The Invisible Helping Hand: Time-based Insurance for the Self-Employed

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Abstract

This paper investigates the role of intra-household time-based insurance as a barrier to women's wage employment. I show descriptively that wage jobs are less flexible than self-employment, that spousal flexibility protects business income but not wage income against shocks, and that the two combined generate co-movement in spouses' job choices that standard explanations do not account for. I build a joint occupational choice model with risk, commitment to wage work and time-based insurance that guides the empirical investigation. Leveraging exogenous variation in droughts and in enrollment in formal insurance in a panel of pastoralists, I find that in this context, wife non-wage work participation is a source of insurance against shocks to the family business income. I illustrate the model numerically and discuss the role of time-based insurance for explaining the high incidence of non-wage employment for women and determining the incidence of wage subsidies, flexibility, and financial inclusion policies.

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1 Introduction

Informal insurance is an important source of risk mitigation in low- and middle-income countries (LMICs), where 31% of adults identify friends and family as their main source of emergency money (World Bank Global Findex Database, 2025). Money, however, is only part of how help is provided: watching over a friend's store or occasionally babysitting their children can save expenses and keep a business running without requiring cash or a formal hiring process. This time-based insurance can be a sizable component of shock mitigation strategies, particularly for spouses, who share consumption and domestic duties, and in contexts where scarcity of wage work limits cash transfers. While frameworks exist for informal insurance based on money or on productive labor (e.g. family firm help, the added worker effect), unified modeling and quantification for time-based insurance are lacking. In this paper I fill this gap, and study the implications of informal, time-based insurance on women's low wage employment.

I start by conceptualizing time-based insurance, before studying how this mechanism binds together the occupational choices of workers within a household. I define time-based insurance as the range of activities individuals perform to help their networks face negative shocks, with no particular skill or input other than time. Since job types differ in terms of the flexibility they offer, in the absence of formal insurance mechanisms the need for insurance affects both the demand for, and the supply of time-based insurance. Self-employed income is determined by marginal productivity, so inputs from third parties convert into consumption more efficiently than they do for wage workers, who are paid a fixed salary. Relative to the self-employed, wage workers also have less short-term flexibility over their tasks and schedule, such as which tasks they perform, when they can leave work, or whether they can take children to work with them.[1] As workers leave self-employment for wage jobs, both their demand for time-based insurance and their capacity to supply it decrease, which simultaneously affects their own resilience and that of their networks. Flexibility to provide and to benefit from help can therefore generate complementarity between the job choice of help providers and receivers.

Because greater access to salaried employment has been associated with economic development (Amodio et al., 2022; Donovan et al., 2018; Bandiera et al., 2022b), cross-household complementarities in wage job entry have important policy implications: if job choices are intertwined, policies that aim to increase wage-job uptake by targeting only one worker category, e.g. gender, might be limited in their effectiveness. What is the cost in terms of policy efficiency of ignoring a potential cause of co-movement between spouses' occupational choices? Understanding the nature of these links is difficult in the absence of a readily available framework in which occupational choices are

[1] Wage work is also less flexible in terms of the choice of tasks and whether workers can take children to work with them. A large literature relates this to higher absenteeism rates at wage jobs in developing countries, in spite of large excess labor supply (Goraya et al., 2025).

linked between spouses. Measuring their quantitative importance is complicated by the lack of data on jobs, time use and earnings linked across spouses, by significant endogeneity in job choice and risk exposure, and by the co-existence of many forms of informal insurance.

This paper takes descriptive, theoretical and empirical steps towards addressing these challenges and towards clarifying what time-based insurance implies for labor policy. I begin with novel individual- and couple-level stylized facts on occupational choice, risk exposure, and time use, which motivate the magnitude of the phenomenon at hand and ground the theoretical framework. Motivated by evidence of a lower prevalence of wage work than in countries with similar GDP per capita, I focus on African countries (Bandiera et al., 2022a) and harmonize five time use surveys from the continent, linking information across spouses.

My first descriptive finding is that wage work is less flexible than self-employed work on several dimensions. Using time-used surveys, I build two complementary measures of flexibility to provide help on short notice: multitasking — the capacity to help while still on the job — and schedule variation — ability to leave one's job on short notice. Workers are less likely to multitask within an hour of wage work than within an hour of self-employed work. This is particularly true of women workers, and of multitasking with domestic or care work, which becomes less than half as frequent in wage work. Wage workers appear less able to help while on the job, and also less able to adjust their schedule when a need arises: in all countries the self-employed have lower mean daily hours of work, but their higher variance results in coefficients of variation 20 to 100% higher. This finding matches the conceptual differences between work arrangements while adding to the literature on multitasking, which has focused on richer countries and, to my knowledge, has not decomposed by work arrangement (Zaiceva, 2023). I carry it through the paper by using wage work as a proxy for lower levels of flexibility.

