the CBI).

We also include expenditures on public transportation (taxi fares, bus fares, and air-plane fares), as components of "energy". These are, properly speaking, services that have a large energy component. However, their aggregate magnitude is not that sizable as to warrant a separate category. To calculate the subsidy rate on these items too, we used the percentage increase in their CBI reported price indices after the reform.

Turning to the calculation of subsidy rate on food item, there is no official data on the subsidies paid to them either. Given the government's plan of totally eliminating these subsidies, we calculated the subsidy rates on these items—different types of bread, eggs, oil, and sugar—by using the percentage increases in their CBI reported price indices after the reform.

2.2 Pre-reform subsidy costs by item and income decile

Given the international market and subsidized price of an item (a component of energy or subsidized food), and the family's expenditure on that item, one can easily calculate

[13] For these items, we took their Persian Gulf FOB dollar prices from the OPEC reports and added a 10% distribution cost.

[14] Export prices for natural gas are reported by National Iranian Gas Company (NIGC). The Energy Balance Report, published by Iran's Ministry of Energy, reports both export prices for natural gas as well as the domestic production cost of electricity.

the cash value of the item's subsidy. Formally, let p_j and q_j denote item j's international market and subsidized prices, y_j^h its consumption (at its subsidized price), and m_j^h the amount household h spends on it (at its subsidized price).[15] The government must be spending $s_j^h = p_j y_j^h - q_j y_j^h = (p_j/q_j - 1)\, q_j y_j^h = (p_j/q_j - 1)\, m_j^h$ to partly finance an h-household's consumption of item j (the subsidy an h-household implicitly receives for consuming item j). Summing over all the components, one can measure the energy and food subsidies as $S_e^h = \sum_j s_j^h$ and $S_f^h = \sum_j s_j^h$.[16]

The monetary value of the pre-reform subsidies for different "income" deciles are given in Tables 1–2.[17] Rows 11 and 12, here and in all other tables, indicate the top 5% and top 1% income groups. The last row refers to a household with average income (again, here and in all other tables). The monetary figures for expenditures are reported in 1000 Iranian tomans (TIT equal to 10,000 rials). This translates into approximately one US dollar using the market exchange rate in 2010, and about \$2.5 using the World Bank's Purchasing Power Parity exchange rate (PPP) for this period.[18] The figures correspond to the monthly average of the four quarters of 2010 (last pre-reform year).

The most striking feature of these numbers is the sheer magnitude of energy subsidies. The monetary value of the subsidy the average family in the first income *decile* receives on its energy consumption is equal to 44% of the family's total expenditures on all seven categories of goods (including energy). It remains as high as 20% for the average family in the top income *percentile*.

[15] This assumes that international market prices are unaffected by the changes in Iran's domestic consumption. While we recognize that this assumption may not always be true, it is the best "working assumption," and closest approximation to "reality," that we can think of in the absence of actual statistics on the size of the subsidies in Iran.

[16] In calculating gasoline subsidies, we have taken its two-tier price into account. The price for the first 60 liters of gasoline car owners purchase per month is lower than the price for purchases that exceed 60 liters. However, both quota and non-quota prices have been heavily subsidized. The same two-tier price applies to motorcycle owners who get a quota of 15 liters per month. The HIES data contain information on car and motorcycle ownership.

[17] By income we mean expenditures on our seven categories of goods and services. This does not include expenditures on health and education so that "income" is not quite "aggregate expenditures" either. Including health and education changes the reported range of incomes of the income groups in the tables to 36–227 , 227–308, 308–376, 376–443, 443–519, 519–607, 607–721, 721–890, 890–1,219, 1,219–5,190, 1,594–5,190, and 2,624–5,190.

[18] According to the World Bank WDI data, the PPP exchange rate was 4,268.8 rials per dollar in 2009 (the last year for which the conversion factor is given).

Table 1: Breakdown of 2010 monthly energy subsidies to urban households (monetary figures in TIT=$1)

Income group	Range of Expenditures	Natural Gas	Gaso-line	Elec-tricity	Kero-sene	LNG	Gas Oil	Motor Oil, etc.	Bus/ Taxi Fares	Air -plane Fares	Rial -road Fares	Total Subsidy	As a % of Household Income
1	36–227	42.909	4.770	8.759	12.717	1.144	0.000	0.014	1.509	0.000	0.000	71.821	44
2	227–308	68.178	10.332	13.728	16.158	1.262	0.201	0.046	2.697	0.000	0.006	112.608	42
3	308–376	77.135	14.430	17.035	20.725	1.344	0.052	0.083	3.120	0.005	0.019	133.946	39
4	376–443	92.619	18.784	18.594	22.104	1.438	0.013	0.111	3.722	0.007	0.012	157.404	39
5	443–519	105.431	23.829	22.547	17.971	1.411	0.000	0.178	4.640	0.000	0.021	176.028	37
6	519–607	113.020	27.807	25.103	23.814	1.352	0.000	0.205	4.789	0.006	0.037	196.133	35
7	607–721	142.275	33.392	28.465	16.937	1.446	0.431	0.326	5.664	0.034	0.053	229.025	35
8	721–890	179.052	39.781	31.318	18.234	1.338	0.000	0.383	6.392	0.099	0.035	276.631	35
9	890–1,219	235.015	46.933	37.048	16.462	1.239	0.262	0.494	7.466	0.229	0.174	345.321	34
10	1,219–5,190	335.117	66.173	49.528	15.922	1.803	0.027	0.742	9.035	1.455	0.201	480.004	27
11	1,594–5,190	395.288	72.198	57.463	9.523	1.665	0.054	0.837	9.212	2.568	0.183	548.992	25
12	2,624–5,190	481.929	77.666	62.488	9.149	1.467	0.000	0.914	12.362	4.972	0.100	651.047	20
Average	651	144.373	28.691	26.216	18.907	1.437	0.103	0.268	5.100	0.187	0.058	225.340	35

Gas Oil is for residential heating only.

Motor Oil, etc. contains motor oil, brake oil, grease, and fuel supplements.

Rows 11 and 12 show budget shares for the top 5% and top 1% income groups.

Average refers to a household with average income.

Table 2: Breakdown of 2010 monthly food subsidies to urban households (monetary figures in TIT=$1)

Income group	Range of Expenditures	Bread 1	Bread 2	Bread 3	Bread 4	Bread 5	Eggs	Solid Oil	Sugar Cubes	Sugar	Total subsidy	As a % of Household Income
1	36–227	1.081	1.837	0.381	1.573	0.548	1.878	2.392	0.892	0.299	10.881	7
2	227–308	1.531	3.306	0.629	1.845	0.626	2.434	3.505	1.295	0.513	15.683	6
3	308–376	2.100	3.568	0.665	2.039	0.666	2.805	4.170	1.576	0.684	18.273	5
4	376–443	2.420	3.572	1.003	1.882	0.722	2.936	4.745	1.739	0.797	19.816	5
5	443–519	2.771	3.759	0.953	2.110	0.742	3.155	5.147	2.019	1.024	21.680	5
6	519–607	2.549	3.721	1.164	2.148	0.824	3.330	5.718	2.135	1.163	22.752	4
7	607–721	2.508	4.398	1.386	2.136	0.866	3.563	6.127	2.394	1.273	24.651	4
8	721–890	2.627	4.719	1.619	2.571	0.891	3.907	6.632	2.467	1.465	26.898	3
9	890–1,219	3.163	5.096	1.802	3.117	0.869	4.115	7.157	2.592	1.620	29.531	3
10	1,219–5,190	3.832	5.972	2.474	3.254	1.001	5.117	9.017	3.071	2.139	35.877	2
11	1,594–5,190	4.262	6.185	3.023	3.536	0.927	5.288	9.168	3.203	2.301	37.892	2
12	2,624–5,190	2.393	5.705	3.006	3.086	0.914	6.256	10.620	3.931	2.400	38.311	1
Average	651	3.085	5.015	1.510	2.846	0.975	4.171	6.848	2.533	1.374	28.357	4

"Bread1", "Bread2", "Bread3", and "Bread4"are types of traditional oven-cooked breads called Taftoon, Lavaash, Sangak, Barbari. "Bread5"refers to machine-cooked bread.

Two aspects of these numbers are worth emphasizing. One is that the subsidy figures point to its undesirable redistributive implications. Given that the more well-off people spend more on almost all goods including energy and food, price subsidies benefit them more (in absolute value terms). The average family in the lowest income decile implicitly receives 71.8 TIT in energy subsidies and 10.9 TIT in food subsidies. Its counterpart in the highest income decile, on the other hand, receives 480.0 TIT in energy subsidies and 35.9 TIT in food subsidies (these figures were 651.0 TIT in energy subsidies and 38.3 TIT in food subsidies for a family in the highest income percentile). Put differently, the government's subsidy to a "rich" family is seven times the amount it spends on a poor family.[19]

The second aspect is the staggering magnitude of energy subsidies that points to a severe misallocation of resources in the economy. To get a better perspective on this, it is instructive to examine how much different households spend on different goods.

2.3 Pre-reform budget shares by category and income decile

The HIES data divides households' expenditures into fourteen categories.[20] These do not match the categorization needed for the purpose of a study focusing on the consequences of removing energy and food subsidies. There is no specific category for subsidized food, and energy consumption spreads over official categories of "utilities" and "transportation" (which also include non-energy items). Moreover, one would think that the responsiveness of demand for, say, energy-consuming goods to the removal of energy subsidies matters more than the responsiveness of demand for non-energy consumer goods. Similarly, the degree of substitution between subsidized and unsubsidized food must also matter. We thus recategorized the HIES data and aggregated consumption expenditures into another seven broad categories: (i) energy (E), (ii) subsidized food (SF), (iii) unsubsidized food (UF), (iv) energy-consuming goods (EG), (v) non-

[19] This is a much higher ratio than the figure reported by Zonor (2011). He estimated the monetary value of energy price subsidies that an average household in the highest income decile received in 2008 to have been three times higher than that for an average household in the lowest income decile.

[20] These are: food and drink, tobacco, clothing, housing and utility, furniture and home equipment, health, transportation, communication, culture and leisure, informal education, hotel and restaurant, miscellaneous items, durables, and investment.

energy consumer goods (NE), (vi) services (S), and (vii) housing (H).[21]

The different income groups' budget shares for the seven categories of goods are given in Table 3.[22] The figures correspond to the monthly average of the four quarters of 2010 (last pre-reform year). According to this table the monthly expenditures of the lowest income *decile* in Iran during 2010 on the seven stated good categories did not exceed 227 TIT. On the other hand, the top *percentile* had a monthly expenditure on these items exceeding 2,624 TIT. As far as the budget shares of the various good categories are concerned, the most interesting observation is that the share of energy is very low for households in all income groups. To a great extent this reflects the fact that energy prices are subsidized so heavily. The share of food items, both subsidized and unsubsidized, and housing decline with income. On the other hand, the share of consumer goods, energy consuming or not, increases substantially with income. These are consistent with one's intuition. Although, as far as housing is concerned, one does not expect that much of a reduction at top income levels. It may very well be that the imputed rent for owner occupied housing of top deciles are underestimated.

