Common Global Warming, Unequal Local Income Consequences*

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Abstract

This paper studies how the effects of global temperature shocks on labor income differ by income group in the United States. Using disaggregated monthly income data and identified global temperature shocks, we estimate the dynamic responses of labor income by income group through local projections. We find that rising global temperature lowers labor income, with losses disproportionately concentrated among lower-income groups. Examining additional income concepts, we further document that the factor income response is largely accounted for by labor income rather than non-labor income, and that taxes and transfers partially mitigate the distributional impact for lower-income households. We also find that the regressive pattern is more pronounced in the post-2000 period. These findings suggest that global warming operates as an inequality multiplier through the labor market, with consequences that have grown more pronounced over time.

Keywords: *Temperature, Inequality, Local Projection, Shocks, Global Warming*
JEL Classification: *E24, E32, Q54.*

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1 Introduction

Climate change, highlighted by rising global temperatures, plays an important role in shaping macroeconomic outcomes (Burke, Hsiang, & Miguel, 2015). Recent studies show that national GDP and sectoral outputs would decrease substantially and persistently as a result (Dell, Jones, and Olken 2012; Dell, Jones, and Olken 2014; Kahn et al. 2021; Newell, Prest, and Sexton 2021; Natoli 2023; Burke, Zahid, Diffenbaugh, and Hsiang 2023; Bilal and Känzig 2024).

At the same time, the literature documents that the effects of global climate change are not homogeneous across geography and industrial sectors. For example, global warming affects countries differently, and such effects are also heterogeneous across sectors and regions within the United States (Deschênes and Greenstone 2011; Burke et al. 2015; Carleton and Hsiang 2016; Hsiang et al. 2017; Diffenbaugh and Burke 2019; Colacito, Hoffmann, and Phan 2019). These heterogeneities naturally raise the question of whether temperature increases also translate into unequal consequences across income groups, given differences in workers' sectoral employment and capacity to adapt (Adom & Amoani, 2021). However, macroeconomic evidence on within-country heterogeneous responses across income groups remains limited.

This paper documents the impact of global warming on labor income distribution in the United States. Using disaggregated monthly income data from Realtime Inequality of Blanchet, Saez, and Zucman (2022) and identified global temperature shocks as in Bilal and Känzig (2024), we estimate the responses of labor income by income group to the increase in temperature through local projections. First, we quantify distributional consequences of global temperature shocks by focusing on the heterogeneous responses of labor income by income group. Second, we extend the analysis to factor, non-labor, pretax, and disposable income to examine which component is a main source of the distributional pattern and how taxes and transfers shape it. Third, we investigate whether the effects of temperature shocks on labor income distribution vary over time.

The findings show that, while temperature shocks decrease aggregate income, the decline is concentrated among lower-income individuals. In contrast, higher-income groups experience smaller and less persistent effects. Specifically, when temperature increases by $1°C$, the aggregate labor income decreases by 0.7 percent six months after the shock. How-

ever, the income of the Bottom 50 falls by 2.2 percent, whereas the Mid 40 and Top 10 show relatively negligible declines.[1] These findings suggest that temperature shocks widen labor income inequality, with the burden disproportionately concentrating on lower-income groups.

Extending the analysis to additional income concepts, we find that the factor income response is smaller in magnitude than the response of labor income, and the non-labor income responds negligibly. These patterns suggest that the labor income channel primarily accounts for the response of factor income. We further document that taxes and transfers mitigate the effects of temperature increases at the bottom of the distribution, highlighting the role of fiscal redistribution in mitigating the unequal burden of climate shocks on lower-income households. Finally, we show that the contractionary effects on labor income have strengthened in recent years, particularly for lower-income groups after 2000, consistent with rising exposure to extreme heat and more frequent temperature anomalies.

This paper contributes to the recent literature on macro-climate (Natoli 2023; Bilal and Känzig 2024; Alessandri and Mumtaz 2025) by linking global temperature shocks to macroeconomic outcomes by income group, highlighting that the macroeconomic costs of climate shocks are not only substantial but also unequally distributed. While prior work in this literature has typically focused on national-level outcomes such as GDP, our analysis shows that aggregate responses conceal substantial heterogeneity, with lower-income groups bearing a disproportionate share of the burden. In addition, the main findings imply that the labor productivity losses fall heterogeneously across income groups, complementing studies on the relationship between global warming and labor productivity (Park, Pankratz, and Behrer 2021; Somanathan, Somanathan, Sudarshan, and Tewari 2021; Goenka, Liu, Nguyen, and Pang 2025).

Second, this paper contributes to the literature on automatic stabilizers and the redistributive consequences of macroeconomic shocks (Auerbach and Feenberg 2000; McKay and Reis 2016; Furceri, Loungani, and Zdzienicka 2018; Choi and Phi 2026) by extending the studies to climate shocks. These findings indicate that taxes and transfers partially buffer the most exposed group from temperature shocks, complementing existing evidence on the role of fiscal redistribution in mitigating the distributional impact of mon-

[1] Throughout the paper, the Bottom 50, Mid 40, and Top 10 refer to the bottom 50 percent, the middle 40 percent (percentiles 50 to 90), and the top 10 percent of the U.S. income distribution, respectively.

etary and uncertainty shocks.

Third, this paper contributes to the literature on the time-varying nature of climate damages (Bilal and Känzig 2024; Kim, Matthes, and Phan 2025) by providing additional evidence that the distributional consequences of temperature shocks have intensified in recent decades. We show that the regressive labor-market effects of global warming become substantial in the post-2000 period, highlighting that climate change is increasingly acting as an inequality multiplier in recent years.

A closely related study is Gilli, Calcaterra, Emmerling, and Granella (2024), which estimates climate damage functions of rising temperatures by within-country income decile from a cross-country panel, and projects their distributional impacts to the year of 2100. We take a different approach by analyzing the dynamic responses of several income concepts to identified global temperature shocks in the United States, and further document that the regressive pattern intensifies in recent decades and the tax-and-transfer system partially mitigates the shock at the bottom of the distribution.

The remainder of the paper is organized as follows. Section 2 describes the empirical framework. Section 3 reports the main results, focusing on the heterogeneous responses of labor income across the distribution, and discusses. Section 4 provides further evidence on the distributional effects. Section 5 concludes.

2 Empirical Strategy

This section describes the empirical framework used to estimate the heterogeneous effects of temperature shocks on labor income across income groups. Subsection 2.1 outlines the income and temperature data. Subsection 2.2 identifies temperature shocks. Subsection 2.3 presents the local projection model used to estimate dynamic responses by income group.

2.1 Data

The income data we use are obtained from Realtime Inequality (Blanchet et al., 2022).[2] The dataset integrates survey information, tax records, and national accounts to produce monthly estimates of the U.S. income distribution in the framework of the Distributional National Accounts microdata of income and wealth by Piketty, Saez, and Zucman (2018).

[2]Source: https://realtimeinequality.org/.

Our main analysis focuses on labor income, and we additionally examine factor, non-labor, pretax, and disposable income to examine the underlying channels and the role of redistribution. We focus on incomes of the Bottom 50, the Mid 40, and the Top 10 percent of the distribution, following Blanchet et al. (2022) and Choi and Phi (2026).

The temperature data used in this paper are provided by Our World in Data, which collects and processes ERA5 reanalysis data from the Copernicus Climate Change Service (C3S) at the European Centre for Medium-Range Weather Forecasts (ECMWF). ERA5 combines a wide range of satellite and in-situ observations with a numerical weather model to produce a physically consistent, high-resolution reconstruction of global temperature fields over time, and it is widely used in the climate–economy literature (e.g. Kalkuhl and Wenz 2020 and Kotz, Wenz, Stechemesser, Kalkuhl, and Levermann 2021). From Our World in Data, we obtain a monthly global mean surface temperature series.

For macroeconomic data, we use the one year Treasury yield (DGS1 from FRED), an real oil price series that is an extended version of that in Känzig (2021), and industrial production (INDPRO from FRED). The sample period runs from 1976m1 to 2025m3, reflecting the availability of income data.[3] All real values are constructed by deflating the corresponding nominal series by the Consumer Price Index (CPIAUCSL from FRED).

