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Abstract

This paper studies the incidence of broad-based energy subsidies, and whether poor households could gain from targeted transfer programs financed by savings from energy subsidy reform. We analyze the tariff differential subsidy program in Pakistan, and find that the subsidy is regressive. We conduct a computable general equilibrium exercise and find that reducing energy subsidy would hurt both poor and non-poor households. However, redistributing savings from subsidy reform to poor households, would improve poor household's welfare.

Keywords:Computational General Equilibrium, Subsidy Reform, Social Safety Net
JEL Code: D58, H53, I38
Competing Interest: None.

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1 Introduction

Many developing countries allocate substantial amounts of public resources to support broad-based energy subsidies. Pre-tax petroleum and electricity subsidies amounted to, respectively, 0.34% and 0.23% of global GDP in 2013. Advanced economies had only a 4% share in the global energy subsidies, while the rest belonged to developing countries (Coady *et al.*, 2015). Consumers, in countries that subsidize energy products, pay a lower price for energy as governments bear a significant part of the energy expenditure burden. Proponents of energy subsidies claim that broad-based subsidies benefits poor households, who otherwise could not consume fuel and electricity at higher prices. However, studies show that substantial part of broad-based subsidy benefits are captured by non-poor households (del Granado *et al.*, 2012). Moreover, energy subsidies in developing countries crowd out priority sector public spending and aggravate fiscal imbalances (Clements *et al.*, 2013). Alternatives to broad-based energy subsidy are targeted subsidies or targeted transfer programs for the poor. However, targeting could be costly[1] and hard to implement in developing countries. Hence, whether a broad-based energy subsidy is a good policy choice or not, is an interesting public finance question for developing countries.

To investigate this issue, we analyze the tariff differential subsidy (TDS) program in Pakistan. Using household level microdata, we first analyze the incidence of the TDS across consumption expenditure quintiles. We find that top quintiles receive higher proportion of subsidy benefits. Our analysis provide evidence in support of the regressive nature of the electricity subsidy program in Pakistan. We then conduct a computable general equilibrium (CGE) analysis for Pakistan, where we run

[1] Costs of targeting include administrative cost, private cost, incentive cost, social cost, and political cost (Coady *et al.*, 2004).

simulations of three different forms of energy reform: energy subsidy reduction, energy subsidy reduction and transfer payment to poor households, and energy subsidy increase. Results from CGE analysis suggest that all types of households get hurt in the medium term from subsidy reductions. However, when savings from subsidy reduction are distributed among poor households, recipient households experience comparative improvement in real income and welfare.

In a similar exercise on Pakistan, Walker *et al.* (2014) analyze reform scenarios where the electricity subsidy as percentage of GDP gradually declines over time, and electricity tariffs are adjusted accordingly to held electricity subsidy expenditures to a certain percentage of GDP. They also analyze scenarios where the government provides targeted compensation to the poorest households. Their analysis differs from ours in that they do not use savings from subsidy reform to be distributed among poor. Rather, they arbitrarily decide to top-up the existing cash transfer program payment[2]. Our counterfactual scenarios are similar to those of Dennis (2016), where energy subsidies are completely eliminated in the first counterfactual simulation, and fiscal savings are fully transferred to households in the second counterfactual simulation. However, unlike our counterfactual scenario, transfers are not targeted by income level, rather all households receive compensation. Rentschler (2016) conducts a similar exercise on Nigeria, where savings from subsidy reform is again redistributed to all Nigerians through a uniform cash compensation scheme. Other studies mostly focus on the welfare effects of subsidy reform, and do not analyze scenarios with targeted transfers (Wesseh *et al.*, 2016; Jiang *et al.*, 2015).

[2]They analyze the scenario where monthly benefit of Benazir Income Support Programme (BISP) is increased by Rs. 300.

The remainder of the paper is organized as following: section 2 provides an overview of the electricity subsidy and analysis of electricity subsidy incidence in Pakistan, section 3 describes the computable general equilibrium specification, section 4 provides data sources, section 5 provides simulation results, and section 6 outlines conclusion and directions for future research.

2 Overview of the Energy Subsidy in Pakistan

The Government of Pakistan runs a sizable energy subsidy program that accounts for 15.1% of the current public expenditure and 2.2% of GDP in 2011-12 (Table 1). Pakistan also runs an annual budget deficit of more than 5% of GDP. Hence, the energy subsidy is a substantial part of public spending in the context of Pakistan. Almost all of the energy subsidy goes to electricity consumers under the Tariff Differential Subsidy (TDS) program. The National Electric Power Regulatory Authority (NEPRA) determines cost-recovery electricity tariffs for different distribution companies (DISCOs) across Pakistan[3]. The Government of Pakistan (GOP), however, sets an uniform tariff for all DISCOs, and pays DISCOs the difference between NEPRA determined tariff and GOP notified tariff via TDS. TDS alone accounts for 96.8% of the total energy subsidy, and 89.2% of the total subsidy in 2011-12. Residential consumers receive half of the TDS in 2012-13; while one quarter goes to industry, and the remainder goes to low-consuming businesses (Walker *et al.*, 2014). In this paper, we focus on domestic electricity consumption, which is 47% of the total electricity consumption in Pakistan.

[3]There are 10 distribution companies in Pakistan. Five are located in Punjab, three in Sindh, one in Balochistan, and two in Khyber Pakhtunkhwa. Cost recovery tariffs vary across regions based on geographic location, proportion of urban and rural consumers, etc.

2.1 Energy Subsidy and Priority Sector Spending

From 2008-09 to 2015-16, Pakistan spent around 7% of current expenditure, on average, on TDS. It was as high as 14.6% in 2011-12[4], but gradually declined to 2.9% of current expenditure in 2015-16 (Table 3). During 2011-12, Pakistan had a budget deficit of 6.5% of GDP, and TDS was 33.4% of the budget deficit. These large subsidy spending limits the government's ability to spend in priority sectors like education, health, and social welfare. During 2008-09 to 2015-16, Pakistan spent only 2.1% of current expenditure on average in health and nutrition, 10.7% in education, and 2.4% in social security and welfare (Table 2). Pakistan's spending in these sectors has been much lower than those of other South Asian countries, India and Bangladesh. From 2008-09 to 2014-15, India and Bangladesh, on average, spent 13.1% and 14.5% of current expenditure respectively in education, while Pakistan's average spending in education during this period was only 10.5%. During the period, Pakistan spent only 2% of current expenditure, on average, on health, while average spending in India and Bangladesh were 3.9% and 5% respectively. The story is similar for social security and welfare, where Pakistan's average spending of 2.2% of current expenditure was significantly lower than India's 3.8%, and Bangladesh's 7.4%.

Lower spending in priority sectors could also cause negative socioeconomic outcomes. The expected years of schooling in Pakistan is 8.1 years, while it is 11.7 years in India, and 10.2 years in Bangladesh. Life expectancy at birth in India and Bangladesh is 68.3 years and 72 years respectively, which is 66.4 years in Pakistan. Infant mortality rate per 1,000 live births is 30.7 and 37.9 respectively in Bangladesh and India, while it is as high as 65.8 in Pakistan (UNDP, 2016). Thus Pakistan is lag-

[4]This was primary due to increase in oil prices in the international market.

ging behind in priority sector spending, but spends substantial amounts of resources on energy subsidies. This is one of the rationales for Pakistan to cut subsidies and to create fiscal space for priority sector spending.

2.2 Calculation of the Tariff Differential Subsidy

For domestic consumption, electricity tariffs in Pakistan are different for different units according to level of usage. There are 5 consumption slabs for residential electricity consumption exceeding 50 kWh[5]. These slabs are - i) 1 to 100 kWh, ii) 101 to 200 kWh, iii) 201 to 300 kWh, iv) 301 to 700 kWh, and v) above 700 kWh. The electricity tariff per kWh increases in ascending order from lower to higher consumption slabs. For example, the GOP announced tariff for "1 to 100 kWh" slab was Rs. 5.8 per kWh in 2011-12, while it was Rs.15.1 per kWh for the "above 700 kWh" slab. Prior to 2013-14, residential consumers, consuming electricity at any slab benefited from lower tariffs at each of the previous slabs. For example, if a household consumed 250 kWh of electricity, then it would pay the "1 to 100 kWh" slab tariff for the first 100 kWh, "101 to 200 kWh" slab tariff for the next 100 kWh, and "201 to 300 kWh" slab tariff for the last 50 kWh. Since 2013-14, consumers are allowed only to use the lower tariff benefits of the previous slab. For consumption of 250 kWh of electricity, the household would now pay "101 to 200 kWh" slab tariff for the first 200 kWh, and "201 to 300 kWh" slab tariff for the last 50 kWh.