By way of comparison, now consider how much the household *and the government* together spend on the family's various expenditures. Table 4 presents the percentage share of public-plus-private expenditures on each of the seven good categories to the total public-plus-private expenditures for all income deciles. This is the counterpart of Table 1 which considered only private expenditures. For all income deciles, the share of energy is simply huge. The government and an average family in the lowest income decile together spend 246 TIT on the family's consumption of all seven categories of goods (including energy), of which 83 TIT is spent on energy. This results in a share of energy

[21] Recall that "Energy" consists of (a) electricity, (b) all forms of fuels and energy carriers households use (at home as well as for non-business purposes including private transportation), and (c) households' expenditures on public transportation (ground and air). Subsidized food contains all food items that received price subsidy before the reform such as bread, sugar, sugar cube, egg, and solid oil. Unsubsidized food contains all other food items and drinks that were not subsidized as well as tobacco. Non-energy consumer goods consists of goods whose consumption do not use energy (such as clothing, furniture, and the like). Energy consumer goods include electrical home appliances, heating and cooling systems, automobiles, motor bikes etc. that use some form of energy for operation. Services exclude education and health. Housing consists of rent and the imputed rental value of owner-occupied housing.

[22] Recall that in our tabulations income excludes expenditures on health and education so that income equals the expenditures on our seven categories of goods and services.

Table 3: Income deciles and their percentage budget shares in urban areas

Income group	Range of expenditures	E	SF	UF	NE	EG	S	H
1	36–227	6.72	7.99	29.43	6.05	0.83	6.31	42.68
2	227–308	7.05	6.66	30.31	7.68	1.34	8.08	38.87
3	308–376	6.82	6.06	30.36	8.91	1.50	8.58	37.77
4	376–443	6.79	5.53	30.72	9.92	1.80	9.60	35.63
5	443–519	7.15	5.12	30.56	10.90	2.18	10.09	33.99
6	519–607	6.69	4.70	29.97	12.59	2.83	10.47	32.75
7	607–721	6.96	4.32	29.82	13.32	3.34	11.06	31.18
8	721–890	6.78	3.85	28.81	14.75	5.28	11.11	29.43
9	890–1,219	6.57	3.20	26.35	16.02	10.19	11.17	26.49
10	1,219–5,190	5.55	2.23	21.22	16.66	22.13	10.30	21.92
11	1,594–5,190	5.14	1.86	18.91	17.37	26.17	10.24	20.30
12	2,624–5,190	4.42	1.36	17.43	20.26	24.83	11.84	19.85

E: energy, SF: subsidized food, UF: unsubsidized food, NE: non-energy consumer goods, EG: energy-consuming-goods, S: services, H: housing.

in this family's aggregate expenditure, regardless of the source of financing, close to 34%. By way of comparison, the share of food—subsidized and unsubsidized—is 29% while the share of housing is 28%. That the amount of money spent on the family's energy consumption far exceeds the amounts spent on food (which is also highly subsidized), and housing points to an immense "over-consumption" of energy. The corresponding numbers for an average family in the highest income percentile are 2,313 TIT for public-plus-private aggregate expenditures and 580 TIT for energy consumption. This yields a share for energy equal to 25%. In comparison, the ratios for food and housing are 20% and 17%.

3 Demand system and its estimation

To shed light on the implication of the subsidy reform on the consumption of energy and food in Iran, as well as its efficiency, redistributive, and environmental effects one requires a systematic framework that describes consumers' demand and preferences. In

Table 4: Public-plus-private expenditure shares for urban households in 2010 (%)

Income group	E	SF	UF	NE	EG	S	H
1	33.65	9.72	19.54	4.02	0.55	4.19	28.33
2	33.12	8.46	20.52	5.20	0.91	5.47	26.32
3	31.84	7.89	21.00	6.17	1.04	5.93	26.13
4	31.60	7.24	21.43	6.92	1.26	6.70	24.85
5	31.04	6.83	21.65	7.72	1.55	7.15	24.07
6	29.93	6.30	21.57	9.06	2.04	7.54	23.57
7	30.07	5.82	21.55	9.62	2.42	8.00	22.53
8	29.98	5.23	20.88	10.70	3.83	8.05	21.34
9	29.40	4.45	19.32	11.75	7.47	8.19	19.43
10	25.06	3.28	16.49	12.94	17.19	8.00	17.03
11	23.67	2.83	14.95	13.73	20.68	8.09	16.05
12	20.11	2.09	14.39	16.73	20.51	9.78	16.39

E: energy, SF: subsidized food, UF: unsubsidized food, NE: non-energy consumer goods, EG: energy-consuming goods, S: services, H: housing.

this section, we try to provide one. To this end, assume that the economy is populated with households who have identical tastes but different income levels. They have preferences over n categories of consumer goods, $\mathbf{x} = (x_1, x_2, ..., x_n)$, and E, the total level of emissions generated by consuming "energy goods"—a subset of consumption goods. Assume further that emissions enter the utility function linearly so that preferences are represented by

$$\mho = \mathbf{U}(\mathbf{x}) - \phi E, \tag{1}$$

where ϕ represents the marginal social damage of emissions assumed to be constant.

In order to proceed with the estimation of the demand system, given that preferences are assumed separable in $\mathbf{x}$ and E, the non-emission component of preferences can alternatively be represented by an indirect utility function that does not include emissions as an argument. Specifically, we shall assume that the non-emission component of preferences subscribe to the Quadratic Almost Ideal Demand System introduced by Banks *et al.* (1997).[23]

[23] There are a number of studies of demand systems in the literature that follow Banks *et al.* (1997)

All consumer goods are produced by a linear technology subject to constant returns to scale in a competitive environment.[24] All households are endowed with one unit of time which they supply inelastically.[25] The efficiency cost of the existing price subsidies can then be measured relative to their first-best producer-price values. We carry out these calculations by directly estimating the parameters of the representative household's indirect utility function.

Let m^h denotes household h's aggregate expenditures on goods $\mathbf{x}$, $\mathbf{p} = (p_1, p_2, \dots, p_n)$ denote the consumer prices of goods, and $\alpha_0, \alpha_i, \beta_i, \lambda_i$ and γ_{ij} $(i, j = 1, 2, \dots, n)$ denote constants. Define

$$\ln a(\mathbf{p}) \equiv \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln p_j, \tag{2}$$

$$b(\mathbf{p}) \equiv \prod_{i=1}^{n} p_i^{\beta_i}, \tag{3}$$

$$\lambda(\mathbf{p}) \equiv \sum_{i=1}^{n} \lambda_i \ln p_i. \tag{4}$$

The h-household's indirect utility function is then of the form (its non-emission component),

$$\ln v^h = \left\{ \left[\frac{\ln m^h - \ln a(\mathbf{p})}{b(\mathbf{p})} \right]^{-1} + \lambda(\mathbf{p}) \right\}^{-1}. \tag{5}$$

The advantage of this formulation is that it allows Engel curves to vary with $\ln m$ linearly for some goods and nonlinearly for others—a property often displayed by empirical Engel curves.[26] Imposing restrictions $\sum_{i=1}^{n} \gamma_{ij} = \sum_{j=1}^{n} \gamma_{ij} = 0$, $\sum_{i=1}^{n} \beta_i = \sum_{i=1}^{n} \lambda_i = 0$, and $\sum_{i=1}^{n} \alpha_i = 1$ on the parameters of (2)–(4) ensures the demand system's homogeneity of

and use QUAIDS. See, among others, Blundell and Robin (1999), Moro and Sckokai (2000), Fisher and Fleissig (2001), and Gil and Molina (2008).

[24] This assumption is clearly unrealistic in the context of Iranian economy. Nevertheless we employ it to enable us to measure, even though approximately, the efficiency cost of taxation by considering how much consumer prices differ from producer prices. Without it, producer prices are also distorted and we will have no way of shedding light on possible efficiency cost of subsidies for goods other than energy. Fortunately, for the purpose of this study, the major portion of subsidies are on energy goods for which we can use international prices for the calculation of efficiency costs.

[25] Allowing for preferences to depend on leisure necessitates the estimation of labor supply elasticities and cross-price elasticities between goods and leisure. We do not have data to undertake such estimates.

[26] If $\lambda_i = 0$, for all $i = 1, 2, \dots, n$, the indirect utility function (5) will be reduced to Deaton and Muellbauer's (1980) Almost Ideal Demand System. In this case, Engel curves will be linear in $\ln m$.

degree zero in income and prices, and its adding up property . The symmetry restriction, of the Slutsky matrix, requires $\gamma_{ij} = \gamma_{ji}$, for all $i \neq j = 1, 2, \ldots, n$. This is also imposed on the estimated parameters.

With the QUAIDS specification, as well as AIDS, it is simpler to estimate the goods' expenditure shares rather than their quantity demanded. We have from Roy's identity,[27]

$$\omega_i \equiv \frac{p_i x_i}{m} = \frac{p_i}{m}\left(\frac{-\partial v/\partial p_i}{\partial v/\partial m}\right) = -\frac{p_i}{m}\frac{\partial \ln v/\partial p_i}{\partial \ln v/\partial m},$$

where ω_i denotes the expenditure share for good $i = 1, 2, \ldots, n$. Partially differentiating (5) with respect to p_i and m, and simplifying through equations (2)–(4), one arrives at the system of equations for expenditure shares:[28]

$$\omega_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln \frac{m}{a(\mathbf{p})} + \frac{\lambda_i}{b(\mathbf{p})}\left[\ln \frac{m}{a(\mathbf{p})}\right]^2, \quad i = 1, 2, \ldots, n. \tag{6}$$

3.1 Data

The data for estimating the demand system come from two sources: The HIES data for expenditures and the CBI data for prices. The HIES data are collected, by the Statistical Center of Iran on a quarterly basis, from a cross section of urban and rural households. The data we use for estimation covers 100 quarters starting from the second quarter of 1987 and ending with the first quarter of 2012.[29]

The CBI price indices, as we mentioned earlier, cover only urban areas. This forces us to exclude the HIES data on rural households' expenditures in our estimation procedure. Another shortcoming of the available price data is that price controls have led to virtually no variations across geographic regions, at least not according to the official data. Which means that we are able to count on only 100 price observation. On the

[27] To avoid cluttered notation, references to households are suppressed. However, it is clear that ω_i, like m and v, varies across households h.

[28] In deriving equation (6) , we have also made use of the symmetry condition $\gamma_{ij} = \gamma_{ji}$. Otherwise, the term $\sum_{j=1}^{n} \gamma_{ij} \ln p_j$ on the right-hand side of (6) must be replaced with $\sum_{j=1}^{n} (\gamma_{ij} + \gamma_{ji}) \ln p_j / 2$.