2.2 Shock Identification

This subsection describes how temperature shocks are identified. To isolate the unanticipated component of temperature variation, as in Bilal and Känzig (2024), we extract deviations from the temperature trend that are unpredictable using past information. Specifically, we regress global temperature h periods ahead on its own lags up to period t:

$$T_{t+h} = \alpha + \beta_1 T_t + \cdots + \beta_p T_{t-p+1} + \epsilon_{t+h}, \tag{1}$$

and construct the temperature shock as the regression residual:

$$\widehat{T^{shock}_{t+h}} = T_{t+h} - (\hat{\alpha} + \hat{\beta}_1 T_t + \cdots + \hat{\beta}_p T_{t-p+1}), \tag{2}$$

[3] Income data starts from 1976m1.

where $\hat{\beta}_i$ represents the coefficient estimates of the regression of temperature on its lag i and $\hat{\alpha}$ is the estimated intercept. This approach accounts for long-run increasing trend and persistent deviations from the trend, aligning with the literature documenting that natural climate variability driven by phenomena, such as the El Niño, can persist for prolonged periods (Bilal & Känzig, 2024). Considering the frequency of data in this paper and the specifications in Bilal and Känzig (2024), we set $h = 12$ and $p = 24$, and thereby, $\widehat{T^{shock}_{t+h}}$ captures shocks that persist typically for h periods.[4]

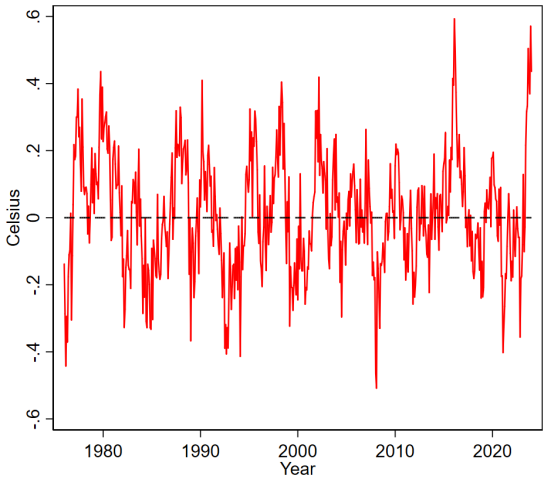


Figure 1: Global Temperature Shock Series

Notes: This figure plots series of global temperature shocks, identified as in Bilal and Känzig (2024), using monthly series with $h = 12$ and $p = 24$ in Equation (2).

Figure 1 shows the identified global temperature shock series over the sample periods. As in Bilal and Känzig (2024), the series oscillates around zero with almost equal numbers of positive and negative values. The largest shock is around $0.6°C$. The series is weakly auto-correlated, as the monthly temperature deviates from its long-run trend for a few periods. Therefore, we control for lagged temperature shocks in the empirical specification (Bilal & Känzig, 2024).

2.3 Local Projection

To estimate the dynamic effects of temperature shocks on the income distribution, we use the local projection method of Jordà (2005). This approach regresses the outcome of interest at different horizons on the identified temperature shocks, and it allows for a flexible

[4] Alternative p and h are investigated in Appendix B.

characterization of impulse responses without imposing a full vector autoregressive structure. We estimate the empirical model separately for each income group, which allows us to trace heterogeneous impulse responses to global temperature shocks across the income distribution. The specification of the model follows:

$$y^g_{t+h} = \alpha^g_h + \theta^g_h T^{shock}_t + B^g_h(L)X_t + \epsilon^g_{t+h}, \tag{3}$$

where y^g_t is the log of disaggregated income for group g, T^{shock}_t is the temperature shock, and θ^g_h captures the impulse response by income group at horizon h. X_t is a vector of control variables and contains lagged values of the global temperature shock. We also control for the one year Treasury yield, the growth rate of industrial production, and global oil prices to account for the fluctuations in macroeconomic conditions. Temperature within the U.S. is additionally controlled.[5] For all lagged variables, we use lags up to 12 months, given the data frequency.[6]

3 Main Results

This section examines the heterogeneous effects of global temperature shocks across income groups. We present results for aggregate labor income, and turn to disaggregated labor income to assess heterogeneity.

3.1 Aggregate-level Evidence

Figure 2 reports the impulse responses of aggregate labor income. The red solid line shows the median response of labor income, and shaded areas illustrate the range between the 16th and 84th percentiles. The responses are scaled to imply the increase in $1°C$ of global temperature.[7]

The results indicate that temperature shocks lead to a decline in aggregate labor income. Specifically, a $1°C$ increase in global temperature is associated with a 0.7 percent decline in aggregate labor income six months after the shock. This suggests that temper-

[5] The local temperature is taken from the same set as global temperature. Results based on the specification without controlling the local temperature in Appendix C.

[6] Alternative lag lengths are considered in Appendix C.

[7] The response of temperature to temperature shocks is reported in Appendix A.

ature shocks are contractionary, consistent with recent evidence on their adverse macroeconomic effects (Bilal & Känzig, 2024). In addition, the labor income responses indicate that temperature shocks propagate through work-related earnings, consistent with evidence that higher temperatures reduce hours worked and output in heat-exposed sectors (Somanathan et al., 2021).[8]

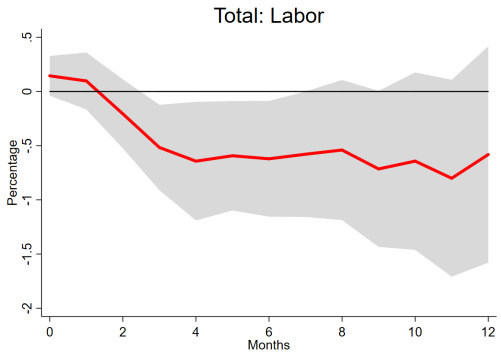


Figure 2: Response of Aggregate Labor Income to Temperature Shocks

Notes: This figure plots the impulse response of aggregate labor income to temperature shocks. The red solid line shows the median response of aggregate labor income to temperature shocks, and shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

3.2 Disaggregate-level Evidence

Figure 3 reports the impulse responses of labor income by group, with the red solid line showing the response for each group and the black dashed line indicating the corresponding aggregate response. The results reveal clear asymmetries across groups. The Bottom 50 percent experiences the largest and most persistent decline following temperature shocks. Specifically, labor income falls by roughly 2.2 percent within six months of the shock, substantially larger and more persistent than the aggregate response. By contrast, the Mid 40 and Top 10 percent show smaller and less persistent declines, broadly comparable to the aggregate response.

[8] Colacito et al. (2019) also document that changes in temperature affect labor productivity.

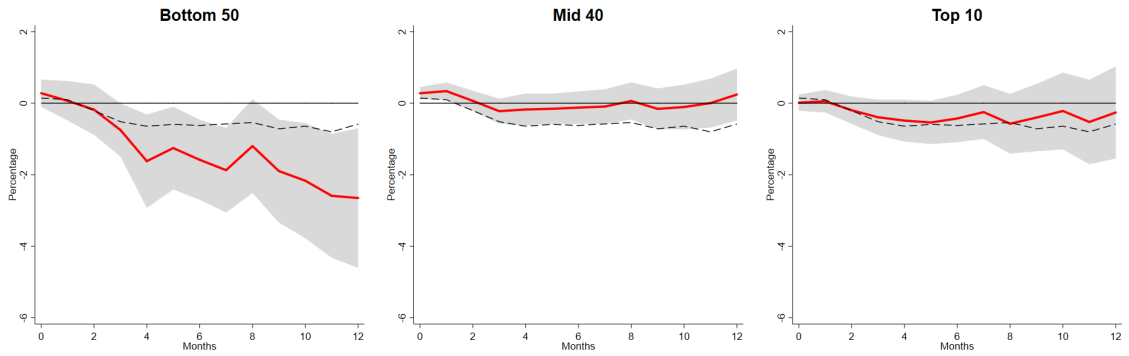


Figure 3: Effects of Temperature Shock on Real Labor Income by Group

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each income group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

To summarize the distributional consequences in a single inequality measure, following Choi and Phi (2026), we investigate the ratio of average labor income between groups. Specifically, we consider the ratio of the Top 10 percent to the Bottom 50 percent (Top 10 / Bottom 50) and the ratio of the Mid 40 percent to the Bottom 50 percent (Mid 40 / Bottom 50), and estimate their dynamic responses to temperature shocks.

Figure 4 reports the impulse responses of these two inequality measures. Both ratios rise following temperature shocks, indicating that labor income inequality widens. The increase emerges approximately four months after the shock and persists over the subsequent horizon. The widening is notably more pronounced between the top and the bottom of the distribution than between the middle and the bottom. While the Mid 40 / Bottom 50 ratio rises by a modest magnitude that remains below 0.25 at all horizons, the Top 10 / Bottom 50 ratio rises more sharply, reaching approximately 0.6 by the twelve-month horizon. These differences indicate that the labor income gap between the top and the bottom widens substantially more than the gap between the middle and the bottom, consistent with the group-level results documented above.

Appendix B confirms the robustness of the findings in this section. The heterogeneous pattern remains robust to alternative lag lengths, control variables, and identification strategies. Across all specifications, the lower income groups consistently show the strongest and most persistent labor income losses.