For each of the 10 DISCOs, NEPRA determines per unit consumption tariffs for each slab. Provincial averages of NEPRA tariffs for different consumption slabs are presented in Table 4. The average NEPRA per unit tariff for the "1 to 100

[5] Residential consumers consuming 1 to 50 kWh of electricity are considered as "Life-line Consumers" and pays a minimal tariff of Rs. 2.00 per kWh.

kWh" consumption slab was lowest in Punjub (Rs. 9.4), and highest in Khyber Pakhtunkhwa (Rs. 11.5) in 2011-12. The GOP determined tariff for each slab is also reported in Table 4. The GOP tariff for the "1 to 100 kWh" consumption slab was Rs.5.8 in 2011-12. The tariff differential subsidy is the difference between the NEPRA tariff and GOP tariff. Hence, the per unit subsidy for "1 to 100 kWh" consumption slab in 2011-12 was Rs.3.6 in Punjab, and Rs.5.7 in Khyber Pakhtunkhwa. The calculated per unit subsidy amounts are presented in Table 5. Since 2013-14, if GOP tariff is greater than NEPRA tariff, then the government imposes a surcharge equal to the tariff difference to ensure uniform GOP tariff across all provinces. Average electricity consumption per domestic connection was 137.21 kWh in 2011-12, average monthly expenditure per domestic connection was Rs.1044[6], and average monthly subsidy benefit received was Rs.635.6.

2.3 Subsidy Incidence

From Table 5, we can see that per unit tariff differential subsidy is different at different consumption slabs. Total subsidy benefits depend on the amount of electricity consumption. For example, a household in Punjab, consuming 250 kWh of electricity in 2011-12 would receive a TDS benefit of Rs.998. The household would receive Rs.786 of TDS benefit if it consumed 200 kWh of electricity, and Rs.1210 of TDS benefit if it consumed 300 kWh of electricity. Subsidy benefits also differ across states. A household in Sindh, would receive TDS benefit of Rs.1520 for consumption of 250 kWh of electricity, which is Rs.521 higher than the TDS benefit for same amount of electricity consumption in Punjab. Since households consuming higher amount of electricity receives higher TDS benefit,[7] we must analyze electricity consumption of

[6]There is a general sales tax (GST) of 16% on electricity consumption.

[7]Since 2013-14, TDS benefit increases with electricity consumption up to 300 kWh, and declines for consumption above 300 kWh. For Balochistan and Khyber Pakhtunkhwa, benefits decline after

households to understand subsidy incidence. If wealthier households consume more electricity than poor households, then TDS would be regressive, that is, wealthier households will acquire larger shares of TDS benefit. We analyze household level microdata from the Pakistan Social and Living Standards Measurement (PSLM) Survey, and the Household Integrated Economic Survey (HIES) of Pakistan to produce evidence for the nature of electricity subsidy incidence in Pakistan. We use data for 2010-11, 2011-12, 2013-14, and 2015-16 rounds of PSLM and HIES, whichever are available for the respective survey year.

From PSLM and HIES data, we know monthly electricity consumption expenditure of the households. The households can be geographically identified across provinces of Punjab, Sindh, Balochistan, and Khyber Pakhtunkhwa; and across urban and rural areas. Since we know the electricity tariff and General Sales Tax (GST) rates on electricity bills, we can calculate the amount of electricity consumption for each household in the sample. Using per unit TDS benefits from Table 5, we can also calculate total TDS benefit received by each household. For subsidy incidence analysis, we first aggregate total TDS benefit by electricity consumption slabs and construct 100% stacked bar graphs for provinces across urban and rural areas. We also construct 100% stacked bar graphs for aggregate number of households in each slab. From the diagrams, we can see that most of the aggregate TDS benefit is received by consumers at "101 to 200 kWh" consumption slab in urban areas (Figure 1). Consumers at "1 to 100 kWh" consumption slab receives very little aggregate TDS benefit compared to share of households consuming at "1 to 100 kWh" slab. This provides initial evidence from household level data that TDS benefit is higher for higher level of electricity consumption. Consumers at "101 to 200 kWh" consump-

700 kWh in 2014-15.

tion slab also receive a majority of the aggregate TDS benefit in rural areas (Figure 1).

Next, we calculate household expenditure quintiles for urban and rural regions for each of the 4 provinces. We then calculate average electricity consumption per household by expenditure quintiles. Average electricity consumption at 1^{st} quintile of urban Punjab is 124.5 kWh in 2011-12, while that is 158.1 kWh and 291.7 kWh at 2^{nd} and 5^{th} quintiles respectively. For both urban and rural, and for all 4 provinces, average electricity consumption increases with ascending order of quintiles. Since the amount of subsidy received varies with the level of electricity consumption, households at bottom quintiles receive relatively lower average subsidy benefits than households at top quintiles. We then calculate average TDS benefit per household at different quintiles, and present results in Table 6 and Table 7 for urban and rural areas respectively. These numbers also show that the average subsidy benefit is higher at higher quintiles. The average TDS benefit at 1^{st} quintile of urban Punjab is Rs.472, whereas it is Rs.1119 at 5^{th} quintile. These results further confirms the regressive nature of electricity subsidy incidence in Pakistan.

Finally, we aggregate TDS benefit by household percentiles, and construct a Lorenz Curve type diagrams for all four provinces (Figure 2). In the horizontal axis we have cumulative share of income, and in the vertical axis we have cumulative share of TDS. Line of equality is defined by points where cumulative share of subsidy receipts equals to cumulative share of income. The subsidy is regressive if the cumulative share of subsidy is less than cumulative share of income. From the diagrams we see that TDS benefit is regressive in all provinces. However, it is more regressive in urban areas, and the distribution is quite close to the equality line for rural areas except for Balochistan. All these analyses provide evidence that rich households receive more benefits from electricity subsidy, compared to poor households. This is another rationale for implementing subsidy reform, and creating fiscal space for social welfare in Pakistan. The disparity in subsidy benefit distribution, however, is relatively smaller in 2015-16, because of government's policy to limit TDS benefit at higher consumption slabs. This suggests that targeted subsidies could generate better distribution outcomes than broad-based subsidy programs.

3 A General Equilibrium Specification

We use a dynamic general equilibrium model similar to Feltenstein & Shamloo (2013), which endogenously generates an underground economy. This type of model had been used in Feltenstein & Cyan (2013) and Feltenstein *et al.* (2017) for a computable general equilibrium analysis of Pakistan economy, which has a sizable informal sector[8]. The model has n discrete time periods, and agents optimize in each period over a 2 period time horizon. Agents have perfect foresight over 2 periods, and expectations for future periods. At period t, agents know prices for period t and period $t+1$, and have expectations[9] for prices for future periods after $t+1$. At period $t+2$, new information are available to agents, and they re-optimize for periods $t+2$ and $t+3$. Details of our general equilibrium framework are presented in the Appendix section.

4 Data

In this paper, we use data from four major sources. First, aggregate subsidy and government expenditure data come from various publications of the Pakistan Ministry

[8]The size of informal economy is more than 30% of GDP in Pakistan (Gulzar *et al.*, 2010).

[9]Agents form expectations based on weighted average of historical prices, and agents' past errors in predicting those prices (Feltenstein & Cyan, 2013).

of Finance. Second, electricity tariff data is obtained from National Electric Power Regulatory Authority (NEPRA) publications. Third, household level microdata from Household Integrated Economic Survey (HIES) of the Pakistan Bureau of Statistics (PBS) are used for subsidy incidence analysis. Finally, for the computable general equilibrium (CGE) analysis, we use the social accounting matrix (SAM) for Pakistan, developed by The World Bank.