[29] The first HIES data set, collected on the basis of the Persian calendar, is for year 1363 (corresponding to the second quarter of 1984), and the last data set is for year 1391(corresponding to the first quarter of 2013). However, we did not use the data covering the first three years because they do not report expenditures on many items that later surveys cover. Moreover, the last data set we used was the first quarter of 2012 because we do not have the CBI price data for the quarters following this.

Table 5: Quadratic Engel curve regressions

Expenditure Shares	Constant	$\ln m$	$(\ln m)^2$
Energy	–1.0510	0.1320	–0.0039
	(0.0302)	(0.0035)	(0.0001)
Subsidized food	0.4590	–0.0191	–0.0003
	(0.0227)	(0.0027)	(0.0000)
Unsubsidized food	–6.1593	0.7951	–0.0244
	(0.0734)	(0.0086)	(0.0003)
Non-energy consumer goods	–2.0974	0.2213	–0.0053
	(0.0660)	(0.0078)	(0.0002)
Energy-consuming goods	9.5042	–1.1744	0.0363
	(0.0605)	(0.0071)	(0.0002)
Services	–0.5931	0.0555	–0.0009
	(0.0432)	(0.0051)	(0.0001)
Housing	0.9364	–0.0108	–0.0015
	(0.0942)	(0.0111)*	(0.0003)

Standard errors in parentheses

* This is the only statistically-insignificant coefficient; all other coefficients are statistically significant at 99% level.

other hand, with a pooled sample of 293,953 urban households, we care able to allow for a wide range of income variations and other socio-economic characteristics amongst the households.

3.2 Engel curves

As a first step to examining whether or not a linear specification for Engel curves is appropriate, we estimate simple quadratic polynomial regressions. Each of the seven expenditures' shares is regressed on ln aggregate expenditures (deflated by the year's average consumer price index) and its square. The results are reported in Table 5. Additionally, Figures 2–5 of the Appendix graph non-parametric kernel regressions and the quadratic polynomial regressions for the seven good categories. The regressions and the graphs provide a prima-facie support for the nonlinear specification. Specifically, with one exception, all parameter estimates in Table 5, and particularly those of the square of ln income, are statistically significant at 99% level.

3.3 Estimation

Expenditure shares ω_i, $i = 1, 2, \ldots, 7$, given by (6), constitute our estimating equations. A particular difficulty with estimating these equations is that they are nonlinear in parameters. However, they are conditionally linear if the value of the price indices $a(\mathbf{p})$ and $b(\mathbf{p})$ are known. We thus follow the Iterated Linear Least Squares Estimator (ILLE) procedure of Blundell and Robin (1999) to estimate our model.[30] We iteratively estimate our model using a three-stage least squares procedure until the parameter estimates converge.

The three-stage least squares procedure is needed because it combines a two-stage least squares procedure with a seemingly unrelated regression model. The two-stage least squares component allows for the use of instruments in controlling for endogeneity. The income term is endogenous being the sum of all expenditures. We thus instrument for it using demographic variables (head's age, years of education, and employment status), ownership dummy variables (TV, refrigerator, freezer, vacuum cleaner, washer, and residence coupled with its square footage), job-related dummy variables for the head of the household (divided into ten job classifications), economic sector dummy variables where the head of household is employed), and the logarithm of real price of oil.

In addition, error terms are potentially correlated across equations because the right-hand side variables are identical. The seemingly unrelated regression model controls for the endogenous error term by taking into account the correlated error structure. It also allows for the imposition of the symmetry and homogeneity restrictions during the

[30] The iteration procedure begins by estimating the AIDS specification while approximating $\ln a(\mathbf{p})$ with Stone's Index:

$$\ln a(\mathbf{p}) \cong \sum_{i=1}^{7} \omega_i \ln p_i,$$

where ω_i is the sample average for the budget share of good i. We use the resulting parameter estimates to recalculate $\ln a(\mathbf{p})$, using equation (2), and calculate $b(\mathbf{p})$, using equation (3), for the next round in the iteration process. A value for α_0 is also needed to arrive at a value for $\ln a(\mathbf{p})$. Deaton and Muellbauer (1980) interpret α_0 as the minimal subsistence expenditure level if all prices are set equal to one. Given this interpretation, we fix α_0 at an estimate for "poverty line" in Iran's urban areas. The estimate is that of Assadzadeh and Paul (2004) adjusted for the inflation rate. After the first round, each stage of iteration uses the QUAIDS specification for estimation. The process continues by using the estimated QUAIDS parameters to update the price indices until the parameters converge.

Table 6: Demand system equations

Variables	E	SF	UF	NE	EG	S	H
E price	0.0328	0.0116	–0.0208	–0.0094	–0.0114	–0.0022	0.0322
	(0.0044)‡	(0.0039)‡	(0.0060)‡	(0.0059)⌈	(0.0032)‡	(0.0058)	–
SF price	0.0116	0.0355	–0.0006	–0.0299	0.0041	0.0065	–0.0156
	(0.0039)‡	(0.0066)‡	(0.0099)	(0.0097)‡	(0.0056)	(0.0053)	–
UF price	–0.0208	–0.0006	0.0069	–0.0117	0.0201	–0.0061	–0.0084
	(0.0060)‡	(0.0099)	(0.0252)	(0.0153)†	(0.0082)	(0.0116)	–
NE price	–0.0094	–0.0299	–0.0117	0.0810	–0.0078	–0.0216	–0.0099
	(0.0059)⌈	(0.0097)‡	(0.0153)	(0.0204)‡	(0.0103)	(0.0066)‡	–
EG price	–0.0114	0.0041	0.0201	–0.0078	–0.0006	–0.0103	–0.0055
	(0.0032)‡	(0.0056)	(0.0082)†	(0.0103)	(0.0055)	(0.0035)‡	–
S price	–0.0022	0.0065	–0.0061	–0.0216	–0.0103	0.0485	–0.0170
	(0.0058)	(0.0053)	(0.0116)	(0.0066)‡	(0.0035)‡	(0.0090)‡	–
H price	–0.0006	–0.0272	0.0123	–0.0005	0.0059	–0.0148	0.0243
	(0.0048)	(0.0078)‡	(0.0182)	(0.0126)	(0.0076)	(0.0069)†	–
Ln income	–0.0030	–0.0456	–0.0445	0.0463	0.0428	0.0229	–0.0218
	(0.0008)‡	(0.0010)‡	(0.0021)‡	(0.0029)‡	(0.0023)‡	(0.0012)‡	–
Ln income^2	–0.0019	0.0044	–0.0212	–0.0341	0.0000	0.0075	0.0433
	(0.0008)†	(0.0012)‡	(0.0025)‡	(0.0037)‡	–	(0.0013)‡	–
Household size	0.0007	0.0085	0.0087	0.0033	–0.0039	–0.0005	–0.0161
	(0.0001)‡	(0.0002)‡	(0.0003)‡	(0.0003)‡	(0.0002)‡	(0.0001)‡	–
Female head	–0.0041	–0.0078	–0.0348	0.0056	–0.0085	–0.0032	0.0488
	(0.0005)‡	(0.0006)‡	(0.0019)‡	(0.0018)‡	(0.0006)‡	(0.0008)‡	–
Constant	0.0634	0.0316	0.2978	0.1210	0.0563	0.0840	0.4093
	(0.0017)‡	(0.0016)‡	(0.0035)‡	(0.0034)‡	(0.0023)‡	(0.0021)‡	–

Notes:

1. E: energy, SF: subsidized food, UF: unsubsidized food, NE: non-energy consumer goods, EG: energy-consuming goods, S: services, H: housing.
2. The figures in the parentheses are bootstrapped standard errors based on 1500 replications.
3. ‡, †, ⌈ denote statistical significance at 99%, 95%, and 90% level.
4. Standard errors are not reported for coefficient of $(\ln \text{income})^2$ in SE and E regressions because the $(\ln \text{income})^2$ term is set to zero in these regressions.

estimation procedure.[31]

To estimate the QUAID system, we drop the equation for housing and only estimate the remaining six equations. We then use the adding up (as well as symmetry and homogeneity) restrictions to compute the parameters of the housing equation. To calculate standard errors, we use a bootstrap procedure consisting of 1,500 replications. Initially, we ran all the estimations with no restrictions on the ln income squared coefficient, λ, in any of the equations. The data did not support a statistically significant non-zero λ value for energy consumers goods (EG). Subsequently, we re-estimated all the equations, while setting $\lambda = 0$ for these goods. Table 6 reports these final estimates.[32]

The coefficient of log income squared is statistically significant in all the equations with a quadratic specification (energy, subsidized food, unsubsidized food, non-energy consumer goods, and services).[33] Own-price coefficients are positive for all goods categories except for energy-consuming goods (which is also statistically insignificant). What this means is that the own-price elasticities are less than one (in absolute value) for all goods except energy-consuming goods. These results are what one intuitively expects (with the possible exception of the demand for non-energy consumer goods).

3.4 Estimation and the two-tier gasoline price

In estimating our demand system, we have used one price for energy (as with every other good). This is unavoidable given that the CBI provides one price index series for each component of the composite energy good. However, there is a potential complication that needs to be addressed. Gasoline prices in Iran have been two-tiered for sometime (and continue to be so post-reform). Specifically, the pre-reform price of gasoline was set at 0.1 TIT per liter for purchases of up to 60 litters per month and at 0.4 TIT for any extra purchase. (Post-reform, these prices were changed to 0.4 TIT and .07 per liter with the monthly quota remaining at 60 litters). Theoretically, this raises the question

[31] Gahvari and Taheripour (2011) use the method suggested by Rothenberg (1973) for estimation under constraints to ensure symmetry of the Slutsky matrix.

[32] The results for the initial regressions where $\lambda \neq 0$ for all goods are not reported; they are very close to the final estimates and available from the authors upon request.

[33] As far as housing is concerned, one cannot tell because its coefficients are recovered from the adding up restriction.

as to where on the demand curve gasoline consumers locate.

Figure 1 depicts this problem. The kinked line ABC indicates the budget constraint for a consumer with income m^h who faces the two-tier price for gasoline (0.1 per liter up to 60 litters and 0.4 per liter for any excess). The household can choose to be on the AB portion, or BC portion for an interior optimum, or at point B. The same problem manifests itself after the reform (except that post-reform, AB will have a slope of 0.4 and BC a slope of 0.7—both in absolute value). Now, examining the expenditures of various households both prior to and post reform, we discovered that practically all households consume gasoline in amounts exceeding the quota allotted to them. That is, they chose a point like E on the BC portion indicating a consumption level equal to $z > 60$. Put differently, the price that matters is the higher price (0.4 pre-reform and 0.7 post-reform). The same choice would be made if the household were to face the hypothetical budget constraint CC' indicating a gasoline price of 0.4 pre-reform and 0.7 post-reform but with an income level equal to $m^h + 18$. Effectively, this is as if the consumer faces the higher price while receiving a lump-sum cash subsidy equal to $0.3 \times 60 = 18$ TIT[34]

The upshot of this discussion is that using one price for our estimation procedure is the right way to go. However, there is a caveat here. The CBI price index is a weighted average of the quota and non-quota price. As such, it is lower than the effective price consumers face. Lack of appropriate data has not allowed us to modify this price in an appropriate manner.