My second descriptive finding is that wage work also limits the capacity to benefit from spousal flexibility. From here to the end of the paper, I link the harmonized data across spouses. I proxy the husband's experience of shocks with income residuals from a regression on a range of controls, separating the wage stream from self-employed earnings and controlling for all productive inputs, including the wife's productive labor at the self-employed activity. All else equal, husbands of wage-working wives experience significantly more severe shocks at their self-employed businesses, which points to an informal insurance role for spousal flexibility. Shocks to wage income, by contrast, are unaffected by the wife's occupational choice. This result holds in Ethiopia and extends to other sectors and to urban areas in Vietnam; it suggests that while the schedule rigidity of wage jobs limits the capacity to provide time-based insurance, their pay rigidity limits the capacity to benefit from it when shocks occur.

My third descriptive finding is that spouses' schedules and job choices co-move in ways that

assortative matching and productive labor complementarity do not entirely account for, as implied by wage work reducing both the demand for and the supply of time-based insurance. On the intensive margin, matching schedules across spouses, I find that having a husband who owns a business significantly reduces time spent in wage work in the majority of countries in my sample of time use surveys. This comparison is made between wage-working women across husband occupation, which points to explanations beyond assortative matching. Furthermore, the schedule shift does not benefit time spent working at the family firm, as an explanation based on labor complementarity patterns at the family firm would predict, but leads instead to increased time spent in leisure and sleep. IPUMS data covering 84 countries confirm these patterns and extend them to the extensive margin: conditional on socio-demographic and geographical controls, women whose husband owns a business are 35% less likely to hold wage work globally, and half as likely in low-income countries.

I take these descriptive results as suggestive that time-based insurance — the ability to supply it and the value of receiving it — may be a quantitatively meaningful determinant of occupational choice within households. Because they are produced on several countries at once, however, they capture cross-population variation in schedules and in the experience of predicted shocks. That is different from the within-individual ability to give and to receive help when an actual shock hits, which requires panel data, a conceptual shock, and a model that works through the potential shock adaptation mechanisms. This is the objective of the rest of the paper.

The paper then develops a novel time allocation model with joint occupational choice and a variety of informal insurance mechanisms against downside business-level risk, including time-based insurance. I add a temporal dimension to a standard time allocation model, with discrete downside business risk and a pre-shock commitment by the wife to wage work: uncertainty over risk is resolved in period two, but women have to commit in period one to whether they work for a wage. Commitment implies that women who participate in wage work do not equalize marginal productivity between wage work and the family firm in period 2, but instead compare expected utilities in period 1. I allow for time-based insurance by adding the wage participation choice as a parameter of the family firm production function. This sets my analysis apart from the way other informal insurance mechanisms may appear. I derive households' responses to risk. I decompose those responses into the part caused by commitment preventing flexible factor reallocation and the part caused by the direct, risk-dependent effect of including the wage work choice in the family firm profit function. This allows me to map variation in the profit function across states of the world into predictions for women's wage work.

The model generates predictions about the wage job choices of wives who know that their wage work choice, made when risk is uncertain, might matter directly for family firm productivity, compared to a counterfactual where wage work also requires pre-shock commitment, but has no such

direct effect. Relative to that benchmark, households adapt differently depending on the direct effect — the effect on firm production at constant hours — of wives taking up wage work in good times and in bad times. If the two share the same sign (i.e., wives being away is always costly to the firms, or always helps, regardless of whether there is a negative shock), households adapt as if the wife's wage participation choice were an omitted variable influencing firm productivity. If the two have opposite signs (e.g., wives make wages that are useful to the firm in good times, but their being away harms firm productivity in bad times), then households sit at a threshold. A new term is added to their decision-making process in which they weigh the severity of the negative effect, the probability of the state of the world in which that effect is negative, and the alternative employment options available to the husband to cope with bad states of the world without large household utility drops.

The theoretical results point to a two-step empirical exercise for assessing the effects of policy in a given setting. The first step is to assert whether wife wage work choice matters for the firm when holding productive inputs at the firm fixed, and how this effect varies with the state of the world. When these signs are opposed, the second step is to estimate how many households sit close to the indifference threshold at which policy could generate wife entry into wage work. I implement both steps in a setting with low female wage participation and no formal risk product at baseline, using data and experimental variation that are uniquely well suited to pinning down these objects.

I use the Borana pastoralists panel collected by the International Livestock Research Institute as part of its work on Index-Based Livestock Insurance (IBLI) in the region (Takahashi et al., 2019; Jensen et al., 2025; Sakketa et al., 2025). The surveyed communities are pastoralist households facing very high drought risk, for whom no formal risk mitigation was available prior to the experimental introduction of drought insurance. The data cover a period of uninsured drought, with detailed information on the income and hours of each household member across all jobs held during the year, along with information on baseline shock exposure and wage labor market access. The absence of formal insurance at baseline allows me to estimate the effect of informal time-based insurance on shock resilience without confounding from endogenous take-up of other formal risk-mitigation products. Its introduction during the panel allows me to estimate the share of households that were previously at a threshold where wives would turn down otherwise attractive wage options because the family firm's protection needs relied on their flexibility.