We obtain subsidy expenditure data from Pakistan Federal Budget, Budget in Brief documents for various years. Sectoral and total expenditure, budget deficit, and GDP data are obtained from "Summary of Consolidated Federal and Provincial Expenditure" in Pakistan Fiscal Operations documents for various financial years, and Pakistan Economic Review various issues. Government of Pakistan (GOP) notified electricity tariff, and NEPRA determined electricity tariff data are obtained from NEPRA's State of Industry Report, various issues. For South Asian comparison of public expenditure in priority sectors, data for India is obtained from Indian Public Finance Statistics 2014-15; and data for Bangladesh come from "Statement III" in Budget in Brief documents, various issues.

We use 2010-11, 2011-12, 2013-14, and 2015-16 rounds of PSLM and HIES data for household level analysis. There are 14,720 households[10] in PSLM 2011-12, of which 45% are urban households, and the rest 55% are rural households. Punjab has the highest proportion of households with nearly 45%, followed by 25% in Sindh, 8% in Balochistan, and remaining 22% in Khyber Pakhtunkhwa. Of the 16,044 households in PSLM 2013-14, only 38% resides in urban areas, and 62% resides in rural areas.

[10]Households, for which electricity consumption data are not available, are excluded from analysis. Around 7% of households in 2011-12 doesn't have electricity consumption data.

Provincial distributions of households are similar to that of PSLM 2011-12. In HIES 2015-16, provincial distribution also remains similar; however, urban and regional distribution of households gets reversed. Of the 22,792 households, 70% are in urban areas, and the rest 30% are in rural areas.

The social accounting matrix for Pakistan, used in the CGE analysis, is based upon Debowicz *et al.* (2013) and provided by The World Bank. This social accounting matrix is similar to the one of 2008, and has been updated for 2010. The original SAM has 18 household categories, 10 types of labor, 13 types of land (including water bodies), and 4 types of capital. Labor is the major factor share for urban quintile 1 and urban quintile 2, whereas formal capital is the major share for urban other category. For 3 medium farm categories, land is the largest factor share. For the rest of the categories, other capital is the largest factor share. There are 50 types of consumption categories, of which 18 are food categories. Food is by far the largest consumption share for all categories except 3 medium farm categories. Food share in consumption is also relatively smaller for urban other and rural non-farm other categories. The 50x50 I-O matrix represents 2010 technology. For computational simplicity, the original I-O matrix is aggregated to 27x27 matrix, where the first 26 rows and columns corresponds to domestic production, and the 27^{th} row and column represent single aggregate import.

5 Simulations

The subsidy incidence analysis for Pakistan suggests that rich households receive more benefits from broad-based electricity subsidies, compared to poor households. Hence, a better policy could be reducing broad-based subsidy expenditure and compensate poor households with targeted transfers. In the CGE analysis for Pakistan, we try to analyze the effects of energy subsidy reduction and transfer of savings from subsidy reduction to poor households. There is a 16-17% GST on electricity consumption in Pakistan. However, because of the tariff differential subsidy, effective GST rates are much smaller and vary across provinces (Figure 3). We calculate that the average effective GST rate in 2012 is approximately 9% (Table 8). In the benchmark simulation, the value added tax rate for energy sector is set at 9%, and in counterfactual simulations, it is set at 16%. We run 2 counterfactual simulations. In the first counterfactual simulation, the energy subsidy is reduced as the effective tax rate is increased to 16%, which essentially generates budgetary savings. In the second counterfactual simulation, the budgetary savings from first counterfactual simulation is distributed as a lump sum to four poor household categories – urban quintile 1, landless farmer Sindh, landless farmer Punjab, and landless farmer other Pakistan. The goal of these simulations is to create fiscal space by reducing energy subsidy expenditure, and to use generated savings in targeted transfers to relatively poor segments of population. To complete our analysis of this issue, we run an additional counterfactual simulation where instead of decreasing subsidy, we increase energy subsidy by setting effective tax rate to 7%. This gives us three different scenarios for comparison - subsidy decrease, subsidy decrease and transfer, and subsidy increase.

The model is first calibrated to historical Pakistan macro data, and then out of sample simulation is carried out for 8 year period from 2012. Fiscal policy parameters remain constant for the entire simulation period. A managed exchange rate is assumed, which is devalued 6% per year. World growth rate and inflation rate are assumed to be 2% and 4% per year respectively. The parameter γ in the bank lending equation (Equation A4) is assumed to be 0, that is there is no credit rationing. The elasticity parameter a_2 in the migration equation (Constraint (viii) in Equation A5) is also assumed to be 0. Parameters for money demand equation (Constraint (vii) in Equation A5) are obtained from Qayyum (2005).

5.1 Benchmark Simulation

The average annual real GDP growth rate in the benchmark simulation is 3.44%, while average rate of inflation is 10.08%. The budget deficit is quite high initially, and gradually stabilizes to 7.3% of GDP in period 8. Interest rates decline over time (Table 11) and the trade deficit gradually improves (Table 12). Aggregate tax revenue and aggregate expenditure are 271.9 and 387.1 respectively over 8 years. Hence, aggregate budget balance is -115.2. Real income for all household categories increases, except for "urban other", and "waged rural landless farmers Punjab" (Table 13). Real income growth is highest for "medium farm Sindh" category, and lowest for "waged rural landless farmers Punjab" category. Aggregate average real income growth for all categories is 4.81%, while it is 5.39% for rural household categories, and 1.92% for urban household categories.

5.2 Subsidy Reduction Simulation

In the first counterfactual simulation, energy subsidy is reduced to create fiscal space. Average annual GDP growth rate in subsidy reduction simulation becomes 3.37%, slightly smaller than the benchmark simulation (Table 9). The average rate of inflation is also smaller than benchmark average inflation. As expected, the budget deficit under subsidy reduction simulation improves. Aggregate expenditure declines to 348.0, and aggregate tax revenue declines as well to 246.5. However, aggregate budget balance improves to -101.5 (Table 10). Hence, an aggregate budget savings of

13.6 is generated over 8 years, which would be distributed to poor households in the second counterfactual simulation.

Average real income growth become smaller than the benchmark simulation for all household categories. The two household categories that experience negative average growth of real income in benchmark simulation, also experience loss in income. Simulation results suggest that reduction in subsidy adversely affects each of the household categories.

5.3 Subsidy Reduction and Transfer Simulation

In the second counterfactual simulation, the budgetary savings of 13.6 is distributed among four poor household categories at the beginning of period 1. These categories are urban quintile 1, landless farmer Sindh, landless farmer Punjab, and landless farmer other Pakistan. A simple distribution rule is followed to make transfers to household categories. Transfers are made in proportion to the share of the household categories in aggregate income during period 1 of benchmark simulation. Urban quintile 1 has the highest share of 54.8%, followed by 22.4% for landless farmer Sindh, 14.7% for landless farmer Punjab, and the remaining 8.1% for landless farmer other. Hence, urban quintile 1 receives 7.5, and the three landless farmer categories receive 3.1, 2.0, and 1.1 respectively.

Average annual real GDP growth declines to 2.91% in this simulation. Average inflation rate declines more than in benchmark and subsidy reduction simulations. The budget deficit at period 8 is -8.3% of GDP which is higher than the other 2 simulations. Unlike the base case and subsidy reform simulations, size of budget deficit is relatively higher in later periods for subsidy reduction and transfer simulation. Similar to the benchmark simulation, average annual real income growth is positive for all household categories, except for "urban other", and "waged rural landless farmers Punjab" (Table 13). As expected, real income growth is relatively higher for the fur recipient consumer groups. Average real income growth rates are higher for most of the non transfer recipient categories, compared to the subsidy reform simulation, except for urban other, rural non-farm households, and small farm Punjab and other.

5.4 Subsidy Increase

The first three simulations tell us about the choices between subsidy, subsidy reform, and targeted transfer programs. The other possible policy option is increasing the energy subsidy. When energy subsidy is increased, we get average annual GDP growth of 3.31%, which is lower than the base case and subsidy reform case, but higher than the transfer case. Interest rate and trade balance remain very similar to the base case. More interestingly, aggregate budget balance over 8 years is -115.128, which is only 0.01 more than that of the base case. Average growth rate in real income is lower for all consumer categories compared to base case.