3.5 Income and price elasticities

On the basis of (6), one can easily calculate the income elasticity of demand for good i, η_i, and its own price and cross price elasticity with respect to good j, ε_{ij}, as

[34] $(0.4 - 0.1) \times 60 = 18$ pre-reform and $(0.7 - 0.4) \times 60 = 18$ post-reform. Of course, to the extent that the higher pre- and post-reform prices of 0.4 and 0.7 remain below the global price, the consumer gets an additional price subsidy on his total consumption level of z as well.

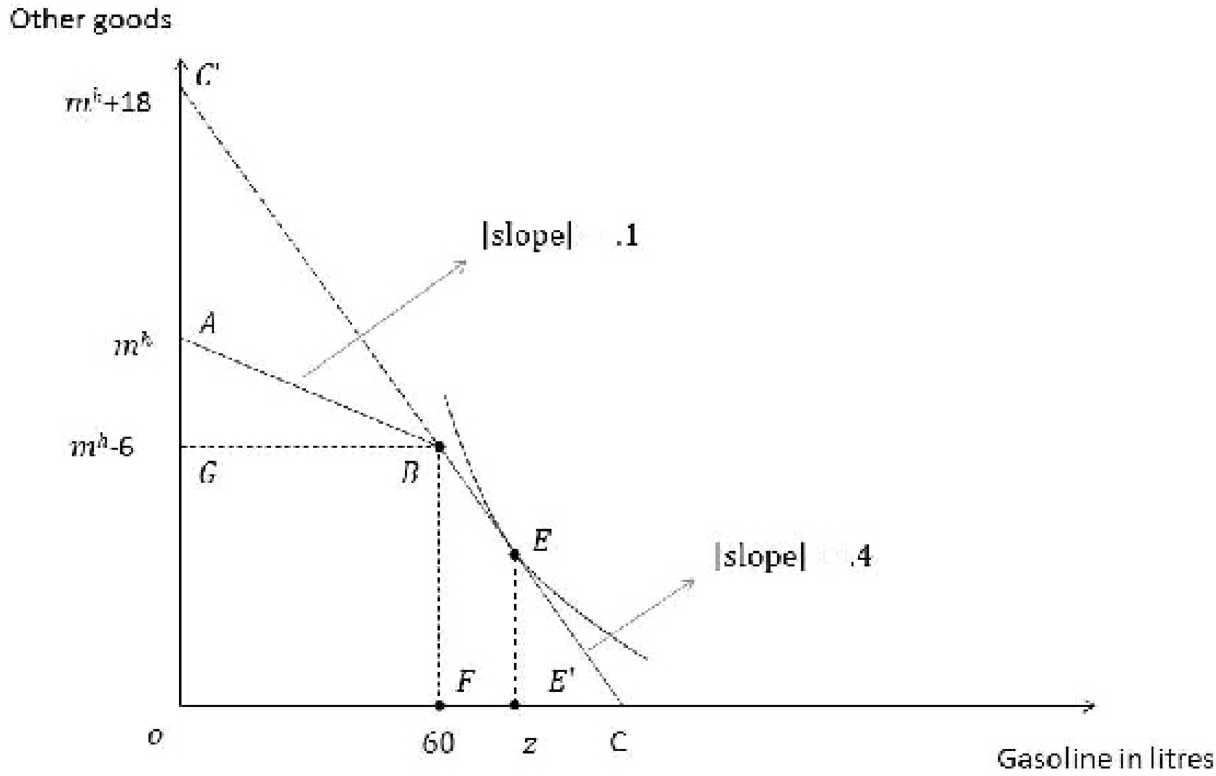


Figure 1: The two-tier gasoline price.

$$
\begin{aligned}
\eta_i \equiv \frac{\partial x_i}{\partial m}\frac{m}{x_i} &= \frac{1}{\omega_i}\frac{\partial \omega_i}{\partial \ln m} + 1, \\
&= \frac{1}{\omega_i}\left[\beta_i + \frac{2\lambda_i}{b(\mathbf{p})}\ln\frac{m}{a(\mathbf{p})}\right] + 1,
\end{aligned} \tag{7}
$$

$$
\begin{aligned}
\varepsilon_{ij} \equiv \frac{\partial x_i}{\partial p_j}\frac{p_j}{x_i} &= \frac{1}{\omega_i}\frac{\partial \omega_i}{\partial \ln p_j} - \delta_{ij}, \\
&= \frac{1}{\omega_i}\Bigg\{\gamma_{ij} - \left[\beta_i + \frac{2\lambda_i}{b(\mathbf{p})}\ln\frac{m}{a(\mathbf{p})}\right]\Big(\alpha_j + \sum_{k=1}^{n}\gamma_{jk}\ln p_k\Big) \\
&\quad -\frac{\lambda_i\beta_j}{b(\mathbf{p})}\left[\ln\frac{m}{a(\mathbf{p})}\right]^2\Bigg\} - \delta_{ij},
\end{aligned} \tag{8}
$$

for i and $j = 1, 2, \ldots, n$ where δ_{ij} is the Kronecker delta. Observe that if $\lambda_i = 0$, both the income and the own and cross price elasticity of demand for good i is independent of income.

Table 7 reports the values of own-price elasticity, income elasticity, and compensated price elasticity of demand for the seven categories of goods for a household with "average income" (average expenditures on the seven categories of goods). Price elasticities follow the pattern mentioned above (somewhat elastic for energy-consuming goods and inelastic for the rest). The price elasticities are particularly low for subsidized food (–0.26), non-energy consumer goods (–0.31), energy (–0.51), and services (–0.53). Turning to income elasticities, energy-consuming goods have the most income elastic demands. Next elastic is the demand for services, followed by housing, and non-energy consumer goods. Demands for energy, unsubsidized- and subsidized-food are all inelastic, with the demand for subsidized food being highly inelastic.

With all goods being normal, their compensated price elasticities are, in absolute value, smaller than the corresponding non-compensated elasticities. The category of energy-consuming goods, which has the highest income and price elasticities (in absolute value), also has the highest compensated price elasticity which is just shy of one. The other goods have substantially lower compensated own-price elasticities. Subsidized food whose subsidies are being totally eliminated has a very low compensated own-price

Table 7: Income and own price elasticities (for an urban household with average income in 2010)

Categories of goods and services	Income elasticity	Uncompensated elasticity	Compensated elasticity
Energy	0.92	–0.51	–0.44
Subsidized food	0.19	–0.26	–0.25
Unsubsidized food	0.76	–0.91	–0.69
Non–energy consumer goods	1.05	–0.31	–0.19
Energy-consuming goods	1.83	–1.06	–0.97
Services	1.33	–0.53	–0.40
Housing	1.11	–0.96	–0.59

elasticity (–0.25). The compensated own-price elasticity of demand for energy, whose subsidies are cut substantially but not eliminated, is somewhat higher in absolute value (at 0.44). These numbers tell us that, as far as the tax efficiency is concerned, energy subsidies are more distortionary than subsidies on food (resulting, everything else equal, in a higher welfare loss).

Table 8 reports the values of uncompensated cross-price elasticities for our seven good categories (again for a household with average income). The interesting observation here is that energy and subsidized food, the two highly subsidized categories, are substitutes (with cross-price elasticities of 0.17 and 0.23). The importance of this observation comes from the fact that price-interaction effects between substitute goods decrease the size of the aggregate welfare loss associated with taxing/subsidizing multiple goods. Specifically, the higher the degree of substitutability between two goods (as indicated by higher positive numbers), the smaller will be the aggregate welfare loss. This follows because increasing the subsidy on one category lowers the consumption of the other subsidized category, and thus leads to lower subsidy payments on this other category. The same argument implies complementarity leads to a lower aggregate welfare loss.

Table 8: Uncompensated cross-price elasticities (for an urban household with average income in 2010)

	E	SF	UF	NE	EG	S	H
E	–0.51	0.17	–0.29	–0.13	–0.16	–0.03	0.02
SF	0.28	–0.26	0.23	–0.51	0.13	0.20	–0.27
UF	–0.06	0.00	–0.91	–0.01	0.09	0.00	0.13
NE	–0.08	–0.26	–0.12	–0.31	–0.07	–0.19	–0.02
EG	–0.27	0.05	0.14	–0.25	–1.06	–0.27	–0.17
S	–0.04	0.06	–0.16	–0.26	–0.13	–0.53	–0.26
H	–0.01	–0.08	0.01	–0.02	0.01	–0.05	–0.96

E: energy, SF: subsidized food, UF: unsubsidized food, NE: non-energy consumer goods, EG: energy-consuming goods, S: services, H: housing.

4 The 2011 price subsidy reform: the benchmark

4.1 Price changes

Starting at the beginning of 2011, Iran implemented its long debated and prepared-for subsidy reform plan.[35] Food subsidies were basically eliminated, but some energy subsidies remained. The plan is to eliminate the remaining subsidies gradually by the end of 2015.[36] At the day of implementation all households got access to lump-sum cash transfers that were already deposited in special savings accounts established for them. The rebates were set at 44.5 TIT per month per individual member of the household.

Table 9 reports the pre-reform and post-reform prices for energy and subsidized food.[37] For greater accuracy, the energy prices are reported from Announcement 1 to 5 of the Bureau of Targeting Subsidies (BTS) published in www.dolat.ir which are based on their customary measurement units. Given the unavailability of official data for other items, their prices are reported on the basis of CBI price indices. However, as stated in

[35] To be exact, the starting date was 19th of December 2010.

[36] More specifically, by then the prices of oil products are mandated to reach the 90% of their Persian Gulf FOB (freight on board) prices, the price of natural gas to 75% of its average export price, the price of electricity to its production costs, and the price of piped water to its delivery costs.

[37] As mentioned above, subsidies on energy items have not been totally eliminated so that their post-reform prices continue to be lower than their corresponding "world-prices". On the other hand, food subsidies have basically been eliminated so that their post-reform prices reflect world prices. Many items show a dramatic price increase.

Section 3, the estimation of the demand system for all goods is based only on CBI price indices.