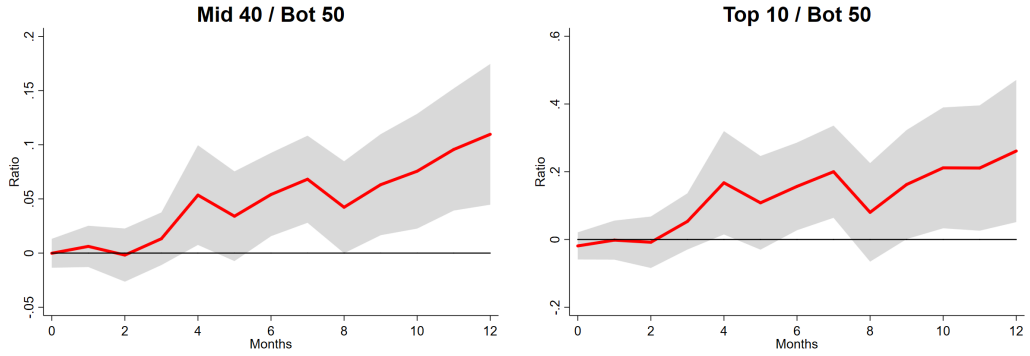


Figure 4: Effects of Temperature Shock on Relative Labor Income

Notes: This figure plots the impulse response of inequality measures of labor income to temperature shocks. The red solid line shows the response of each ratio for labor income. Mid 40 / Bot 50 represents the ratio of the Mid 40 percent to the Bottom 50 percent and Top 10 / Bot 50 shows the ratio of the Top 10 percent to the Bottom 50 percent. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

3.3 Discussion

The findings in this section indicate that the contractionary effects of temperature shocks on labor income are concentrated at the lower end of the income distribution, with the Bottom 50 percent experiencing larger and more persistent declines than higher-income groups. Consistent with this pattern, the top-to-bottom income ratio rises following the shock.

Global temperature shocks are contractionary in the aggregate level as the shocks are closely associated with the incidence of extreme climatic events, including extreme heat, extreme precipitation, extreme wind, and drought, causing aggregate economic disruptions (Bilal and Känzig 2024). This aligns with Kim et al. (2025) which show that the effects of severe weather shocks in the United States are contractionary, reducing industrial production and raising unemployment, with effects that have grown notably larger in recent decades.

The documented heterogeneity across income groups can be interpreted through differences in the capacity to adopt to climatic disruptions. Park et al. (2021) document that workplace injury risks from hotter temperatures are larger for workers at the lower end of the income distribution, suggesting that workplace heat exposure may exacerbate labor market inequality. Related evidence from natural disasters points in the same direction. Coulombe and Rao (2025) show that fires depress county-level employment growth and

that counties with more educated workforces and more diversified economies are more resilient to these shocks. Similarly, Coronese, Crippa, Lamperti, Chiaromonte, and Roventini (2025) find that thunderstorms reduce income and wage growth in U.S. counties, with stronger negative impacts in economically disadvantaged regions for little evidence of effective adaptation and resilience.

Moreover, the main results complement the uneven distribution of climate damages documented in the existing literature, both across regions within the U.S. (Hsiang et al. 2017) and across countries (Diffenbaugh and Burke 2019), by pointing to the income distribution as an additional margin along which climate damages are uneven. The persistent responses observed for lower-income groups further suggest that the income consequences of temperature shocks for vulnerable groups can last over extended horizons, consistent with evidence that higher temperatures can affect growth rates rather than only the level of output (Dell et al., 2012).

Taken together, the results in this section reveal distributional consequences of climate shocks that the aggregate effects documented in the literature have concealed. Aggregate labor income declines persistently, but the burden of this decline is concentrated among workers at the lower end of the distribution. As a result, labor income inequality widens, with the most pronounced widening observed between the top and the bottom of the distribution.

4 Additional Evidence

The results in Section 3 establish that temperature shocks generate regressive responses in labor income, with lower-income groups experiencing substantially larger declines than higher-income groups. To better understand these distributional consequences, this section presents three additional analyses. Section 4.1 documents the responses of factor income and non-labor income, and examines which component, labor or non-labor income, primarily accounts for the factor income response. Section 4.2 then compares the responses of pretax and disposable income to assess the role of redistribution. Section 4.3 investigates the time-varying effects of temperature shocks on labor income.

4.1 Factor Income and Non-labor Income

We begin by examining the response of factor income, which consists of labor and non-labor income, in order to assess the distributional effects within a broader income concept. Figure 5 reports the impulse responses of real factor income by group, shown by the blue solid line in each panel.[9] The responses are negative across all three groups, with the magnitude largest for the Bottom 50 percent, reaching roughly -1.5 percent from six months onward, and smaller for the Mid 40 and the Top 10 percent. Notably, the factor income response is smaller in magnitude than the labor income response, particularly for the Bottom 50 percent. Factor income at the bottom of the distribution declines by less than the corresponding labor income, with the gap pronounced beyond the six-month horizon.

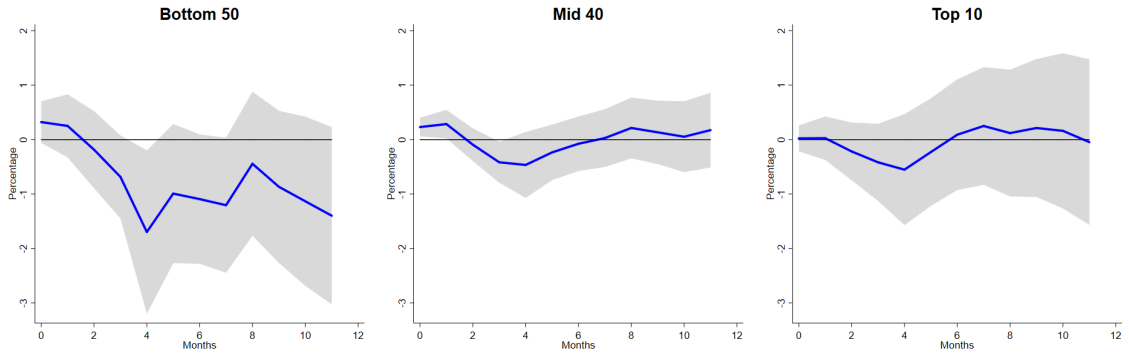


Figure 5: Effects of Temperature Shock on Real Factor Income by Group

Notes: This figure plots the impulse response of factor income by income group to temperature shocks. The blue solid line shows the response of factor income for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

To further investigate the regressive pattern, Figure 6 reports the response of inequality measures of factor income (blue solid line), alongside the corresponding labor income ratio (red dashed line). Both the Mid 40 to Bottom 50 ratio and the Top 10 to Bottom 50 ratio rise following the shock, indicating that factor income inequality widens. The magnitude of the increase, however, is substantially smaller than that of the labor income ratio. At the twelve-month horizon, the Top 10 to Bottom 50 factor income ratio rises by less than half of the corresponding labor income ratio, and a similar gap is observed for the Mid 40 to Bottom 50 ratio. This contrast indicates that factor income inequality widens to a lesser degree following a temperature shock than labor income inequality.

[9]The response of aggregate factor income is reported in Appendix A.

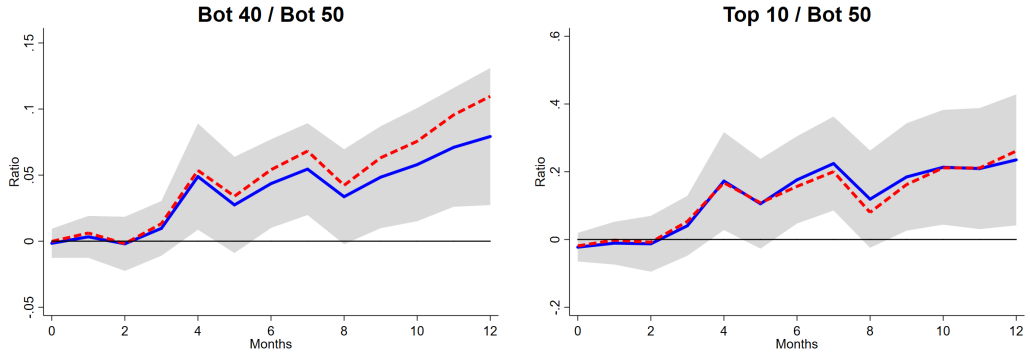


Figure 6: Effects of Temperature Shock on Relative Factor Income

Notes: This figure plots the impulse response of inequality measures of factor and labor income to temperature shocks. The blue solid line shows the response for each ratio, while the red dashed line indicates the corresponding response of labor income. Mid 40 / Bot 50 represents the ratio of the Mid 40 percent to the Bottom 50 percent and Top 10 / Bot 50 shows the ratio of the Top 10 percent to the Bottom 50 percent. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

We now turn to the response of non-labor income, the other component of factor income, to assess its contribution to the regressive factor income pattern. Figure 7 reports the response of relative non-labor income (green solid line), alongside the corresponding labor income ratio for reference (red dashed line).[10] In sharp contrast to the labor income ratio, the non-labor income ratio remains close to zero for both the Mid 40 / Bottom 50 and Top 10 / Bottom 50 comparisons over the full horizon. The contrast between the labor and non-labor income ratios suggests that the regressive pattern of factor income is mainly driven by the changes in labor income.