6 Conclusion

Pakistan spends substantial amount of resources in electricity subsidy, which aggravates budget deficit and crowds out priority sector spending. Moreover, non-poor households receive comparatively larger subsidy benefits than poor households. Broad-based electricity subsidy, therefore, may not be the right policy for serving the best purposes of poor households. The alternative policy could be generating fiscal savings by cutting the subsidy, and making transfer to poor households. From the CGE analysis it appears that subsidy reduction and transfer of savings improve welfare of the transfer recipient poor households. However, it hurts economic growth and trade balance. The macro-economic intuition of this outcome is that the lower income categories, to whom the transfers are made, have lower savings rates than do higher income households. Hence the transfers lead to lower rates of investment than would otherwise be the case.

One caveat of our results is that we consider each household category in the social accounting matrix as one single household in the simulations. We do not know how many households there are in each category. The distribution rule for transfer of savings was based on each household category's share in aggregate real income. This share can be larger if there are more households in the category. The share can also be larger if incomes of the households in the category are higher. Hence, a larger share of transfers could be allocated to a smaller number of households, which could cause upward bias in the utility calculation for any of the recipient categories. Though we don't know population distribution for SAM 2010 household categories, we have information about SAM 2008 population distribution. Aggregate population counts for the four recipient categories in SAM 2008 was 16.4 million, and "urban quintile 1" category has the largest share, 52.3% of this population. The "urban quintile 1" category also receives more than 50% of the transfer share, based on the decision rule. It is unlikely that population proportions change drastically for the 2010 SAM. Hence, utility calculations for the "subsidy reduction and transfer" simulation is not affected by smaller number of households receiving larger share of transfers. However, information on population distribution will allow more accurate welfare analysis, which could be one of the extensions of this research.

International development organizations like The World Bank and IMF regularly recommend for developing countries to reform regressive energy subsidies, and to implement targeted transfer programs. However, implementing targeted transfer programs, particularly in developing countries could be quite difficult and financially not viable. In this exercise we simply transfer the total savings from subsidy reduction to poor households without considering any cost of targeting. Welfare impacts could be much smaller or quite different if targeting and implementation costs were considered. The next step of this research will be to develop a model with costs associated with targeting and implementation of transfer schemes, and to conduct welfare analysis in presence of targeting cost.

Another possible extension could be linking the CGE outcomes with household level microdata, and conduct welfare analysis thorough micro-simulations. This will allow an in depth analysis of how poor and non-poor households are affected by subsidy reform. This paper provides primary results in support of the regressive nature of energy subsidy; and welfare improvement for poor households from transfer of savings. However, effective policy formulation for subsidy reform would require further analysis of this issue. One definite finding of this paper is that cutting energy subsidies hurts both poor and non-poor households. Poor households are only better off when targeted transfers are made to them.

References

Clements, Mr Benedict J, Coady, David, Fabrizio, Ms Stefania, Gupta, Mr Sanjeev, Alleyne, Mr Trevor Serge Coleridge, & Sdralevich, Mr Carlo A. 2013. *Energy subsidy reform: lessons and implications*. International Monetary Fund.

Coady, David, Grosh, Margaret E, & Hoddinott, John. 2004. *Targeting of transfers in developing countries: Review of lessons and experience*. Vol. 1. World Bank Publications.

Coady, David, Parry, Ian WH, Sears, Louis, & Shang, Baoping. 2015. *How large are global energy subsidies?* IMF Working Paper 15/105. International Monetary Fund.

Debowicz, Darío, Dorosh, Paul, Haider, Hamza Syed, & Robinson, Sherman. 2013. A disaggregated and macro-consistent social accounting matrix for Pakistan. *Journal of Economic Structures*, **2**(1), 4.

del Granado, Francisco Javier Arze, Coady, David, & Gillingham, Robert. 2012. The unequal benefits of fuel subsidies: A review of evidence for developing countries. *World Development*, **40**(11), 2234–2248.

Dennis, Allen. 2016. Household welfare implications of fossil fuel subsidy reforms in developing countries. *Energy Policy*, **96**, 597–606.

Feltenstein, Andrew, & Cyan, Musharraf R. 2013. A computational general equilibrium approach to sectoral analysis for tax potential: an application to Pakistan. *Journal of Asian Economics*, **27**, 57–70.

Feltenstein, Andrew, & Shamloo, Maral. 2013. Tax reform, the informal economy, and bank financing of capital formation. *International Tax and Public Finance*, **20**(1), 1–28.

Feltenstein, Andrew, Mejia, Carolina, Newhouse, David, & Sedrakyan, Gohar. 2017. The poverty implications of alternative tax reforms: Results from a numerical application to Pakistan. *Journal of Asian Economics*, **52**, 12–31.

Gulzar, Ahmed, Junaid, Novaira, & Haider, Adnan. 2010. What is hidden, in the hidden economy of Pakistan? Size, causes, issues, and implications. *The Pakistan Development Review*, 665–704.

Jiang, Zhujun, Ouyang, Xiaoling, & Huang, Guangxiao. 2015. The distributional impacts of removing energy subsidies in China. *China Economic Review*, **33**, 111–122.

Qayyum, Abdul. 2005. Modelling the demand for money in Pakistan. *The Pakistan Development Review*, 233–252.

Rentschler, Jun. 2016. Incidence and impact: The regional variation of poverty effects due to fossil fuel subsidy reform. *Energy Policy*, **96**, 491–503.

UNDP. 2016. *The Human Development Report 2016: Human Development for Everyone*. Annual Human Development Report. United Nations Development Programme.

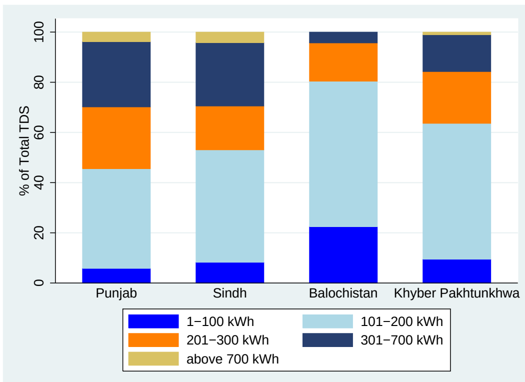
Walker, Thomas, Sahin, Sebnem, Saqib, Mohammad, & Mayer, Kristy. 2014. *Reforming Electricity Subsidies in Pakistan: Measures to Protect the Poor*. Policy Paper Series on Pakistan PK 24/12. The World Bank.

Wesseh, Presley K, Lin, Boqiang, & Atsagli, Philip. 2016. Environmental and welfare assessment of fossil-fuels subsidies removal: A computable general equilibrium analysis for Ghana. *Energy*, **116**, 1172–1179.

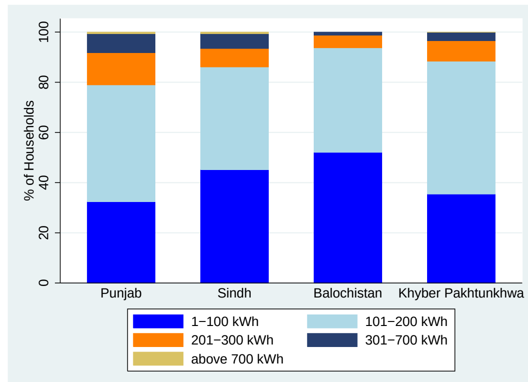
Figures and Tables

Figure 1: Distribution of Tariff Differential Subsidy and Recipient Households by Consumption Slab in 2012

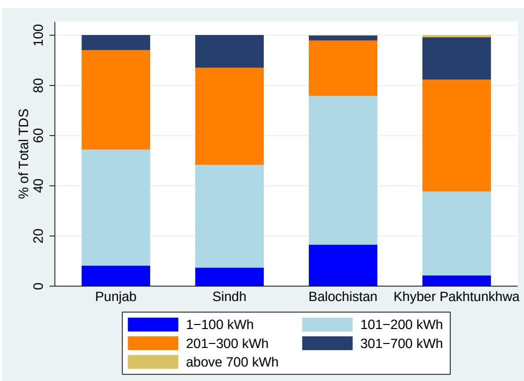
(a) Subsidy (Urban)