Table 9: Pre-reform and post-reform prices and their percentage increases (monetary figures in TIT=$1; indices have 2004 as the base year)

	Unit of measurement	Pre-reform price	Post-reform price	Percentage increase
Energy:				
Natural gas - piped	m3	0.0115	0.0700	509
Gasoline - quota	liter	0.1000	0.4000	300
Gasoline - non quota	liter	0.4000	0.7000	75
Electricity	kwh	0.0165	0.0270	64
Kerosene	liter	0.0165	0.1000	506
LNG - liquefied natural gas	kilo	0.0772	0.1800	133
Gas oil - residential heating	liter	0.0165	0.1000	506
Motor oil, etc	index	259	303	17
Bus and taxi fares	index	224	295	32
Air transportation fares	index	174	219	26
Railroad transportation fares	index	171	193	13
Subsidized food:				
Bread (type 1: Taftoon)	index	251	883	252
Bread (type 2: Lavash)	index	300	840	180
Bread (type 3: Sangak)	index	312	815	161
Bread (type 4: Barbari)	index	362	884	144
Bread (Type 5: machine-cooked)	index	425	506	19
Eggs	index	178	335	88
Solid oil	index	209	359	72
Sugar cubes	index	353	549	56
Sugar	index	284	556	95

The pre-reform and post-reform TIT prices of energy items are from Announcement 1 to 5 of the Bureau of Targeting Subsidies (BTS) published in www.dolat.ir. These are NOT the prices used for estimation.

The price indices are from CBI data.

The price indices for various fares are authors' calculations based on the CBI price indices.

Natural gas, kerosene, and residential gas oil prices rose by over 500% while gasoline prices rose by 300% for the quota purchases and 75% for non-quota purchases. The lowest increase was in railroad fares which went up by just about 13%. As far as food prices were concerned, different types of traditional oven-cooked bread showed the highest jump in prices (varying from 144% to 252%). The lowest increase was in the machine-cooked bread which went up by only 19%. The prices of other subsidized foods increased between 56% to 95%. Based on the price increases of their various components, we calculate the percentage increase in the "price of a unit of energy" and the "price of subsidized food" to have been 171% and 87% in the urban areas. These calculations use the ratio of urban households' 2010 expenditures on each of the components of energy and subsidized food to the expenditures on all their respective components as weights.[38]

4.2 Subsidy reform and households

To determine how the subsidy reform might affect the consumption pattern and the well-being of Iranian households, we rely on our estimates of the QUAID system. They provide us with consumption levels—budget shares to be more precise—of the seven category of goods at the post-subsidy prices for energy and subsidized food and the new income levels of households in various income groups that include their cash subsidies from the government.

Specifically, let p_e and p_f denote the international market price, and q_e and q_f the pre-reform domestic price (the weighted average of their components in Table 9). Denoting the vector of domestic market prices for the other five goods categories by $\overline{\mathbf{p}}$, an h-household's pre-reform demands for consumption of energy and subsidized food, based on our estimated demand system, are given by $x_e^h\left(q_e, q_f, \overline{\mathbf{p}}, m^h\right)$ and $x_f^h\left(q_e, q_f, \overline{\mathbf{p}}, m^h\right)$ where m^h is the household's total expenditure on all seven categories of goods. One may then measure the pre-reform subsidies to an h-household by

$$\begin{aligned} S^h &= S_e^h + S_f^h \\ &= \left(p_e - q_e\right) x_e^h\left(q_e, q_f, \overline{\mathbf{p}}, m^h\right) + \left(p_f - q_f\right) x_f^h\left(q_e, q_f, \overline{\mathbf{p}}, m^h\right). \end{aligned} \tag{9}$$

The subsidy reform increases the domestic prices of energy and subsidized food from q_e and q_f to q_e' and q_f'. Given the elimination of price subsidies on food, there will be no food subsidies post-reform so that $q_f' = p_f$. Some price subsidies to energy will remain.

[38] To the extent that these ratios differ for rural households, the increases in the "price of energy" and the "price of subsidized food" for rural households will differ from our calculated values of 171% and 87%.

4.2.1 Households' virtual income

The calculation of the subsidies must also take note of the fact that all households receive cash subsidies. Let n^h denote the number of members in an h-household, and a denote the lump-sum cash payment to a family member. Then the h-household receives $A^h = n^h a$ in cash subsidies. Consequently, the monetary value of the post-reform subsidies to the h-household will be equal to

$$\begin{aligned} S'^h &= A^h + S'^h_e \\ &= A^h + \left(p_e - q'_e\right) x^h_e \left(q'_e, p_f, \overline{\mathbf{p}}, m^h + A^h\right). \end{aligned} \tag{10}$$

The subsidy reform thus changes the cash value of all subsidies an h-household receives by

$$\Delta S^h = S'^h - S^h = A^h + S'^h_e - \left(S^h_e + S^h_f\right). \tag{11}$$

Table 10: Change in monetary values of the subsidies (per urban household, monthly, in TIT=$1)

Income group	Range of expenditures	Pre-reform price subsidies	Post-reform price subsidies	Direct rebates	Change in the amount of subsidies
1	36–227	84.246	31.159	115.652	62.564
2	227–308	124.662	42.088	148.262	65.688
3	308–376	151.049	49.815	161.994	60.761
4	376–443	174.676	55.051	169.842	50.216
5	443–519	184.584	57.206	176.971	49.593
6	519–607	213.674	65.691	179.890	31.907
7	607–721	236.202	70.019	185.536	19.353
8	721–890	282.724	80.726	186.326	–15.672
9	890–1,219	347.913	96.788	189.221	–61.903
10	1,219–5,190	508.787	142.042	194.852	–171.892
11	1,594–5,190	592.932	168.260	191.987	–232.685
12	2,624–5,190	718.259	209.710	191.951	–316.598
Average	651	239.962	69.519	170.853	0.410

Tables 10 reports these values. The most interesting feature of these numbers is their redistributive implications. Poorer families gain in monetary terms while the richer families lose. An average household in the first decile experiences a net gain of 62.6 TIT per month (nearly 38.3% percent of its income). On the other hand, an average family in the highest decile loses the equivalent of 171.9 TIT per month (it rises to 316.6 TIT per month for the highest percentile). A household with average income appears to neither gain nor lose (the actual figure shows a net gain of 0.4 TIT per month).

4.2.2 Households' welfare (non-environmental)

The subsidy reform will affect the welfare of households in two distinct ways. First, there are the income effects highlighted in Table 10; this tends to be in the "right" direction redistributing away from the richer households towards the poorer households. Second, there is the efficiency gains of aligning consumer prices of energy and food more in line with their opportunity costs. This should benefit all households. To determine their combined effect, we resort to the Hicksian equivalent variation measure. This is the amount of money one needs to give an h-household under the pre-reform policy regime so that it will experience the utility level it will have under the post-reform policy regime. Formally, let $v(\cdot)$ denote the household's indirect utility function, $\mathbf{q}$ denote the pre-reform vector of consumer prices, and $\mathbf{q}'$ denote the post-reform vector of consumer prices. The equivalent variation of the subsidy reform, EV^h, is found from

$$v\left(\mathbf{q}, m^h + EV^h\right) = v\left(\mathbf{q}', m^h + A^h\right)$$

Observe that EV^h is defined such that it is positive for a change which makes the household better off.

Table 11 reports EV^h computations for the ten income deciles as well as the top 5 and top one percentiles. For ease of comparison, it also repeats the change in monetary values of the subsidies (reported in the last column of Table 10). The bottom eight deciles gain from the reform; the top two deciles lose. Observe that the eight decile gains despite the fact that the monetary value of its subsidies decline. The poorest income group values the reform equivalently to receiving a monthly lump-sum income of 63.2 TIT. This is huge considering that the average income of this group is only 163.4 TIT. The income equivalent falls to 11.0 TIT for the eighth income decile, turning to a

Table 11: Equivalent variation of the change in subsidies (per urban household, monthly, in TIT=$1)

Income group	Range of Expenditures	Monetary value of subsidy changes	Equivalent variations
1	36–227	62.564	63.217
2	227–308	65.688	67.381
3	308–376	60.761	64.142
4	376–443	50.216	59.307
5	443–519	49.593	53.421
6	519–607	31.907	42.806
7	607–721	19.353	31.699
8	721–890	–15.672	10.967
9	890–1,219	–61.903	–20.342
10	1,219–5,190	–171.892	–119.545
11	1,594–5,190	–232.685	–173.615
12	2,624–5,190	–316.598	–293.058

loss of just 20.3 TIT for the ninth decile, and increasing to a loss of 119.5 TIT for the top decile.

All income groups show a higher gain (or a smaller loss) in terms of equivalent variation as compared to pure income effects. The differences between the two measures are due to the efficiency gains in moving from price subsidies to cash subsidies. Additionally, observe that the EV gains decline with income. This reflects the redistributive gains due to the reform as the richer people experience more cuts than the poorer people (in the cash value of their subsidies).[39] Clearly, this reform has a lot going for it.

Finally, to be able to aggregate the welfare changes of different households we need to rely on a social welfare function. For this purpose, we use the iso-elastic specification introduced by Atkinson (1970). This is particularly useful as it allows for a wide range

[39] Recall that the richer people consumed more of the subsidized goods and thus received higher amounts of subsidies.

of attitudes towards inequality in the society. It is defined by

$$\begin{aligned} W &= \frac{1}{1-\eta}\sum_{h=1}^{H}\pi^h\left(v^h\right)^{1-\eta} \qquad \eta\neq 1 \quad \text{and} \quad 0\leq\eta<\infty, \\ &= \sum_{h=1}^{H}\pi^h \ln\ v^h, \qquad \eta=1, \end{aligned} \tag{12}$$

where $\eta \geqq 0$ denotes the inequality aversion index and u^h is the utility of household h. As is well-known, this social welfare function reduces to the utilitarian function for $\eta = 0$ and to the Rawlsian function when $\eta \to \infty$.

Armed with this social welfare function, one can compute a dollar value for change in welfare of the whole society. To this end we use the concept of the "social equivalent variation", EV^s.[40] We define this analogously to the Hicksian concept of equivalent variation for a h-household who faces higher prices for energy and subsidized food while being compensated by a uniform rebate, a. Specifically, one defines EV^s from the following relationship:

$$\sum_{h=1}^{H}\pi^h\left[v\left(\mathbf{q},m^h+EV^s\right)\right]^{1-\eta}=\sum_{h=1}^{H}\pi^h\left[v\left(\mathbf{q}',m^h+A^h\right)\right]^{1-\eta}. \tag{13}$$

It measures the amount of money one can give each household under the pre-reform policy regime such that the social welfare will be equivalent to its value under the implemented subsidy reform. Observe that EV^s is positive if the reform is welfare improving and negative if it is welfare reducing.

Table 12 reports EV^s for different η values. Observe that as η increases so does EV^s. For a utilitarian social welfare function, $\eta = 0$, the reform affects the society's welfare in the same way as a 23.7 TIT uniform lump-sum rebate to all households. If the inequality aversion index for the society is ten rather than zero, the reform will be equivalent to a 58.0 TIT uniform lump-sum rebate. *The more the society dislikes inequality, the more social welfare enhancing is the reform. This makes sense in that the reform redistributes from the more well-off to the less well-off households.*

[40] See Cremer, Gahvari, and Ladoux (2003).