Taken together, these results indicate that the labor income channel accounts for a substantial part of the factor income response across the income distribution. Factor income inequality widens following temperature shocks, but to a lesser extent than labor income inequality, and the response of the non-labor income inequality measure is negligible.

[10]The group-level and aggregate responses of non-labor income are reported in Appendix A.

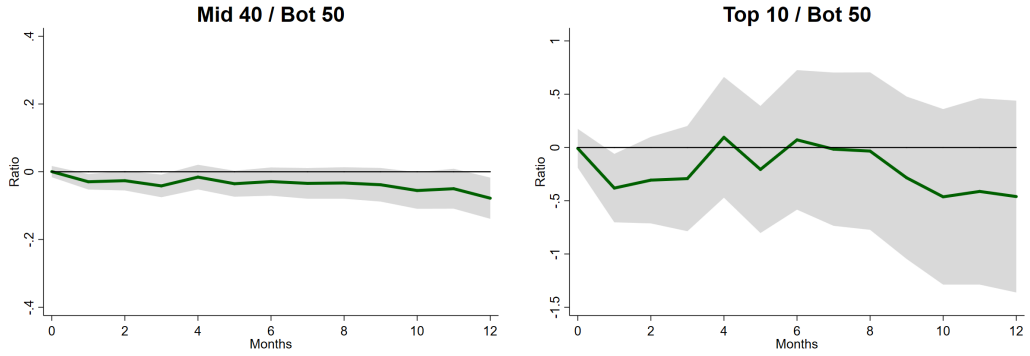


Figure 7: Effects of Temperature Shock on Relative non-labor Income

Notes: This figure plots the impulse response of inequality measures of non-labor and labor income to temperature shocks. The green solid line shows the response for each ratio, while the red dashed line indicates the corresponding response of labor income. Mid 40 / Bot 50 represents the ratio of the Mid 40 percent to the Bottom 50 percent and Top 10 / Bot 50 shows the ratio of the Top 10 percent to the Bottom 50 percent. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

4.2 The Role of Redistribution

How do taxes and transfers affect the distributional consequences of temperature shocks? This subsection compares the responses of two additional income measures defined by Blanchet et al. (2022): pretax income, which adds social insurance benefits net of contributions to factor income, and disposable income, which further subtracts direct taxes and adds cash transfers.[11] We focus on the Bottom 50 percent, the group for which redistribution is most directly relevant.

Figure 8 reports the impulse responses of real pretax income (orange solid line, left panel) and real disposable income (purple solid line, right panel) for the Bottom 50 percent.[12] The two responses display markedly different dynamics. Pretax income declines gradually after the shock, reaching approximately -1 to -1.5 percent after six months, and remains negative over the full twelve-month horizon. By contrast, disposable income drops comparably but the decline dissipates within several months, with the response returning toward zero by the end of the horizon.

The differences between the two responses indicate that taxes and transfers partially mitigate the temperature-induced income shock at the bottom of the distribution, consistent with the long-standing view that the U.S. tax-and-transfer system serves as an auto-

[11] Cash transfers include unemployment insurance benefits, welfare and other cash assistance, and veterans' benefits, following the classification in Blanchet et al. (2022).

[12] Results for the Mid 40 and Top 10 percent are reported in Appendix A.

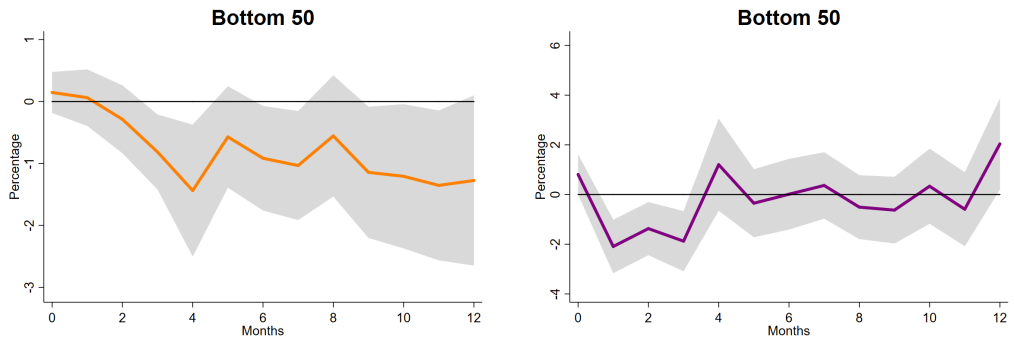


Figure 8: Responses of Pretax Income and Disposable Income of the Bottom 50

Notes: This figure plots the impulse response of pretax and disposable income of the Bottom 50 to temperature shocks. The orange solid line shows the response of real pretax income of the Bottom 50, while the purple solid line represents the response of real disposable income of the same group. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

matic stabilizer of household income (Auerbach and Feenberg 2000; McKay and Reis 2016). This pattern also aligns with evidence on the stabilizing role of redistribution following other macroeconomic shocks, including monetary policy shocks (Furceri et al. 2018) and uncertainty shocks (Choi and Phi 2026), and suggests that redistributive policy mitigates the distributional consequences of temperature shocks at the bottom of the distribution over time.

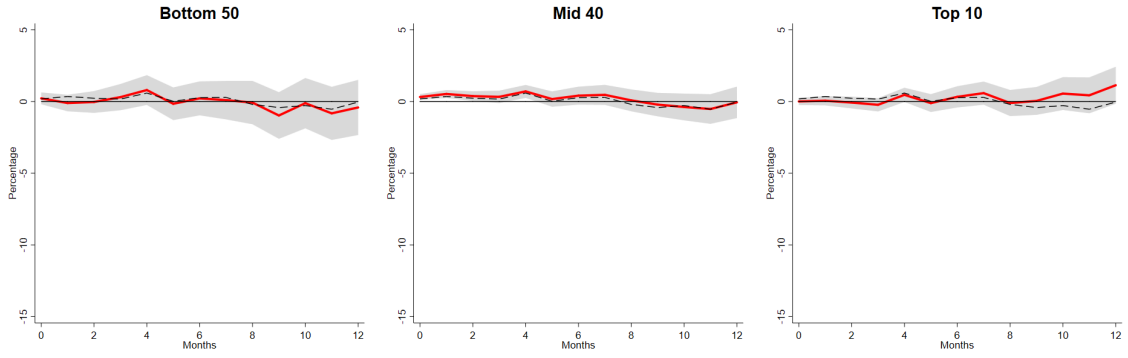
4.3 Has the impact of temperature shocks intensified since 2000?

This subsection examines whether the distributional effects of global temperature shocks have changed over time. Motivated by evidence that extreme temperature events have become more frequent and intense since the late twentieth century, with implications for the magnitude of climate damages in recent decades (e.g., Kim et al. 2025 and Colacito et al. 2019), we split the sample into a pre-2000 and a post-2000 period and re-estimate the local projection model separately for each subsample.[13]

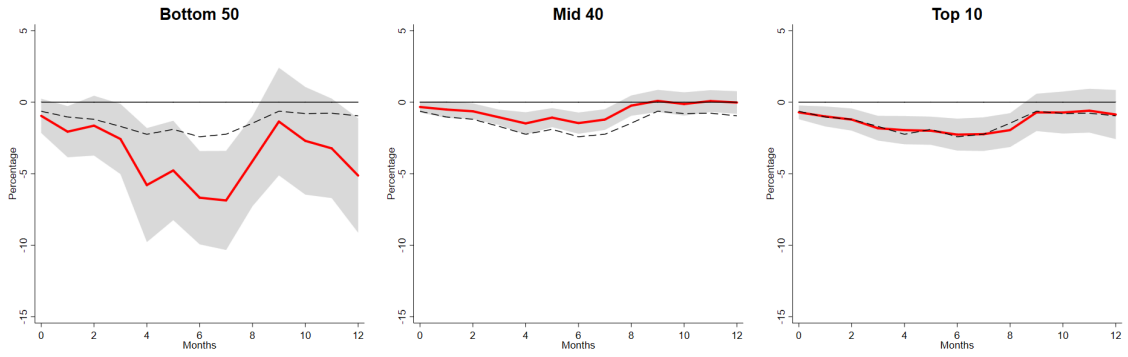
Figure 9 reports the impulse responses of real labor income by group for the two subsamples. The differences are substantial across sample periods. In the pre-2000 sample (Panel a), labor income responses are negligible across all three groups, with point estimates fluctuating around zero. By contrast, in the post-2000 sample (Panel b), the re-

[13]To verify that the time-varying pattern is not driven by the specific choice of 2000, we re-estimate the model with alternative break points of 1995 and 2005. Appendix C shows that the regressive pattern is robust across these alternatives.

sponses are considerably larger in magnitude and display clear heterogeneity across the distribution. The Bottom 50 percent experiences a sharp decline that reaches approximately 7 to 8 percent within four to six months after the shock and remains negative over the subsequent horizon. The Mid 40 and Top 10 percent also show moderate declines, with magnitudes larger than those in the pre-2000 sample. The responses of the Bottom 50 percent in the post-2000 subsample are substantially larger in magnitude than those obtained from the full sample in Section 3, indicating that the regressive distributional pattern of the full sample is largely attributable to the more recent period. Figure B.4 in the Appendix reports the corresponding responses of the labor income ratio, with the widening of labor income inequality more pronounced in the post-2000 period.