(b) Recipient Households (Urban)



(c) Subsidy (Rural)



(d) Recipient Households (Rural)

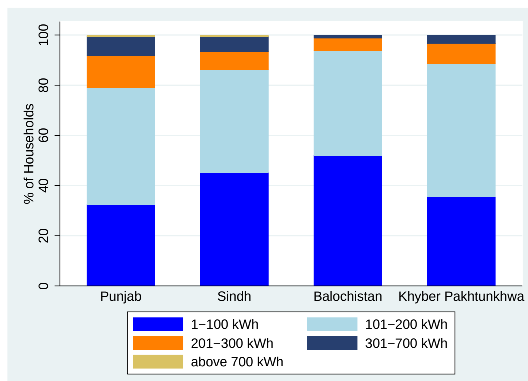
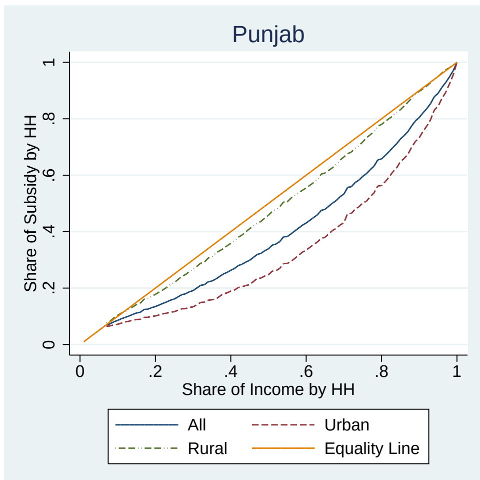
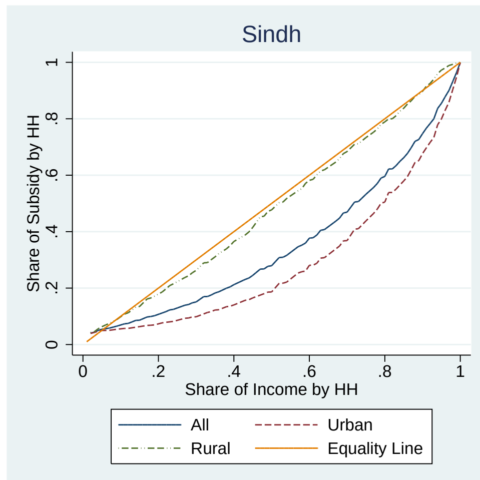


Figure 2: Distribution of Tariff Differential Subsidy Share by Income Share in 2012

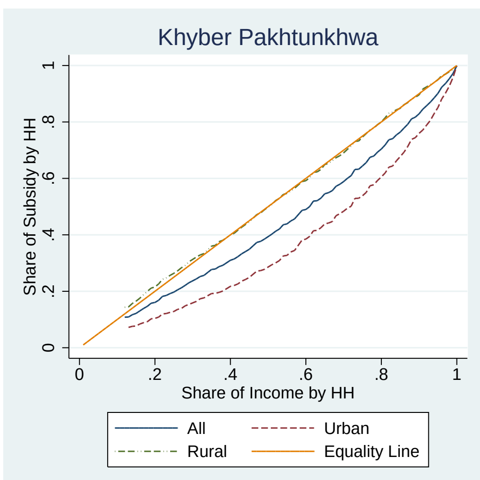
(a) Punjab



(b) Sindh



(c) KP



(d) Balochistan

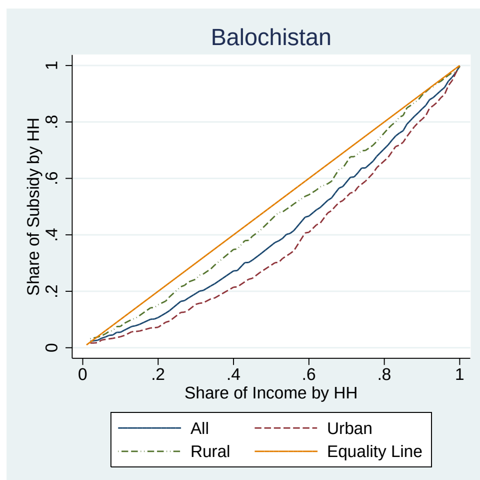
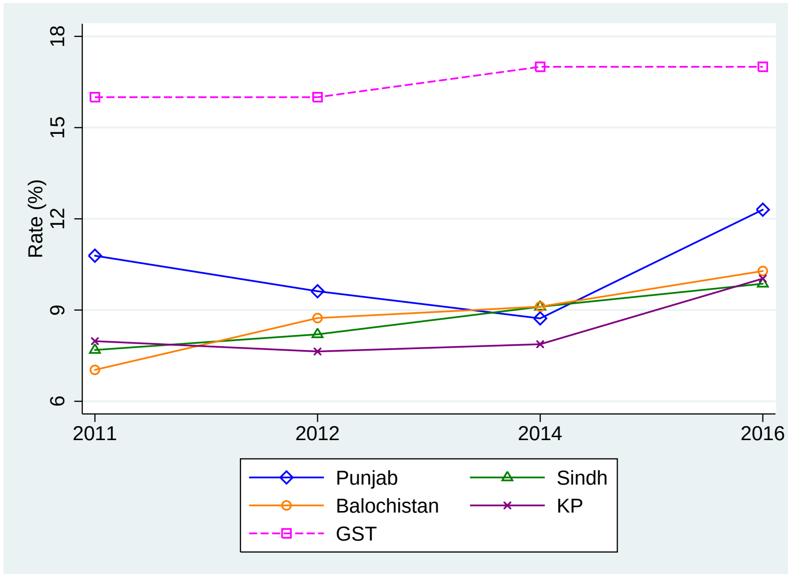


Figure 3: GST and Avg. Effective GST Rate



Note: Avg. effective GST rates are calculated using PSLM and HIES data.

Table 1: Summary of Energy Subsidy

	2009-10	2011-12	2013-14	2015-16
	(Rs in Million)			
Electricity Subsidy	179526	464256	309317	171205
Fuel Subsidy	11224	7921	0	0
Total Energy Subsidy	190750	472177	309317	171205
Total Subsidy	228992	512292	323020	196541
	(% of Current Expenditure)			
Electricity Subsidy	7.52	14.87	7.72	3.65
Fuel Subsidy	0.47	0.25	0	0.00
Total Energy Subsidy	7.99	15.12	7.72	3.65
Total Subsidy	9.6	16.41	8.07	4.19
	(% of GDP)			
Electricity Subsidy	1.16	2.2	1.16	0.54
Fuel Subsidy	0.07	0.04	0	0.00
Total Energy Subsidy	1.24	2.24	1.16	0.54
Total Subsidy	1.48	2.43	1.21	0.62

Source: Budget in Brief; Pakistan Fiscal Operations; Pakistan Economic Review, Various Issues.

Table 2: Sectoral Allocation of Consolidated Current Expenditure

	2009-10	2011-12	2013-14	2015-16
	(% of Current Expenditure)			
Health and Nutrition	1.72	0.92	2.86	3.14
Education	9.22	10.58	11.33	11.96
Social Security and Welfare	2.29	2.1	2.33	3.70
Energy Subsidy	7.99	15.12	7.72	3.65
	(% of GDP)			
Health and Nutrition	0.27	0.14	0.43	0.47
Education	1.43	1.57	1.71	1.78
Social Security and Welfare	0.35	0.31	0.35	0.55
Energy Subsidy	1.24	2.24	1.16	0.54

Source: Budget in Brief; Pakistan Fiscal Operations;
Pakistan Economic Review, Various Issues.

Table 3: Tariff Differential Subsidy

	2009-10	2011-12	2013-14	2015-16
	(Rs in Million)			
Tariff Differential Subsidy	108700	457018	294000	135716
	(%)			
As Percentage of:				
i) Total Energy Subsidy	57	96.8	95	79.3
ii) Total Subsidy	47.5	89.2	91	69.1
iii) Total Current Expenditure	4.6	14.6	7.3	2.9
iv) Budget Deficit	11.7	33.4	21.2	10.1
v) GDP	0.7	2.2	1.1	0.4

Source: Budget in Brief, Government of Pakistan,
Finance Division, Various Issues.