4.3 Environmental benefits

We now turn to a third potential source of gain that will flow from the subsidy reform (in addition to the efficiency and redistributive considerations already discussed). Burning fossil fuels for production of energy leads to emission of greenhouse gases which entail "social costs". The 2009 Iran Energy Balance Report (IEBR) provides some data on this. This publication gives, for the year 2009, the emission figures for a number of hazardous gases associated with that year's consumption of fossil-fuel-burning components of the "energy good." Rows 1–7 in Table 13 present a modified version of these figures.[41] According to Table 13, country-wide households' consumption of energy in 2010 resulted in 234.1 million tons of carbon dioxide (CO_2), 42.1 thousand tons of methane (CH_4), 6.1 thousand tons of nitrous oxide (N_2O), 945.2 thousand tons of mono-nitrogen oxides (NO_x), 395.7 thousand tons of sulphur dioxide (SO_2), over 4.1 thousand tons of sulphur trioxide (SO_3), 8.4 million tons of carbon monoxide (CO), and 302.0 thousand tons of suspended particulate matter (SPM). Row 8 in Table 13 shows the social cost of each of these pollutants per ton.[42] Multiplying these numbers together (each of the first set of numbers by its corresponding number in the second set of numbers), one finds the social cost of emissions associated with different components of households' energy consumption in Iran in 2010. Summing them up, the total social cost of emissions for the whole country amounts to 14.4 billion TIT.[43]

To calculate the environmental benefits, we need to determine the country-wide reduction in energy consumption; not just in urban areas. Now comparing 2011 and 2010 HIES data (covering all four quarters), we find that according to our estimated

[41] Table 8.10 on page 282 of IEBR gives the emission levels for consumption of kerosene, gas oil, LNG, and natural gas by households, businesses, and the public sector in 2009. It also gives households' share of consumption in each (97.9% for kerosene, 29.9% for gas oil, 100% for LNG, and 88.9% for natural gas). In deriving the numbers presented in rows 2–5 of Table 13, we have applied these shares to the numbers given in Table 8.10 of IEBR while assuming that energy consumption and emission levels in 2010 are the same as in 2009. The figures for road transportation (row 1), railroad transportation (row 6), and air transportation (row 7) come from Table 8.12 of IEBR (page 283).

[42] The 2009 IEBR records social costs for 2002 prices. We have used the CBI general consumer price index to convert these numbers into 2010 prices.

[43] The "exact" figure, excluding the social costs associated with nitrous oxide and sulphur trioxide which are not available, is 14,383,787,356 TIT.

QUAID system, the subsidy reform reduces the domestic consumption of energy in urban areas by 23.76%. Following our previous assumption of similar rural and urban area responses, we assume a 23.76% reduction in energy consumption in rural areas as well so that the reduction in energy consumption for the entire country is 23.76%.

If we were to assume that there is a linear relationship between emissions and energy consumption, then the reform will reduce emissions too by 23.76%. This amounts to 3,418 million TIT less social damage.[44] Put differently, 3,418 million TIT is the environmental benefit of the subsidy reform.[45]

4.4 Government finances and the economy

We have thus far discussed the consequences of the reform on individuals. However, for these outcomes to actually materialize, one should also consider what the reform does to government's finances and how the government responds to the changes in its revenues and costs.

To determine how the subsidy reform affects government finances, consider the change in the government's subsidy costs as a result of the reform (implicit and explicit). This is simply equal to the changes in monetary values of the subsidies summed over all households living in both rural and urban areas. Algebraically, it is found from equation (11),

$$\sum_h \Delta S^h = \sum_h \left[A^h + S_e'^h - \left(S_e^h + S_f^h \right) \right].$$

[44] 14,383,787,356 × 0.2376 = 3,417,587,876.

[45] A note of caution is in order. Carbon dioxide, methane, nitrous oxide, and mono-nitrogen oxides are greenhouse gases with *global* social costs (even if not uniform everywhere). At the same time, the reform we have been discussing is predicated on the assumption that it reduces *domestic* consumption of energy but not its *global* consumption. What is not consumed domestically will be sold overseas. Consequently, in this setting, it is somewhat questionable to consider their reduction domestically as a social benefit. On the other hand, the other four items of hazardous gases—sulphur dioxide, sulphur trioxide, carbon monoxide, and suspended particulate matter—pertain to air quality. (We do not have data for the other three important determinants of air quality: lead, nitrogen dioxide, and ozone.) As such, one would expect that the domestic reduction in their consumption would lead to domestic environmental benefits. If we were to include only the reduction in the emissions of the last four items (SO_2, SO_3, CO, and SPM), we will come up with 1,886 million TIT (7,939,093,921 × 0.2376 = 1,886,328,716, for the environmental benefit of the subsidy reform.

Table 12: Social equivalent variation of the change in subsidies (per urban household, monthly, in TIT=$1)

Inequality aversion index	0.0	0.5	1.0	2.0	5.0	10.0
Social equivalent variation	23.746	36.257	45.031	54.504	58.710	58.025

Table 13: Emissions of hazardous gases in tons and their social costs for year 2010 in TIT=$1

Emissions of:	CO_2	CH_4	N_2O	NO_x	SO_2	SO_3	CO	SPM
Due to country-wide yearly consumption of: ↓								
Road transportation	115,820,357	39,526	5,364	807,245	340,992	3,642	8,312,710	270,761
Kerosene	16,424,210	686	137	3,155	15,138		4,920	0
Gas Oil	1,848,895	75	15	3,281	10,302	131	131	656
LNG	5,754,104	91	9	1,253	27		12,534	0
Natural Gas	89,524,950	1,596	159	82,792	332		11,094	7,907
Railroad transportation	919,273	51	355	8,809	5,481	65	2,351	4,307
Air transportation	3,807,949	27	107	38,642	23,389	277	43,208	18,388
Total emissions	234,099,737	42,052	6,146	945,177	395,660	NA	8,386,948	302,019
Social cost per ton	22	464	NA	1,326	4,032	NA	414	9,500
Social cost of emission	5,172,214,956	19,510,922	NA	1,252,967,557	1,595,369,024	NA	3,474,408,465	2,869,316,432

We first calculate this for urban households based on our previous calculations and the estimated demand system. The resulting figure is on a monthly basis. We multiply it by 12 to arrive at the yearly figure. This will give us a figure corresponding to the government savings from the urban areas. To "estimate" the corresponding figure for the rural areas, we simply assume that in the aggregate rural area households respond the same way as urban area households do to the changes in energy and food prices, and their new lump-sum rebates. This assumption is of course somewhat heroic; nevertheless, in lieu of the required information for the rural areas, we use it to come up with a very rough approximation as to what the country as a whole may experience. Thus whatever aggregate number we estimate for the urban areas, we multiply it by $5,757,799/15,427,848 = 0.3732$, which is the ratio of the number of rural to the number of urban households, and use it as the corresponding number for the rural areas.

Table 14 provides a macro picture of what the subsidy reform would do to the Iranian economy as a whole on an annual basis. Prior to the reform, according to our estimated QUAID system, the monetary costs of price subsidies were about 58.7 billion TIT per year (what the government could have received had it been selling energy products domestically at their international market prices). Our estimated model predicts that the subsidy reform would reduce the value of the price subsidies to about 17.6 billion TIT per year. At the same time, the reform distributes 43.4 billion TIT per year in cash to households. Consequently, the monetary values of the subsidies increase by over 2.3 billion TIT. This increase in implicit and explicit subsidies paid to households is effectively a net cost to the government. Which raises the question of how the government could have financed it. With no increase in tax revenues or public debt, the only mechanism that could support our reported calculations is an increase in government revenues through increasing its oil exports.[46] However, the dependence of the reform's outcome on oil exports is more entangled than the financing of the extra 2.3 billion TIT. We will take on this question in the next section.

[46] Of course, the government could also print money to finance the extra subsidy costs. However, this would be inflationary. It would also mean that our calculations could not materialize as reported requiring some modifications in the reported numbers.

Table 14: Economy-wide pre- and post-reform subsidy costs (yearly in 10^6TIT= \$1 million)

	Number of households	Pre-reform price subsidy costs	Post-reform price subsidy costs	Post-reform direct rebates	Change in the government's subsidy costs
		$\sum_h S^h$	$\sum_h S_e'^h$	$\sum_h A^h$	$\sum_h \Delta S^h = \sum_h \left(S_e'^h + A^h - S^h\right)$
Urban	15,427,848	42,739	12,785	31,631	1,678
Rural	5,757,799	15,950	4,772	11,805	626
Country	21,185,647	58,689	17,557	43,436	2,304

5 Export constraint and the feasible subsidy reform

In the previous section, we paid no attention to the fact that Iran is an oil producing and oil exporting country. This can, potentially, make a huge difference. As far as food subsidies are concerned, by eliminating their price subsidies the government will make immediate savings that can be used for other purposes (including paying cash rebates to households). With energy subsidies, the story is more complicated. To the extent that there are some refined energy products the government imports, cutting their consumption entails direct savings. For example, the present Iranian administration has admitted that despite its predecessors' claim to the contrary Iran continues to import a portion of its domestic gasoline consumption (with some estimates putting the figure at 30%).[47]

The fact remains, however, that most energy products consumed in Iran are produced domestically and "sold" by the government to domestic consumers at extremely low prices. Our discussion in the previous section implicitly assumes that whatever is no longer consumed domestically as the result of the reform will be sold abroad at their global prices (while the country's production remains unchanged). As it turns out, this has not been Iran's experience. Just about the time the country embarked on its energy

[47] See International Iranian Times, September 2013, and Press TV, July 2010.

subsidy reform, it also started to face more severe sanctions on its oil exports.[48]

With the sanctions applying to Iran's total oil exports (existing and potential), Iran appears to have experienced, subsequent to the reform, a reduction in its revenues from oil exports rather than an increase. To be sure, Iran has been taking actions to mitigate the effects of the sanctions including bilateral barter deals with India, China, and other countries.[49] The covertness of these deals, and lack of reliable data, make it practically impossible to know what exactly has happened to Iran's oil exports. What is certain is that Iran's oil production has fallen quite a bit. The US Energy Information Administration (July 2014 report) estimates a fall of nearly 25% between 2011 and 2013.

To highlight the critical role export constraints play in determining the effects of domestic reforms, we adopt the working assumption that Iran has been unable to increase its oil exports after the reform (thus balancing the reduction in its domestic consumption of energy by cutting its oil production). We then redo all the calculations of Section 4 under this alternative assumption. Put differently, while we recognize the subsidy reform has cut energy consumption and resulted in real savings for the economy, the savings have not led to any increase in the country's purchasing power. Rather, the savings have been in terms of oil that has remained in the ground for future generations and not immediately used to increase the consumption of other goods by the current generation (who have lost their price subsidies).

Figure 2 which depicts the domestic demand for energy is a good vehicle for describing the point. Let p denote the international market price of energy, q its pre-reform domestic price, and q' its post-reform domestic price. The reform reduces domestic consumption by $x'x = ox - ox'$ assuming no concomitant cash rebates.[50] Denote the area of $ox'Eq$ by (1), the area of $x'xAE$ by (2), the area of $qEDq'$ by (3), the area of EAD by (4), the area of $DABC$ by (5), and the area of $q'DCp$ by (6). Clearly, the

[48] The US has imposed sanctions on Iran since 1995. Starting in 2006, the UN passed a number of resolutions on Iran sanctioning various sectors of the economy. In 2007, the EU joined in too agreeing to an oil embargo in 2012.