(a) Before 2000



(b) After 2000

Figure 9: Time-varying Effects of Temperature Shock on Real Labor Income

Notes: This figure plots the impulse response of labor income by income group to temperature shocks in two different sample periods. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ of global temperature. Panel (a) shows the response before 2000, and Panel (b) represents after 2000.

These results indicate that the distributional consequences of global temperature shocks

have strengthened markedly in recent decades. This pattern is consistent with evidence of Kim et al. (2025) that climate damages to economic activity have grown larger in recent years, and aligns with findings of Colacito et al. (2019) that recent temperature fluctuations have had pronounced effects on labor productivity and output.

The time-varying effects can be explained by the nonlinear relationship between temperature and economic activity. Productivity declines at an increasing rate once temperature exceeds a moderate level (Burke et al. 2015; Kalkuhl and Wenz 2020). After decades of rising baseline temperatures, temperature shock of a given magnitude would generate larger losses than an identically sized shock did in earlier decades. At the same time, the conditions of the labor market in the U.S. have changed over time. For instance, the share of U.S. workers in alternative work arrangements in recent years (Katz and Krueger 2019) and earnings in these arrangements are tied more closely to hours worked.[14] Since high temperatures reduce hours worked in industries with high exposure to climate (Graff Zivin and Neidell 2014), this channel is consistent with the more pronounced regressive pattern after 2000.

Taken together, the time-varying evidence further highlights the interpretation of climate change as an inequality multiplier whose distributional consequences have become more pronounced over time.

5 Conclusion

This paper examines the distributional consequences of global temperature shocks for labor income in the United States. Using disaggregated monthly income data and identified global temperature shocks, we estimate the dynamic responses of labor income by income group through local projections.

The results highlight four main findings. First, global temperature shocks decrease aggregate labor income. Second, and more importantly, the effects are highly heterogeneous across the distribution. Lower-income groups experience larger and more persistent losses, while higher-income groups are much less affected. Third, the factor income response is

[14] Katz and Krueger (2019) define alternative work arrangements as temporary help agency workers, on-call workers, contract workers, and independent contractors or freelancers, and report that the share of U.S. workers in such arrangements rose recently. They also show that among these categories, temporary help agency and on-call work are more prevalent at the lower end of the predicted wage distribution.

largely accounted for by labor income rather than non-labor income, and the persistent decline in pretax income at the bottom of the distribution is partially mitigated by taxes and transfers. Fourth, the regressive pattern is especially pronounced in the post-2000 period.

These findings show that the labor-market costs of global temperature shocks are not evenly distributed and are concentrated among workers at the lower end of the distribution. Climate adaptation and income-support policies may therefore need to account not only for the aggregate effects of climate shocks, but also for their unequal incidence on labor income across the distribution.

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Appendix A Aggregate Response

This section reports the response of aggregate variables to global temperature shocks. Figure A.1 shows that the immediate response of global temperature is equal to one after the shock occurs. Figure A.2 and Figure A.3 show the response of factor income and non-labor income, respectively.

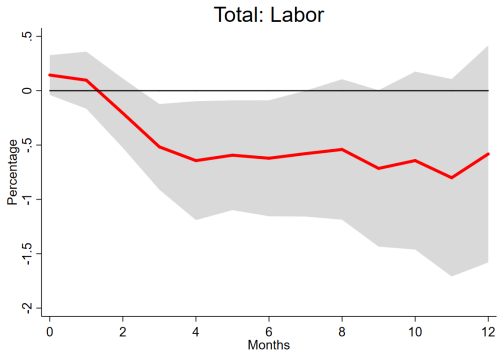


Figure A.1: Response of Global Temperature to Temperature Shocks

Notes: This figure plots the impulse response of global temperature to temperature shocks. The solid line shows the response of global temperature to global temperature shocks. Shaded areas illustrate the range between the 16th and 84th percentiles.

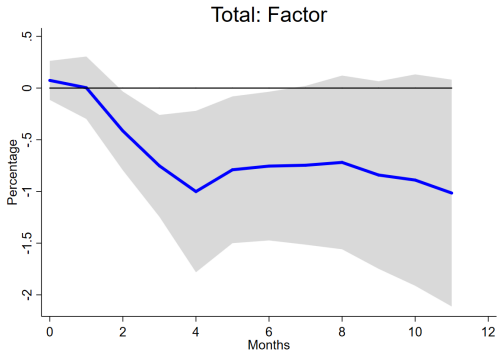


Figure A.2: Response of Factor Income to Temperature Shocks

Notes: This figure plots the impulse response of aggregate factor income to temperature shocks. The solid line shows the response of factor income to global temperature shocks. Shaded areas illustrate the range between the 16th and 84th percentiles.

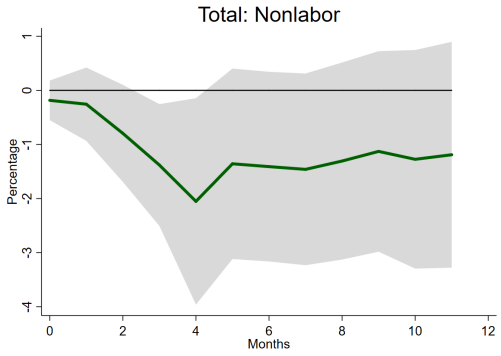


Figure A.3: Response of non-labor Income to Temperature Shocks

Notes: This figure plots the impulse response of aggregate non-labor income to temperature shocks. The solid line shows the response of non-labor income to global temperature shocks. Shaded areas illustrate the range between the 16th and 84th percentiles.

Appendix B Additional Results

This section reports additional results. Figure B.1 shows the response of non-labor income for each group to temperature shocks, and Figure B.2 and B.3 represent the responses of pretax income and disposable income, respectively. Figure B.4 reports the response of relative labor income to temperature shocks before and after 2000.

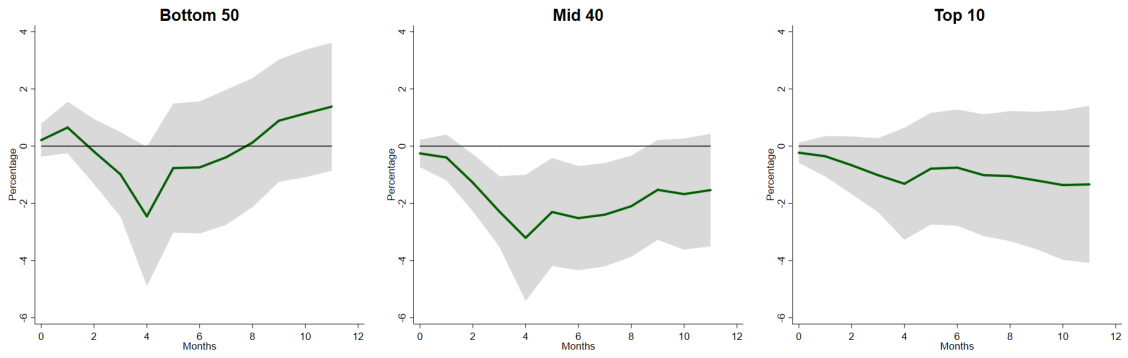


Figure B.1: Effects of Temperature Shock on Real non-labor Income by Group

Notes: This figure plots the impulse response of non-labor income by income group to temperature shocks. The green solid line shows the response of non-labor income for each group. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