Table 4: NEPRA Tariff for Residential Consumption Exceeding 50 Units

	2009-10	2011-12	2013-14	2015-16
		(Rs./kWh)		
Punjab				
1-100 kWh	7.95	9.41	11.57	8.15
101-200 kWh	10.57	12.35	14.53	10.82
201-300 kWh	10.57	12.35	14.53	11.82
301-700 kWh	13.00	14.98	16.16	13.44
above 700 kWh	14.53	16.60	18.10	15.02
Sindh				
1-100 kWh	9.48	10.65	10.78	10.23
101-200 kWh	12.33	15.00	12.50	13.00
201-300 kWh	12.33	15.00	12.50	13.63
301-700 kWh	13.53	17.00	15.50	16.03
above 700 kWh	14.83	19.00	17.50	18.20
Balochistan				
1-100 kWh	9.42	10.00	10.50	9.70
101-200 kWh	11.63	13.20	12.50	12.10
201-300 kWh	11.63	13.20	12.50	12.15
301-700 kWh	13.25	14.30	15.00	14.10
above 700 kWh	14.92	16.50	17.50	16.10
Khyber PK				
1-100 kWh	9.80	11.50	12.85	10.03
101-200 kWh	15.22	15.50	15.37	13.18
201-300 kWh	15.22	15.50	15.37	13.68
301-700 kWh	11.08	17.50	17.20	14.58
above 700 kWh	17.52	19.50	18.25	15.53
GOP Tariff				
1-100 kWh	4.19	5.79	5.79	5.79
101-200 kWh	6.33	8.11	8.11	8.11
201-300 kWh	6.33	8.11	12.09	10.20
301-700 kWh	10.22	12.33	16.00	16.00
above 700 kWh	12.75	15.07	18.00	18.00

Source: State of Industry Report, NEPRA, Various Issues.

Table 5: Per Unit TDS for Residential Consumption Exceeding 50 Units

	2009-10	2011-12	2013-14	2015-16
		(Rs./kWh)		
Punjab				
1-100 kWh	3.76	3.62	5.78	2.36
101-200 kWh	4.24	4.24	6.42	2.71
201-300 kWh	4.24	4.24	2.44	1.62
301-700 kWh	2.78	2.65	0.16	-2.56
above 700 kWh	1.78	1.53	0.10	-2.98
Sindh				
1-100 kWh	5.29	4.86	4.99	4.44
101-200 kWh	6.01	6.89	4.39	4.89
201-300 kWh	6.01	6.89	0.41	3.43
301-700 kWh	3.31	4.67	-0.50	0.02
above 700 kWh	2.09	3.93	-0.50	0.20
Balochistan				
1-100 kWh	5.23	4.21	4.71	3.91
101-200 kWh	5.31	5.09	4.39	3.99
201-300 kWh	5.31	5.09	0.41	1.95
301-700 kWh	3.03	1.97	-1.00	-1.90
above 700 kWh	2.17	1.43	-0.50	-1.90
Khyber PK				
1-100 kWh	5.61	5.71	7.06	4.24
101-200 kWh	8.89	7.39	7.26	5.07
201-300 kWh	8.89	7.39	3.28	3.48
301-700 kWh	0.87	5.17	1.20	-1.43
above 700 kWh	4.78	4.43	0.25	-2.48

Source: Authors' Calculation from State of Industry Report, NEPRA, Various Issues.

Table 6: Distribution of Average Subsidy per Household - Urban

	2010-11	2011-12	2013-14	2015-16
Punjab				
1^{st} Quintile	277	472	703	311
2^{nd} Qunitile	319	610	833	369
3^{rd} Quintile	385	679	928	393
4^{th} Quintile	416	816	971	406
5^{th} Quintile	542	1119	958	289
Sindh				
1^{st} Quintile	471	488	489	515
2^{nd} Qunitile	585	714	612	693
3^{rd} Quintile	702	810	649	800
4^{th} Quintile	765	956	680	869
5^{th} Quintile	1229	1766	703	895
Balochistan				
1^{st} Quintile	406	443	452	454
2^{nd} Qunitile	460	446	489	489
3^{rd} Quintile	511	570	545	478
4^{th} Quintile	565	558	556	513
5^{th} Quintile	595	630	649	547
Khyber PK				
1^{st} Quintile	481	735	923	651
2^{nd} Qunitile	559	845	1024	737
3^{rd} Quintile	588	998	1069	801
4^{th} Quintile	624	961	1133	859
5^{th} Quintile	739	1348	1157	847

Table 7: Distribution of Average Subsidy per Household - Rural

	2010-11	2011-12	2013-14	2015-16
Punjab				
1^{st} Quintile	215	307	512	217
2^{nd} Qunitile	240	385	608	263
3^{rd} Quintile	266	485	682	297
4^{th} Quintile	281	524	758	329
5^{th} Quintile	346	634	817	328
Sindh				
1^{st} Quintile	310	291	267	270
2^{nd} Qunitile	369	354	306	326
3^{rd} Quintile	406	391	343	379
4^{th} Quintile	486	493	385	422
5^{th} Quintile	663	807	511	556
Balochistan				
1^{st} Quintile	322	333	305	351
2^{nd} Qunitile	357	384	417	450
3^{rd} Quintile	400	416	418	390
4^{th} Quintile	451	446	442	404
5^{th} Quintile	472	437	494	395
Khyber PK				
1^{st} Quintile	368	625	749	445
2^{nd} Qunitile	425	663	772	495
3^{rd} Quintile	459	697	821	542
4^{th} Quintile	488	756	866	626
5^{th} Quintile	537	829	906	708

Table 8: Average Electricity Consumption and Effective GST Rate in 2012

	Punjab	Sindh	Balochistan	Khyber PK	Average
Consumption (kWh)	135.55	93.98	92.64	116.99	109.79
Expenditure (Rs.)	914.46	607.40	550.32	751.31	705.87
Bill (Rs.)	788.33	523.62	474.41	647.68	608.51
GST Paid (Rs.)	126.13	83.78	75.91	103.63	97.36
Subsidy (Rs.)	513.29	492.21	393.39	702.34	525.31
Bill w.o. Subsidy (Rs.)	1301.62	1015.83	867.80	1350.01	1133.82
GST Rate (%)	16.00	16.00	16.00	16.00	16.00
Effective GST Rate (%)	9.62	8.20	8.74	7.64	8.55

Note: Average consumption (kWh) and expenditure (Rs.) for each province is the average of rural average and urban average of the respective province. Rural and urban averages are averages consumption (kWh) and expenditure (Rs.) of households between 45^{th} and 55^{th} percentile of consumption (kWh) in respective areas. Household consumption expenditure data from PSLM 2011-12 are used for calculating the averages.

Table 9: Real GDP

Period	Base Case	Subsidy Reform	Subsidy Reform & Transfer	Subsidy Increase
1	100.00	97.73	102.20	100.07
2	100.23	97.51	99.68	100.09
3	98.95	96.25	99.60	98.85
4	102.64	99.73	102.02	102.41
5	109.84	106.61	109.80	109.83
6	113.88	111.21	113.98	114.21
7	120.97	116.76	119.46	120.56
8	126.70	123.24	124.93	125.67
Avg. Growth	3.44	3.37	2.91	3.31

Table 10: Government Surplus

Period	Base Case	Subsidy Reform	Subsidy Reform & Transfer	Subsidy Increase
1	-14.277	-14.000	-13.175	-14.274
2	-14.519	-14.307	-14.963	-14.536
3	-12.292	-10.837	-11.261	-12.241
4	-12.642	-11.233	-12.203	-12.649
5	-13.502	-11.277	-12.744	-13.341
6	-14.541	-12.321	-14.177	-14.319
7	-15.466	-12.546	-15.476	-15.564
8	-17.900	-14.998	-18.265	-18.206
Total	-115.13853	-101.5197	-112.26471	-115.12827