[49] See, for example, Kozhanov (2011), The Financial Times (July 24, 2011), and Press TV (October 16, 2012).

[50] With cash rebates, the demand curve will shift upwards depending on the amount of the rebate. The same story can be told using this enlarged diagram, but the depiction will be somewhat less obvious to see.

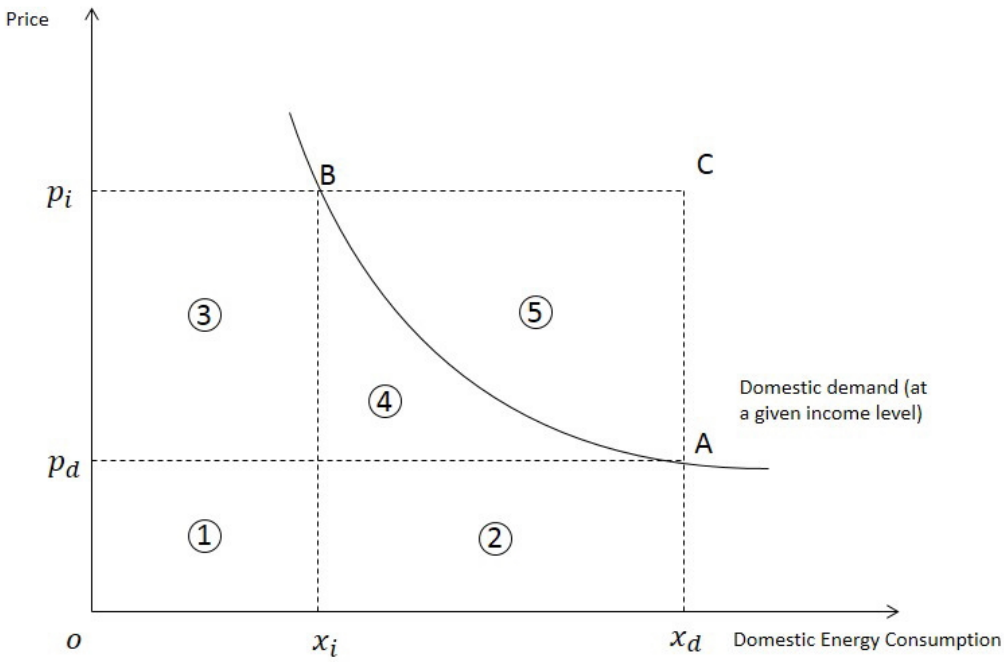


Figure 2: Welfare change in the presence of export constraints.

international market value of the reduced demand is equal to (2) + (4) + (5).

Now consider the monetary values of the pre-reform and post-reform implicit subsidies. These are given by (3) + (4) + (5) + (6) and (6), so that the monetary value of the price subsidy changes by $-[(3) + (4) + (5)]$. At the same time, given that the government sells energy domestically at pre- and post-reform prices of q and q', the pre- and post-reform *domestic* revenues are equal to (1) + (2) and (1) + (3). Hence the subsidy reform changes the government revenue from domestic sources by only $(3) - (2)$. It is only when $x'x$ is *actually* sold at the international price of p that the government also receives its international market value of (2) + (4) + (5) so that it experiences a *net* surplus of (3) + (4) + (5) from both foreign and domestic sources (as we assumed in Section 4). Observe also that this is equal to the negative of the change the monetary value of the price subsidy to the domestic consumers.

If the government is unable to sell $x'x$, its actual revenue changes only through its domestic component and by $(3) - (2)$.[51] Of course, this is not to suggest that $x'x$ has gone to waste. It will stay unexploited under the ground and is part of the country's national wealth. It can make some future generations better off but is *not* available for current consumption. Consequently, the welfare calculus for the current generations that was done in Section 4) needs to be modified.

The government's inability to increase its exports limits what it can pay to households as cash rebates. The current individual monthly rebates of 44.5 TIT may indeed be infeasible. In order to determine the maximum cash rebates the government can pay, one has to make sure that the government's revenues with the rebates remain the same as without (while recognizing that any extra revenues from higher energy prices can come only from domestic consumers).

Recall that m_j^h denotes the amount household h spent on the jth component of energy (with the components being specified in Table 9). Let $M_e^h = \sum_j m_j^h$ denote the amount household h spent on all components of energy at their pre-reform sub-

[51] Observe that this change can be negative. If this were to happen, domestic consumers will end up consuming not only less energy but also less of the other goods. This will certainly make them even further worse off.

sidized prices. With energy goods being purchased directly from the public sector, the pre-reform government revenues from domestic sales of energy products must have been $\sum_h M_e^h$.[52] Let b denote the lump-sum cash rebate to an Iranian consumer after the reform. The domestic sales of energy products after the reform will be equal to $q_e' \sum_h x_e^h \left(q_e', p_f, \overline{\mathbf{p}}, m^h + n^h b\right)$.[53] Additionally, after the reform, the government saves all the food subsidies it used to incur, amounting to $\sum_h S_f^h$, while having to pay $\sum_h n^h b$ in rebates. For the government to "domestically break even," the value of b is found as the solution to[54]

$$\sum_h \left[q_e' x_e^h \left(q_e', p_f, \overline{\mathbf{p}}, m^h + n^h b\right) - M_e^h + (p_f - q_f)\, x_f^h \left(q_e, q_f, \overline{\mathbf{p}}, m^h\right) - n^h b\right] = 0. \quad (14)$$

Solving equation (14) numerically, we find $b = 12.8$ TIT.[55] In words, if the government cannot sell the energy that the country no longer consumes domestically because of the reform, it can only pay each individual 12.8 TIT per month, rather than its currently mandated 44.5 TIT, in order to avoid a deficit. What has actually happened in Iran is that the government has "borrowed" the required funds for rebates from its Central Bank. Put differently, it has simply printed money to finance the cash rebates that it does not have funds for (because it cannot sell the extra oil that it has on its hands). In effect, the extra 31.7 TIT paid to each individual has gone only to feed inflation.[56] To asses the welfare properties of a non-inflationary reform, one needs to examine the effects of a reform that is based on a "real" monthly cash payment of 12.8 TIT per person.

Table 15 reproduces Table 10 based on the 12.8 TIT payment. The pre-reform subsidies in this table are identical to the corresponding entries in Table 10. As is also clear, the households' direct rebates (column 5), are less than those in Table 10. Less obvious is the fact that the implicit post-reform price subsidies are also less than

[52] A small fraction of the transportation component goes to services. We have ignored this component in our calculations.

[53] We are assuming that, with this reform too, households continue to buy gasoline in excess of its quota.

[54] This summation is carried out over all households, rural as well as urban.

[55] The more precise figure is $b = 12.777$.

[56] See Gahvari (2012) for a discussion of inflation in connection with the Iranian subsidy reform.

Table 15: Change in monetary values of subsidies with export restrictions and domestically revenue-neutral rebates (per urban household, monthly, in TIT=$1)

Income group	Range of Expenditures	Pre-reform price subsidies	Post-reform price subsidies	Direct rebates	Change in the amount of subsidies
		S^h	$S_e'^h$	$B^h = n^h b$	$\Delta S^h = B^h + S_e'^h - S^h$
1	36–227	84.246	21.968	33.206	–29.073
2	227–308	124.662	31.611	42.568	–50.482
3	308–376	151.049	38.680	46.511	–65.858
4	376–443	174.676	43.890	48.764	–82.022
5	443–519	184.584	46.630	50.811	–87.143
6	519–607	213.674	54.825	51.649	–107.199
7	607–721	236.202	59.619	53.270	–123.313
8	721–890	282.724	70.478	53.497	–158.749
9	890–1,219	347.913	86.811	54.328	–206.774
10	1,219–5,190	508.787	133.082	55.945	–319.759
11	1,594–5,190	592.932	159.709	55.122	–378.101
12	2,624–5,190	718.259	202.499	55.112	–460.647
Average	651	239.962	59.716	49.055	–131.192

those reported in Table 10 (as indicated by the entries in the fourth column of the two tables). The reason for this is the fact that with less direct rebates, households become less "well-off" than previously. As a result, they will consume less of all goods including energy. This in turn implies that their implicit price subsidies will also be lower. The final outcome is reflected in the negative entries for the last column in Table 15 (as opposed to the previously discussed reform depicted in Table 10 which had positive entries for the lower 7 deciles and negative entries for the upper 3 deciles). What this tells us is that the reform *reduces* the monetary value of the subsidies to households in *all* income groups.

Similarly, Tables 16–17 reproduce Tables 11–12 for the 12.8 TIT payment. According to Table 16, equivalent variations are now all negative; indicating that all households are becoming worse off as a result of this reform (despite the fact that the prices have moved in the "right" direction). Observe that all income groups show a smaller loss in terms of equivalent variation as compared to pure income effects. This is the result of the efficiency gains in moving from price subsidies to cash subsidies. Observe also that the EV losses increase with income. This reflects an improvement in income distribution: Richer households received more implicit price subsidies and thus lose more. But the improvement in income distribution is of cold comfort for the current generations of Iranians. The crucial point is that the reform makes all households worse off. The bottom decile becomes worse off in the same way as it would under a per month lump sum tax of 8.8 TIT (with no price changes); the top decile by a monthly lump-sum tax of 240.6 TIT (with no price changes).[57]

The same lessons emerge from the computations reported in Table 17. The social equivalent variation is negative for all inequality aversion indices reported; households become worse off regardless of the society's aversion to inequality. For a utilitarian social welfare function, the reform affects the society's welfare in the same way as a 79.0 TIT uniform lump-sum tax on all households (with no price changes). If the inequality aversion index for the society is ten rather than zero, the reform will be equivalent to a uniform lump-sum tax of 8.9 TIT (with no price changes). *That the losses decline in absolute value indicates that the subsidy reform becomes "less undesirable" as the society cares more about inequality. This is in line with our earlier observation that the reform improves the income distribution.*

5.1 Environmental benefits

Recall that in subsection 4.3, we calculated that the total pre-reform social cost of emissions for the whole country was 14.4 billion TIT. Based on our estimated QUAID system, we now find that, with a per person rebate of 12.8 TIT, the subsidy reform reduces the domestic consumption of energy in urban areas by 34.68%. Per our earlier discussion, we assume the same reduction for rural areas and the country as a whole. Again, assuming a linear relationship between emissions and energy consumption, the reform will reduce emissions by 34.68% as well. This amounts to 4,988 million TIT less

[57] The figure is as high as 415.2 for the highest percentile.