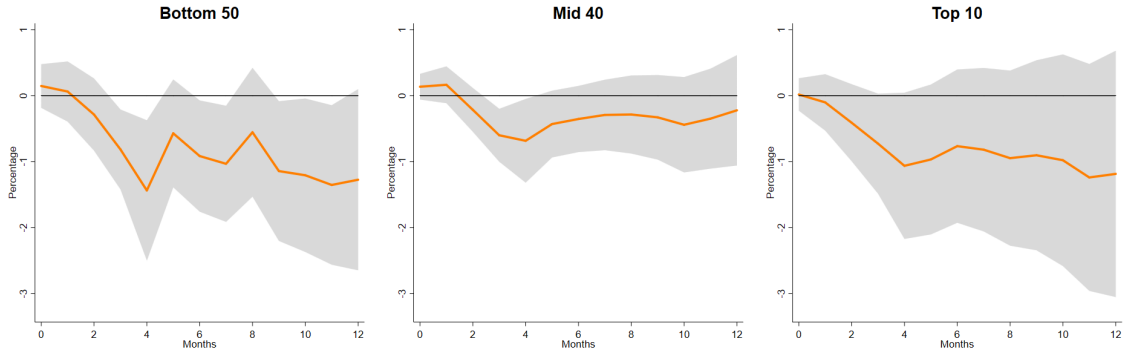


Figure B.2: Effects of Temperature Shock on Real Pretax Income by Group

Notes: This figure plots the impulse response of pretax income by income group to temperature shocks. The orange solid line shows the response of pretax income for each group. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

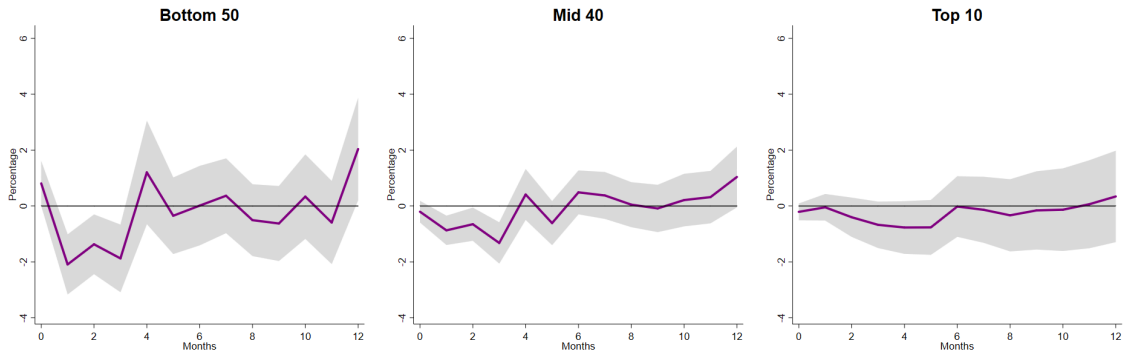
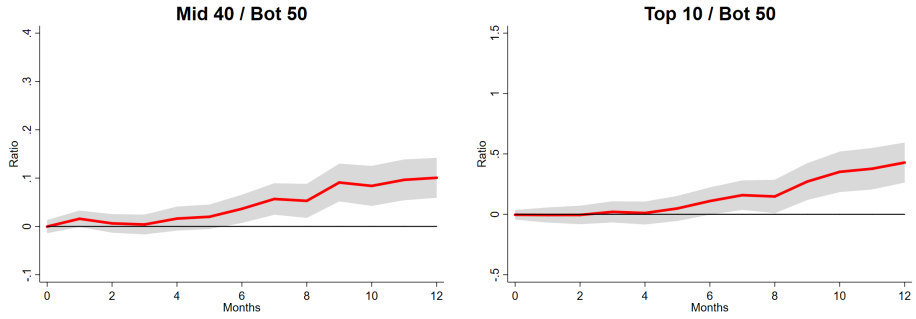
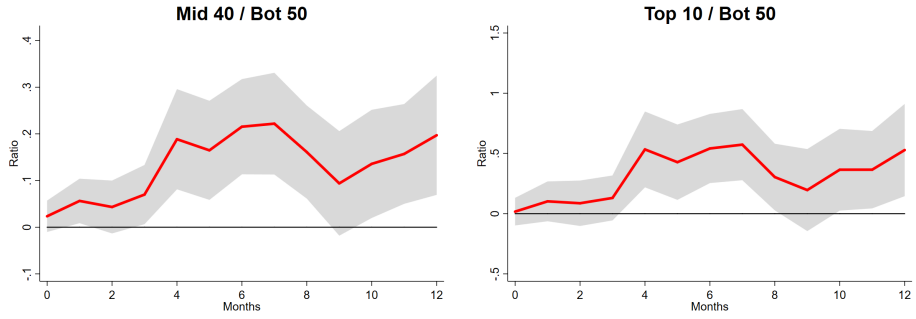


Figure B.3: Effects of Temperature Shock on Real Disposable Income by Group

Notes: This figure plots the impulse response of disposable income by income group to temperature shocks. The purple solid line shows the response of disposable income for each group. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ of global temperature.



(a) Before 2000



(b) After 2000

Figure B.4: Time-varying Effects of Temperature Shock on Relative Labor Income

Notes: This figure plots the impulse response of inequality measures of labor income to temperature shocks in two sample periods. The red solid line shows the response for each ratio. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ of global temperature. Panel (a) shows the response before 2000, and Panel (b) represents after 2000.

Appendix C Robustness Checks

This section examines the robustness of the main findings across alternative specifications.

We re-estimate Equation (3) with 3, 6, and 18 lags, and as shown in Figures C.1, C.2, and C.3, the results are not driven by the choice of lag length. In the shock identification procedure, we alternatively construct the shock using 12-month-ahead innovations with 48 lags and 24-month-ahead innovations with 48 lags. Figures C.4 and C.5 indicate that the main pattern remains robust. We further consider an alternative specification excluding the growth rate of industrial production from the controls. The results in Figure C.6 confirm the robustness of the main findings. When excluding U.S. temperature from the control variables in Equation (3), Figure C.7 shows that the distributional effects remain unchanged. Figures C.8 and C.9 examine the robustness of the time-varying evidence to alternative choices of the structural break point, where we re-estimate the local projection model using 2005 and 1995, respectively, as alternative cutoffs. The results are consistent with the main findings, suggesting that the findings are not sensitive to the specific choice of the 2000 break point. Figure C.10 reports the results based on seasonally adjusted global temperatures using the X-13ARIMA-SEATS procedure, and the main findings are similarly robust.

Overall, the main results are robust across alternative specifications.