Table 11: Inflation

Period	Base Case	Subsidy Reform	Subsidy Reform & Transfer	Subsidy Increase
1	-	-	-	-
2	20.09	19.03	10.45	20.25
3	9.13	7.75	7.38	1.25
4	9.17	8.00	6.88	17.32
5	12.25	10.52	10.72	11.98
6	5.31	3.57	3.32	5.16
7	15.15	14.45	14.98	15.46
8	-0.54	-2.47	-1.65	-0.61

Table 12: Trade Balance (as % of GDP)

Period	Base Case	Subsidy Reform	Subsidy Reform & Transfer	Subsidy Increase
1	-5.22	-5.00	-6.57	-5.22
2	-5.49	-4.90	-4.92	-5.46
3	-4.69	-3.97	-5.79	-4.62
4	-1.85	-0.72	-2.32	-1.68
5	-1.48	-0.58	-3.27	-1.41
6	4.52	5.72	2.67	4.52
7	4.75	5.41	1.84	4.77
8	16.26	16.85	12.49	16.52

Table 13: Income Growth by Consumer Groups

Consumer Group	Base Case	Subsidy Reform	Subsidy Reform & Transfer	Subsidy Increase
Urban quintile 1	4.95	4.62	7.18	4.88
Urban quintile 2	1.87	1.42	1.74	1.81
Urban other	-1.06	-1.33	-1.49	-1.12
Medium Farm Sindh	14.48	13.78	13.91	14.43
Medium Farm Punjab	4.64	4.20	4.60	4.59
Medium Farm Other	1.78	1.36	1.90	1.72
Small farm Sindh	2.55	2.14	2.57	2.50
Small farm Punjab	5.47	5.18	4.98	5.39
Small farm Other	5.90	5.54	5.52	5.83
Landless Farmer Sindh	7.91	7.48	10.42	7.85
Landless Farmer Punjab	11.98	11.59	12.97	11.92
Landless Farmer Other	9.08	8.77	10.98	9.01
Waged rural landless farmers Sindh	0.63	0.21	0.59	0.56
Waged rural landless farmers Punjab	-2.23	-2.67	-2.14	-2.29
Waged rural landless farmers Other	5.61	5.22	5.37	5.53
Rural non-farm quintile 1	3.15	2.83	2.71	3.08
Rural non-farm quintile 2	4.66	4.36	4.25	4.59
Rural non-farm other	5.16	5.09	4.65	5.11

Note: Urban quintile 1, landless farmer Sindh, landless farmer Punjab, and landless farmer other are the 4 consumer groups that receive transfers in the "Subsidy Reform & Transfer" simulation.

Appendix : General Equilibrium Specification

A1 Production

There are 8 factors of production in the model – 2 types of labor, 5 types of capital, and land. The labor types are – i) Urban Labor, and ii) Rural Labor. The capital types correspond to aggregate of the following non-agricultural productive sectors – i) Light Manufacturing, ii) Heavy Industry, iii) Electricity, Water, and Sewage, iv) Transport, and v) Hotels, Housing, and Health Services. There are 3 types of financial assets – i) Domestic Currency, ii) Bank Deposits, and iii) Foreign Currency. Intermediate and final production in period t is determined by a 50x50 input-output (I-O) matrix, taken from the most recent social accounting matrix for Pakistan. The first 49 rows and columns in the I-O matrix correspond to domestic production, and the final row and column represent import of intermediate and final goods. 5 types of capital and urban labor is used to produce sector specific value added for non-agricultural sectors; and land and rural labor is used to produce value added in agricultural sector. The production of value added in j^{th} non-agricultural sector in period i is:

$$va_{ji} = va_{ji}(y^j_{Ki}, y^j_{Li}, Y_{Gi}) \tag{A1}$$

Where, y^j_{Ki} and y^j_{Li} are capital and urban labor inputs to j^{th} non-agricultural sector, and Y_{Gi} is the outstanding stock of public infrastructure in period i. Capital and labor in j^{th} sector are taxed at the rates of t_{Kij} and t_{Lij} respectively in period i. Capital tax is the tax on firm's profit,[11] and labor tax is personal income tax, withheld at source.

There are sector-specific investment technologies, which produce each type of sectoral capital using capital and labor inputs. Firms borrow from the banking sector to acquire inputs used in production of new capital. If H_1 quantity of capital is produced in period 1, then the borrowing cost to produce H_1 quantity of capital must equal the present value of the return on H_1 quantity of capital. Suppose, C_{H1} be the cost-minimizing cost of producing H_1 quantity of capital in period 1, then

$$C_{H1} = \sum_{i=2}^{n} \frac{P_{Ki}(1 - t_{Ki})(1 - \delta)^{i-2} H_1}{\prod_{j=1}^{i-1}(1 + r_j)} \tag{A2}$$

Where, P_{Ki} is return to capital in period i, δ is depreciation rate of capital, and $r_j = \frac{1}{P_{Bj}}$ is interest rate in period j. P_{Bj} is the price of bond in period j. Firm's decision to invest in new capital also depends on its decision of whether to pay taxes

[11] Capital tax in the model is equivalent to corporate income tax. However, the production functions are constant returns to scale, and, hence, capital tax here is a tax on returns to capital.

or not; and if the firm decides not to pay taxes, then it enters into the underground economy. The firm compares the tax rate on capital with the rate of return on new capital, and pays tax only if return on new capital is greater than tax. In a two period world, the firm pays full tax on capital input if $\frac{P_{K2}}{1+r_1} \geq t_{K1}$, where, $\frac{P_{K2}}{1+r_1}$ is the present value of the return on one unit of new capital. Conversely the firm evades capital tax and enters into the underground economy if $\frac{P_{K2}}{1+r_1} \leq t_{K1}$. In this case, the gap between the tax rate and the rate of return on new capital determines the extent to which the firm goes into the underground economy. The firm's implicit capital tax rate is:

$$\bar{t}_{K1} = t_{K1}\left[1 - \left(\frac{t_{K1} - \frac{P_{K2}}{1+r_2}}{t_{K1}}\right)\right]^{\alpha} \tag{A3}$$

Where, α is a firm-specific behavioral variable, and $\alpha \geq 0$. If $\alpha = 0$, then $\bar{t}_{K1} = t_{K1}$, that is, the firm pays full taxes. If $\alpha > 0$, then $\bar{t}_{K1} < t_{K1}$, that is, the firm evades tax by under-reporting income. Higher the value of α, higher the degree of tax evasion, and $\frac{\bar{t}_{K1}}{t_{K1}}$ is the share of the sector that operates in underground economy in the model.

A2 Banking

Firms borrow from banks; and in order to obtain loans, require to provide banks with tax returns. Firms face a single, flat corporate income tax rate. Banks then asses the value of firm's capital from its tax return, and decide on the amount of loan. If a firm evades tax, then banks will assess a lower value of the firm's capital, based on the submitted tax return. This could limit access to credit for the firm. There are 5 banks in the economy, each corresponds to one of the five non-agricultural sectors mentioned earlier. A bank primarily lends to the sector to which it is associated with; however, is not fully specialized in that sector. Each bank holds a fixed share of outstanding debt of its corresponding sector, and additional fixed shares of debt of each of the other sectors. This diversification of asset allows tax evading firms to receive varying degree of credit rationing from different banks.

If the firm fully complies with its tax obligation in period 1 and pays T_{K1} amount of tax, then the value of the firm's capital is $\hat{K}_1 = \frac{T_{K1}}{t_{K1}}$. Bank will lend to the firm an amount L_1, which is less than C_{H1}. This is because in case of a default, the bank would not be able to seize the full value of the firm's capital. Hence, under perfect certainty, there will be credit rationing if requested amount of loan is higher than firm's estimated value of capital; and no credit rationing if requested loan amount is less than firm's capital. Under uncertainty, the amount lent by bank is following:

$$L_1 = C_{H1}\left[\frac{\frac{\hat{K}_1}{C_{H1}}}{1 + \frac{\hat{K}_1}{C_{H1}}}\right]^{\gamma} = C_{H1}\left[\frac{\hat{K}_1}{C_{H1} + \hat{K}_1}\right]^{\gamma} \tag{A4}$$

Where, γ is the measure of risk aversion for the bank. If $\gamma = 0$, then $L_1 = C_{H1}$ and there is no credit restriction. For $\frac{\hat{K}_1}{C_{H1}+\hat{K}_1} < 1$, the bank increasingly restricts lending as γ rises. Estimated value of capital, $\hat{K}_1$ is 0 for a firm that operates entirely in underground, and receives $L_1 = 0$ amount of loan from the banking sector.