Table 16: Equivalent variation of the change in subsidies with export restrictions and domestically revenue-neutral rebates (per urban household, monthly, in TIT=$1)

Income group	Range of Expenditures	Monetary value of subsidy changes	Equivalent variations
1	36–227	–29.073	–8.775
2	227–308	–50.482	–21.210
3	308–376	–65.858	–31.151
4	376–443	–82.022	–41.106
5	443–519	–87.143	–51.700
6	519–607	–107.199	–64.766
7	607–721	–123.313	–79.582
8	721–890	–158.749	–101.464
9	890–1,219	–206.774	–135.701
10	1,219–5,190	–319.759	–240.561
11	1,594–5,190	–378.101	–293.825
12	2,624–5,190	–460.647	–415.181

Table 17: Social equivalent variation of the change in subsidies with export restrictions and domestically revenue-neutral rebates (per urban household, monthly, in TIT=$1)

Inequality aversion index	0.0	0.5	1.0	2.0	5.0	10.0
Social equivalent variation	–78.984	–59.035	–44.055	–25.589	–10.618	–8.881

Table 18: Pre- and post-reform subsidy costs with export restrictions and domestically revenue-neutral rebates (yearly in 10^6 TIT= \$1 million)

	Number of households	Pre-reform price subsidy costs	Post-reform price subsidy costs	Post-reform direct rebates	Change in monetary values of subsidies received
		$\sum_h S^h$	$\sum_h S_e'^h$	$\sum_h B^h$	$\sum_h \Delta S^h = \sum_h \left(S_e'^h + B^h - S^h\right)$
Urban	15,427,848	42,739	10,878	9,082	–22,778
Rural	5,757,799	15,950	4,060	3,389	–8,501
Country	21,185,647	58,689	14,938	12,471	–31,280

social damage to the environment so that 5.0 billion TIT is the environmental benefit of the subsidy reform.[58]

5.2 Economy-wide changes

Table 18 is the counterpart of Table 13 for a per person rebate of 12.8 TIT. The entries there are found from deriving the monthly subsidy figures for the urban households, multiplying them by the corresponding numbers of households in urban and rural areas, and then multiplying by 12.

Note in particular that the reduction in monetary value of subsidies to households in this scenario cannot be considered as a net gain to the government. The gain to the government is the value of the energy that is no longer consumed domestically and the oil which remains under the ground. What value one should assign to this is uncertain. It depends crucially on what will happen to oil prices in light of future demand increases for energy and the development of alternative energy sources. It also depends on market and social discount rates and how one ought to evaluate the welfare of future generations as compared to current generations.

[58] 14,383,787,356 × 0.3468=4,988,297,455. Under this scenario, the reduction in domestic consumption of energy is not exported and one need not worry about global offsetting social costs.

5.3 Inflation to the "rescue"

We close our discussion by a word of caution as to the actual effects of the subsidy reform in Iran. Thanks to inflation, Iranian households did not experience the losses we have depicted here. The point is that the calculations reported in this section pertain to the outcome of a feasible reform that would not trigger inflation. It could also describe how the economy might look like, at least approximately, if the ensuing inflation were to affect the entire economy uniformly: A proportionately uniform increase in all prices tends to leave "real" economic variables unaffected. However, this could not have been the outcome of the subsidy reform in Iran. The point is that the government sets the energy prices in Iran. Consequently, the extra money that was in fact printed and given to households as rebates (in order to finance the extra monthly payments of 31.7 TIT to each person), could not have gone to increase domestic energy prices. Inflation could have manifested itself only in non-energy commodity prices (not set by the government).

The above observation has important implications about the actual effects of the subsidy reform. To start with, it implies that the increase in the domestic price of energy *relative* to non-energy goods could not have been as huge as posited in our calculations. In turn, the lower increase in the relative price of energy means a smaller reduction in the post-reform domestic demand for, and consumption of, energy. Consequently, the end result of the subsidy reform must be one in which the welfare of current generations of Iranians could not have been lowered by as much as the computed numbers in this section suggest. Of course, the environmental benefits would also be less and the unexploited oil left under the ground that could benefit of future generations would also be smaller.

Unfortunately, at this point, we have no means of calculating the magnitudes of these other changes (resulting from the special way that inflation has affected the structure of relative prices). First, there are no reliable data on inflation in recent years. On top of this, there have been many other reasons for recent inflation in Iran besides the rebates. The most important of these is of course the sanctions that the international community has imposed on Iran. It will be an extremely difficult exercise to disentangle these effects and isolate the part that has been caused by the excessive rebates.

6 Conclusion

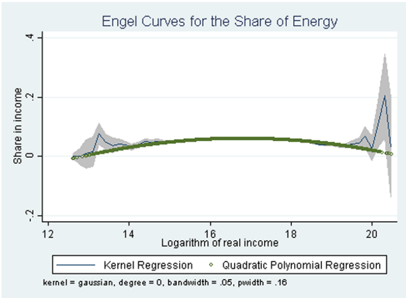
This paper has estimated a Quadratic Almost Ideal Demand System, consisting of seven broad categories of goods, for the Iranian economy. The data for estimation consists of 293,953 urban households. It has come from repeated cross sections of the Household Budget Survey of the Statistical Center of Iran for the period 1987–2011 coupled with the price data from the Central Bank of Iran. It has used the estimated model to study the recent elimination of price subsidies on energy and basic foodstuff in Iran and replacing them with cash subsidies.

The estimate of the underlying indirect utility function has allowed us to compute exact welfare measures for non-marginal tax/subsidy reforms (in contrast to the prevalent use of Ahmad and Stern (1984) approach in the literature for examining marginal commodity tax reforms.) Our findings have shed light on the questions of the efficiency and equity gains in switching from price to cash subsidies, the incidence of the reform on different income groups (who gained, who lost, and by how much), and the environmental benefits that come with a reform that cuts energy consumption.

In studying these questions, the paper has distinguished between two scenarios. In one, there is no export constraint with the reduction in domestic consumption of energy being sold overseas at international market prices. In the other, the country faces an export constraint. As a result, what is not consumed domestically cannot be sold overseas to benefit the current generations of Iranian. The paper has shown that under this constraint the country does not have the financial wherewithal to fund the promised cash rebates. As a result, its cash rebate policy has led to inflation in the country. The paper has calculated the maximum cash rebate that the government could afford to distribute to its citizens, under a budget revenue neutral reform, without causing inflationary pressures. It has redone the welfare calculus of the reform under the "affordable" rebate. The result is that a seemingly welfare improving policy may turn out to be quite the opposite—at least for the current generations.

It goes without saying that the unconsumed energy has not vanished into thin air. More oil has remained under the ground. However, what value one should assign to this is uncertain. It depends crucially on what the future has in store for oil prices in light of international market demand conditions for energy and the development of alternative energy sources. It also depends on market and social discount rates and how one ought to evaluate the welfare of future generations as compared to current generations. Even more importantly, there is no reason to believe that the current Iranian oil production/extraction is optimal to begin with. A thorough examination of these issues remains beyond the scope of this paper.

Appendix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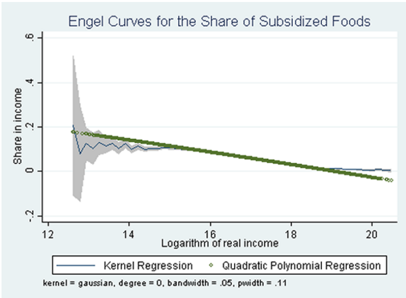
Share in income
Logarithm of real income
Kernel Regression
Quadratic Polynomial Regression
kernel = gaussian, degree = 0, bandwidth = .05, pwidth = .16


Engel Curves for the Share of Subsidized Foods
Share in income
Logarithm of real income
Kernel Regression
Quadratic Polynomial Regression
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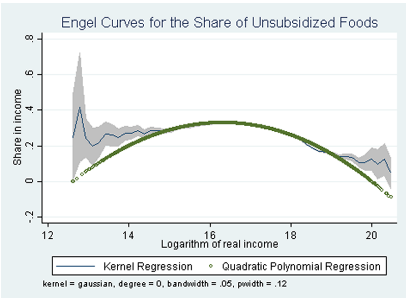
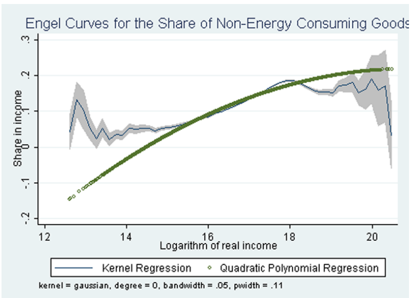
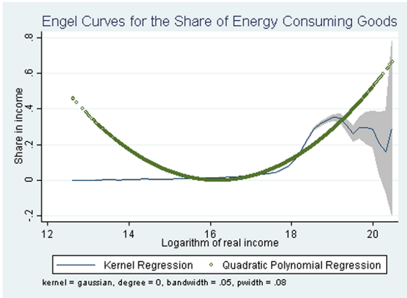
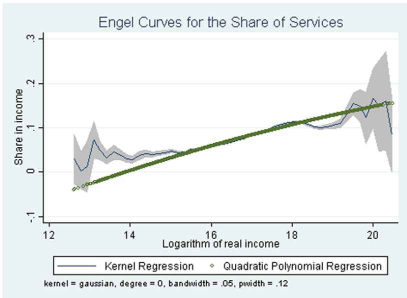

Engel Curves for the Share of Unsubsidized Foods
Share in income
Logarithm of real income
Kernel Regression
Quadratic Polynomial Regression
kernel = gaussian, degree = 0, bandwidth = .05, pwidth = .12

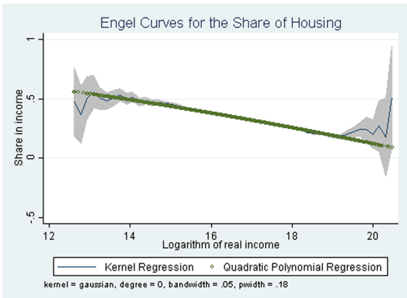

Engel Curves for the Share of Non-Energy Consuming Goods
Share in income
Logarithm of real income
Kernel Regression
Quadratic Polynomial Regression
kernel = gaussian, degree = 0, bandwidth = .05, pwidth = .11



Engel Curves for the Share of Energy Consuming Goods
Share in income
-.2
0
.2
.4
.6
.8
12
14
16
18
20
Logarithm of real income
Kernel Regression
Quadratic Polynomial Regression
kernel = gaussian, degree = 0, bandwidth = .05, pwidth = .08



Engel Curves for the Share of Services
Share in income
-.1
0
.1
.2
.3
12
14
16
18
20
Logarithm of real income
Kernel Regression
Quadratic Polynomial Regression
kernel = gaussian, degree = 0, bandwidth = .05, pwidth = .12



Engel Curves for the Share of Housing
Share in income
-.5
0
.5
1
12
14
16
18
20
Logarithm of real income
Kernel Regression
Quadratic Polynomial Regression
kernel = gaussian, degree = 0, bandwidth = .05, pwidth = .18

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