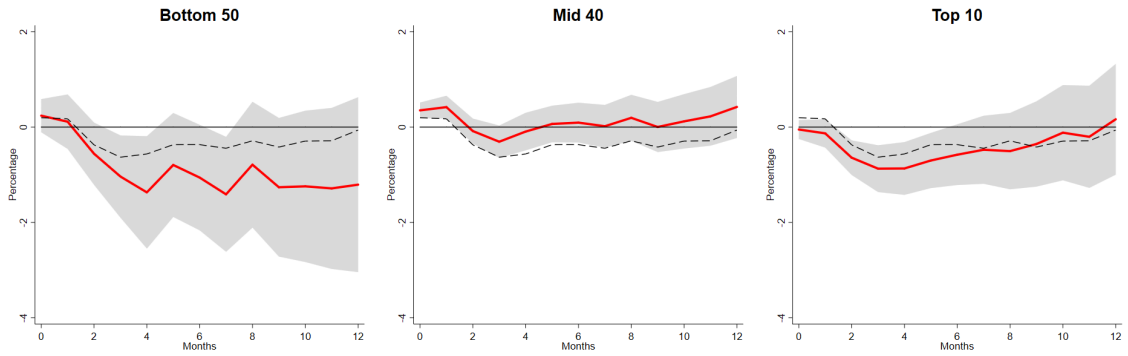


Figure C.1: Response of Labor Income: Lag=3

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

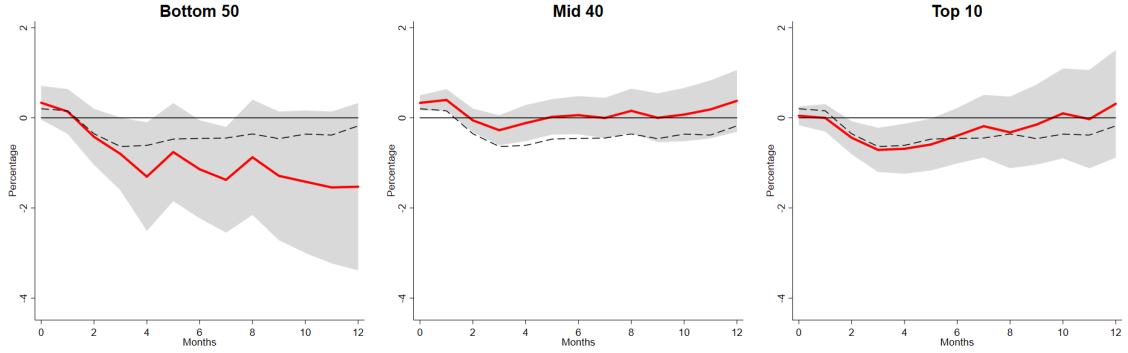


Figure C.2: Response of Labor Income: Lag=6

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

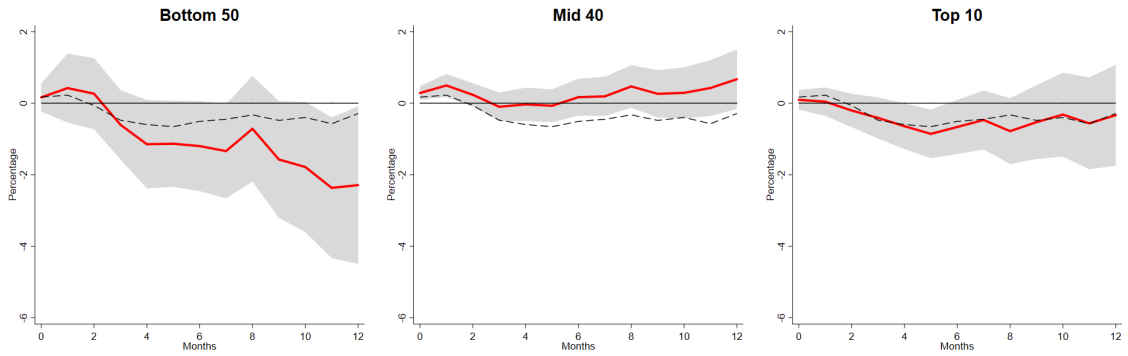


Figure C.3: Response of Labor Income: Lag=18

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

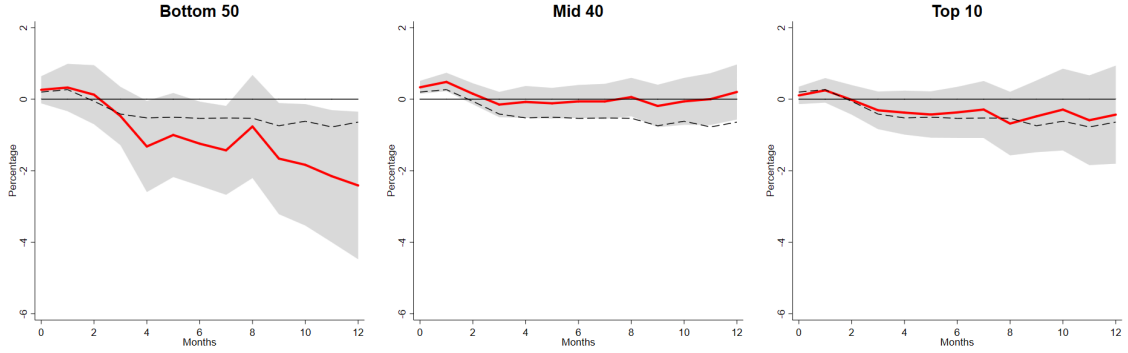


Figure C.4: Response of Labor Income: $p = 48$ and $h = 12$

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

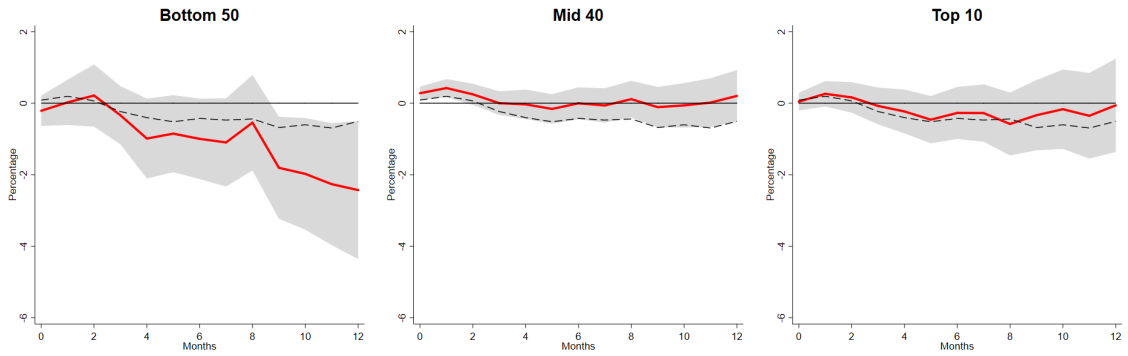


Figure C.5: Response of Labor Income: $p = 48$ and $h = 24$

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ of global temperature.

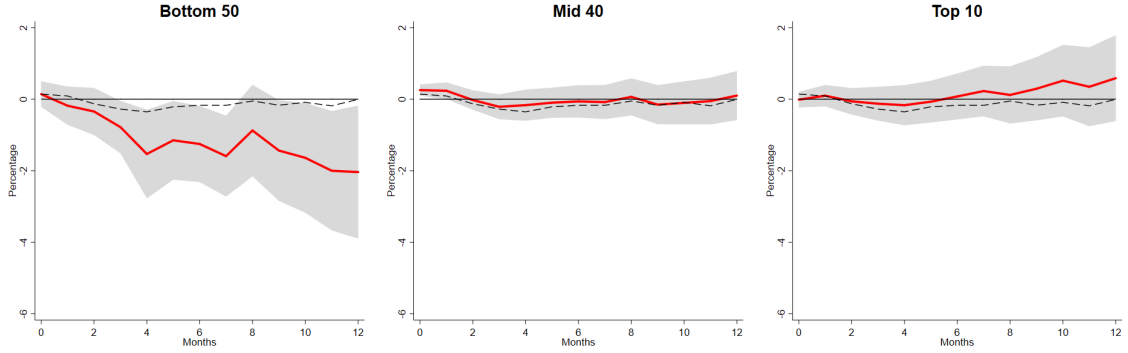


Figure C.6: Response of Labor Income: Excluding Industrial Production

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ of global temperature.

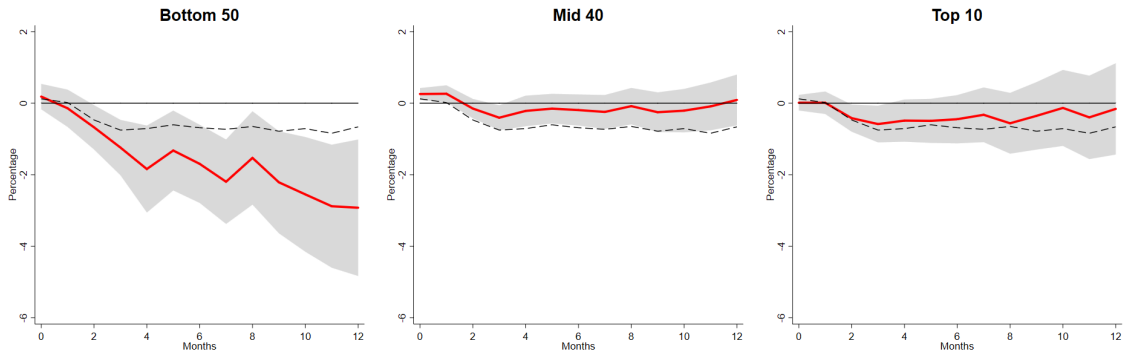
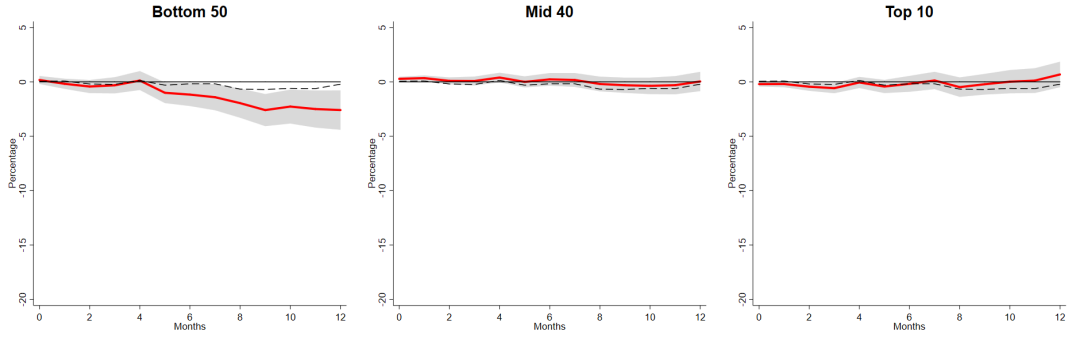
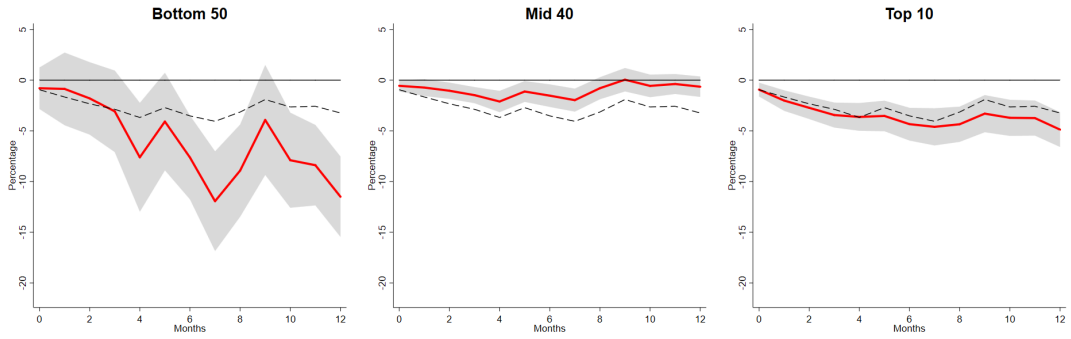