A3 Consumption

Consumers in the model maximize inter-temporal utility functions which have arguments of consumption goods and leisure in each of the two periods. There are 18 consumer categories, of which 3 are urban, and the rest 15 are rural. Urban consumer categories are: i) Urban Quintile 1, ii) Urban Quintile 2, and iii) Urban Other. Rural consumer categories are: i) Landless Farmer Sindh, ii) Landless Farmer Punjab iii) Landless Farmer Other Pakistan, iv) Waged Rural Landless Farmers Sindh, v) Waged Rural Landless Farmers Punjab, vi) Waged Rural Landless Farmers Other Pakistan, vii) Small Farm Sindh, viii) Small Farm Punjab, ix) Small Farm Other Pakistan, x) Medium Farm Sindh, xi) Medium Farm Punjab, xii) Medium Farm Other Pakistan, xiii) Rural Non-farm Quintile 1, xiv) Rural Non-farm Quintile 2, and xv) Rural Non-farm Other. Each of the consumer categories has initial allocation of land, 5 types of capital, and financial assests – money, bond, and foreign currency. The urban consumer categories have urban labor, and rural consumer categories have rural labor. The consumer's problem is following:

$$
\begin{aligned}
\max_{\{\mathbf{x}_i, x_{Lui}, x_{Lri}\}} \; & U(\mathbf{x}) = U(\mathbf{x}_1, x_{Lu1}, x_{Lr1}, \mathbf{x}_2, x_{Lu2}, x_{Lr2}) \\
& s.t. \\
& i)\ (1+\mathbf{t}_i)\mathbf{P}_i\mathbf{x}_i + P_{Lui}x_{Lui} + P_{Lri}x_{Lri} + P_{Mi}x_{Mi} + P_{Bi}x_{Bi} \\
& \quad + e_i P_{BFi} x_{BFi} = C_i \\
& ii)\ P_{K1}K_0 + P_{A1}A_0 + P_{Lu1}L_{u1} + P_{Lr1}L_{r1} + P_{M1}M_0 + r_0 B_0 + P_{B1}B_0 \\
& \quad + e_1 P_{BF1} B_{F0} + TR_1 = N_1 \\
& iii)\ P_{K2}(1-\delta)K_0 + P_{A2}A_0 + P_{Lu2}L_{u2} + P_{Lr2}L_{r2} + P_{M2}x_{M1} + r_1 x_{B1} \\
& \quad + e_2 P_{BF2} B_{F0} + TR_2 = N_2 \\
& iv)\ C_i = N_i,\ i \in \{1,2\} \\
& v) \log P_{Bi}x_{Bi} - \log e_i P_{BFi} x_{BFi} = \alpha + \beta\left(\log r_i - \log \frac{e_i+1}{e_i} r_{Fi}\right) \\
& vi) P_{B2}x_{B2} = d_0 + d_1(1+\mathbf{t}_2)\mathbf{P}_2\mathbf{x}_2 + d_2\left[\frac{r_2-\pi_2}{1+\pi_2}\right] \\
& vii) \log P_{Mi}x_{Mi} = a + b\log(1+\mathbf{t}_i)\mathbf{P}_i\mathbf{x}_i + c\log r_i \\
& viii) \log\left(\frac{L_{ui}}{L_{ri}}\right) = a_1 + a_2 log\left(\frac{P_{Lui}-P_{Lri}}{P_{Lui}+P_{Lri}}\right)
\end{aligned}
\tag{A5}
$$

Where, subscripts i, L, K, u, r, M, B, and F correspond to period, labor-leisure, capital, urban, rural, money, bank, and foreign respectively. x_{Lui} is demand for urban leisure, x_{Lri} is demand for rural leisure, x_{Mi} is holding of money, x_{Bi} is quantity of bank deposits, and x_{BFi} is quantity of foreign currency in period i. $\mathbf{x}_i$ is vector of consumption, $\mathbf{P}_i$ is vector of prices of consumption goods, and $\mathbf{t}_i$ is vector of value added taxes in period i. P_{Lui} and P_{Lri} are prices of urban and rural labor, P_{Mi} is price of money, P_{Bi} is discount price of a certificate of deposit, P_{BFi} is price of foreign currency in period i, and e_i is exchange rate[12] in period i. C_i is aggregate consumption and N_i is aggregate income in period i. K_0, A_0, M_0, B_0, and B_{F0} are initial holdings of capital, land, money, bank deposits, and foreign currency, and L_{ui} and L_{ri} are allocations of urban and rural labor respectively in period i. δ is rate of depreciation of capital, TR_i transfer payment from government, and r_i is interest rate in period i. Constraint (i) represents the total value of consumption of goods, leisure, and financial assets. Constraints (ii) and (iii) represent value of consumer's holding of capital, labor, and principals and interest earnings from domestic and foreign financial assets in periods 1 and 2 respectively. Constraint (iv) imposes budget restrictions in each period, that is, total consumption equals to total income.

r_{Fi} is foreign interest rate in period i, and π_2 is the domestic rate of inflation in period 2. Constraint (v) describes how relative domestic and foreign interest rates, deflated by change in exchange rate, affects proportion of savings made up of domestic and foreign bonds. Constraint (vi) shows the relationship between domestic bond holding, consumption, and real interest rate in period 2. Constraint (vii) is money demand equation, showing the relationship between money holding, consumption, and interest rate. Finally, constraint (viii) is a migration equation showing the relationship between relative holding of urban and rural labor, and relative wage rate. a, b, α, and β are estimated constants, and d_0, d_1 and d_2 are constants estimated from calibration. Cobb-Douglas utility functions are assumed for each consumer categories, for which weights are derived from the Pakistan social accounting matrix consumption data.

A4 Government

The government, in the model, collects personal income tax (labor tax), corporate tax (capital tax), value added taxes, and import duties. Government provides public goods, and pays for subsidies. Government covers domestic and foreign interest obligations on public debt and satisfies no-Ponzi scheme condition. Government deficits are financed by a combination of monetary expansion, and domestic and foreign borrowing. Government deficit in period 1 is:

$$D_1 = G_1 + S_1 + r_1 B_0 + e_1 r_{F1} B_{F0} + T_1 \tag{A6}$$

Where, G_1 is spending on public goods, S_1 is subsidy, and T_1 is tax revenue in period 1. $r_1 B_0$ and $e_1 r_{F1} B_{F0}$ are domestic and foreign interest obligations respectively, based

[12] Units of domestic currency per unit of foreign currency.

on initial stock of debt. Government deficit in period 2 is:

$$D_2 = G_2 + S_2 + r_2(\Delta y_{BG1} + B_0) + e_2 r_{F2}(C_{F1} + B_{F0}) + T_2 \tag{A7}$$

Where, G_2, S_2, and T_2 are public spending, subsidy, and tax in period 2. Δy_{BG1} is the face value of domestic bonds sold, and C_{F1} is foreign borrowing in period 1. $r_2(\Delta y_{BG1} + B_0)$ is domestic interest obligation, and $e_2 r_{F2}(C_{F1} + B_{F0})$ is foreign debt obligation in period 2. Foreign is exogenously determined by the lender, and domestic bond sale is determined later by the government. The remainder of the budget deficit in period i is financed by monetization.

A5 Foreign Sector

A simple equation of aggregate demand for exports represent the foreign sector in the model. The export equation is following:

$$\Delta X_i = \sigma_1 \left[\frac{\pi_1}{\Delta e_i + \pi_{Fi}} \right] + \sigma_2 \Delta y_{wi} \tag{A8}$$

Where, ΔX_i is change is dollar value of export, π_i and π_{Fi} are domestic and foreign rates of inflation, Δe_i is percentage change in exchange rate, and Δy_{wi} is percentage change in world income in period i. σ_1 is the elasticity between aggregate export demand, and domestic and foreign price indices; and σ_2 is the elasticity between aggregate export demand and world income.