Figure C.7: Response of Labor Income: Excluding U.S. Temperature

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*



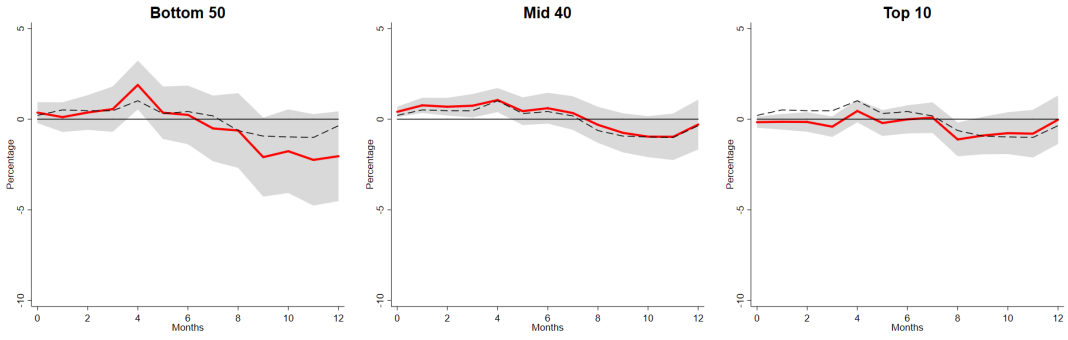
(a) Before 2005



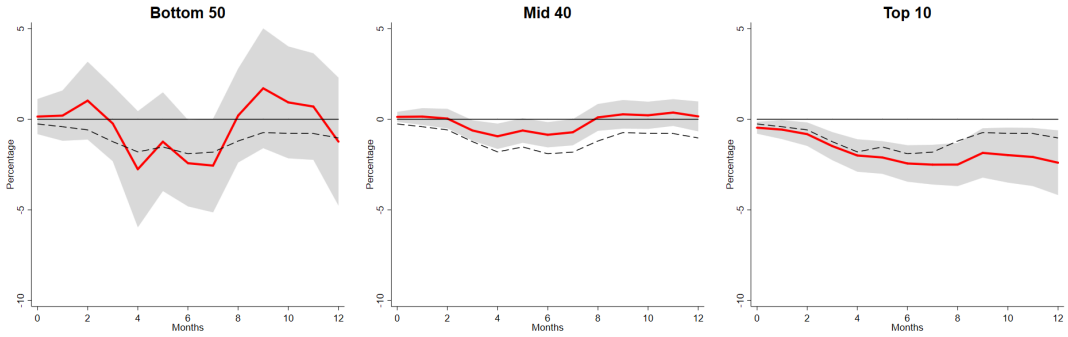
(b) After 2005

Figure C.8: Time-varying Effects of Temperature Shock on Real Labor Income

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature. Panel (a) shows the response before 2005, and Panel (b) represents after 2005.*



(a) Before 1995



(b) After 1995

Figure C.9: Time-varying Effects of Temperature Shock on Real Labor Income

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature. Panel (a) shows the response before 1995, and Panel (b) represents after 1995.*

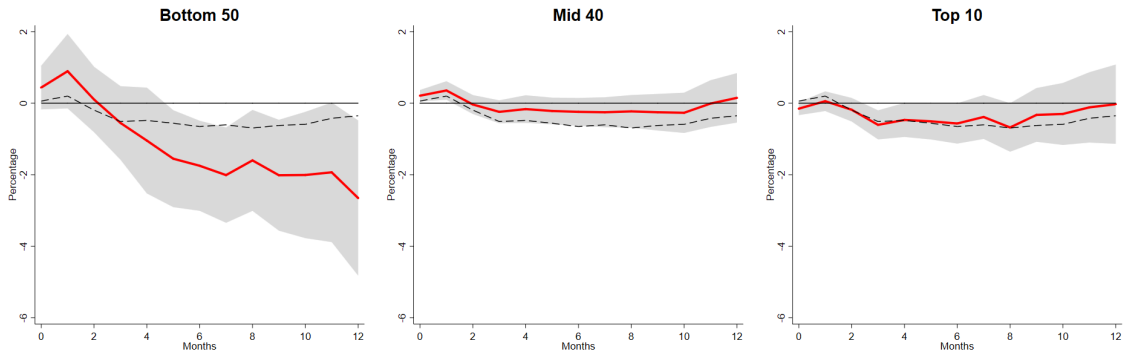


Figure C.10: Response of Labor Income: Seasonally Adjusted Temperature

Notes: This figure plots the impulse response of labor income by income group to temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature.*

F DDDDDDDDDDDDDDDDDDDDDDDDDDDDD

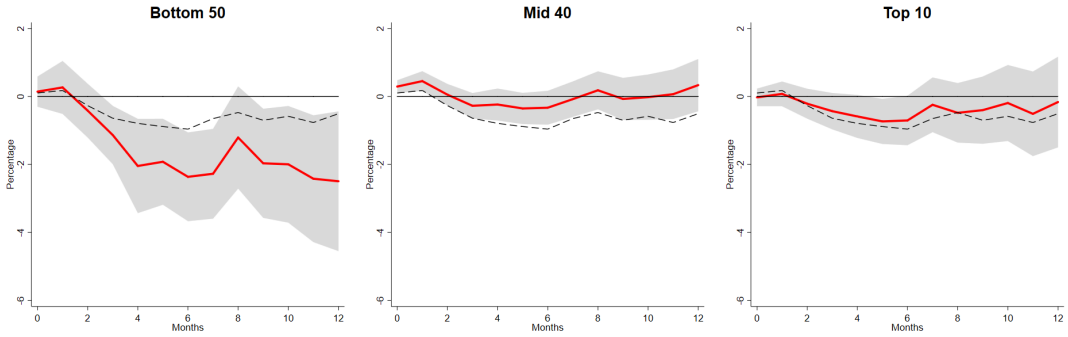
Specification (Shock identification and local projection) as in Bilal and Känzig (2024).

local temperature shock, $T_t^{shock,US}$, is identified as in Section 2.2 by using US temperature.

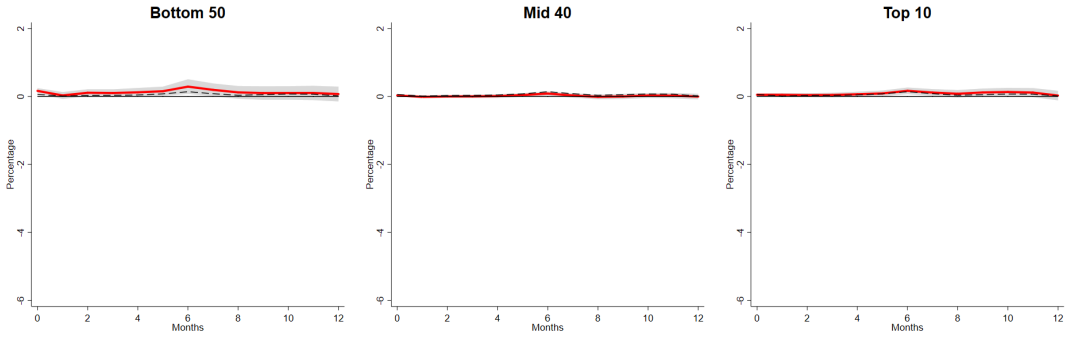
$\theta_h^{g,Local}$ represents the effects of local temperature shocks on y_{t+h}^g

lag of local temperature shock series is controlled.

$$y_{t+h}^g = \alpha_h^g + \theta_h^{g,Global} T_t^{shock,Global} + \theta_h^{g,Local} T_t^{shock,US} + B_h^g(L) X_t + \epsilon_{t+h}^g, \tag{4}$$



(a) Global Temperature Shocks



(b) Local Temperature Shocks

Figure F.0: Effects of Global and Local Temperature Shocks

Notes: This figure plots the impulse response of labor income by income group to global and local temperature shocks. The red solid line shows the response for each group, while the black dashed line indicates the corresponding aggregate response. Shaded areas illustrate the range between the 16th and 84th percentiles. Impulses are scaled to imply the increase in $1°C$ *of global temperature. Panel (a) shows the response to global temperature shocks, and Panel (b) represents the effects of local tempearture shocks.*