My first empirical exercise uses variation in shock exposure and in wife wage work and recovers the risk-dependent effect of wife wage work choice on firm production, holding inputs fixed. I use drought occurrence and wife wage participation in panel regressions, instrumenting each spouse's labor inputs at the pastoralist activity and adding a comprehensive set of dynamic controls to capture omitted variables related to wage job take-up. I find that droughts have catastrophic effects on households' livestock earnings, equivalent to a 37% reduction in livestock income net of re-

allocation of labor. Households where the wife is less available because of wage work see even larger productivity reductions, which cannot be attributed to differences in hours worked, bringing livestock income, with all productive hours fixed, to less than half of its non-drought value. In the absence of drought, conceptually, wage-working wives could contribute to the firm productivity by reinvesting some of their income. However, insignificant results and smaller magnitudes than the negative impact of unavailability during droughts mentioned above challenges this view in this context, meaning time-based insurance dominates here. Robustness tests and extensions give more detail into inputs at the family firm - as controlling for domestic labor inputs increases the magnitude and significance of estimates, suggesting these inputs might partly represent mismeasured productive labor - and channels of circulation for the effect of time-based insurance, which seems to be more crucial for women with children and those with fewer other adult household members around.

As empirical investigation of firms' coping mechanisms points to time-based insurance — negative effects in the bad state that are less than compensated for by effects in the good state — the model delivers specific predictions : wives who would otherwise have accepted wage work may decline it, provided risk is likely enough, the cost of unavailability is high enough, and the husband's wages are not high enough to prevent large drops in utility when unprotected risk hits the family firm. To establish whether a large share of households in the Borana setting sit close to that threshold, I leverage experimental variation in the risk-mitigating alternatives available to households. ILRI introduced index-based livestock insurance (IBLI) together with randomized encouragements to enroll, in order to measure its impact. Using the RCT as an instrument for insurance demand, I study whether a change in the risk environment faced by households generates wage entry by making the wife's unavailability less costly to the firm.

Results indicate sizable wage entry effects of the policy on households that were induced to enroll by the discount. The effect occurs even when netting out for the concurrent channel of increases in expected firm productivity and survives alternative explanations based on herd type shifts affecting child labor demand, or income effects affecting childcare demand. In line with time-based insurance being particularly valuable for women with childcare responsibilities, entry effects are stronger for women with children, and they are lower for women with higher perceived productivity at the pastoralist activity. This result bears important policy implications for financial inclusion initiatives, which could act as an instrument for wage work entry if they provide an alternative to the risk-induced exclusion of informal, short-notice helpers from wage work.

The end of the paper illustrates the model and the particular problem faced by households where time-based insurance appears. I set parameters for a numerical illustration — meaning that I show potential policy effects, not policy counterfactuals — and explore three policy-relevant cases. Illustrating the model across levels of women's wages allows me to compute reservation wages, which

industrial policy can influence through subsidies. I find that time-based insurance modifies reservation wages relative to a counterfactual case with no direct effect of the wage choice on the production function. Adding this counterfactual also allows me to discuss wage job flexibility. That flexibility is not a given: recent changes in wage employment, notably the rise of remote work, and policy experiments seeking to accommodate women's domestic duties in developing countries are examples of how it can be shifted. I find that in this setting, more flexible wage work would generate higher entry by women at all levels of women's wages. Finally, the changing risk environment allows me to address the question of alternative financial products that can untangle spouses' occupational choices.

Relationship to the literature This paper contributes to several strands of literature. First, I contribute to the literature on flexibility and job choice. A significant literature finds large worker demand for job flexibility: workers in developing countries are willing to forgo wage for the option to leave work on short notice (Goraya et al., 2025), and women are found accepting lower wages for jobs with predictable schedule, work-from-home options that are part-time or closer to home (Mas and Pallais, 2020; Le Barbanchon et al., 2021; Goldin and Katz, 2011) or move to lower-paying informal or self-employed jobs that grant more flexibility (Delecourt and Fitzpatrick, 2021; Leyva, 2025). Descriptively, I add to this literature by adding evidence that wage work allows for less flexibility on different dimensions, such as ability to multitask (Zaiceva, 2023) or schedule flexibility. I also further this literature conceptually by linking flexibility to capacity to provide insurance for others, which delivers new insights on job choice.

Second, my paper contributes to the literature focused on modeling and testing for sources of co-movement between spouses' labor market decisions. Joint production of consumption and domestic duties generate substitutability between spouses' decision to integrate the labor market (Erten and Keskin, 2021; Cullen and Gruber, 2000) and time spent working (Dinkelman and Ngai, 2021; Gottlieb et al., 2024). In low-income countries, family firm productions can generate co-movement in family members' productive time inputs, with directions depending on labor complementarity patterns (Dumas, 2020; Adhvaryu and Nyshadham, 2017). Importantly, these co-movements are not a given, but are instead contingent on the environment, such as infrastructures, property rights, norms or labor market completeness (Chen et al., 2025; Dumas, 2020; Munshi and Singh, 2024; Dumas, 2020). My paper explores a new source type of co-movement — between job types — and a novel source for complementarity across spouses: job-specific capacity of give and benefit from informal insurance. I build on several examples of informal risk protection and coping strategies (Barrett et al., 2024; Mobarak and Rosenzweig, 2013) and I propose descriptive, theoretical and empirical evidence that short-notice inputs from more available spouse could constitute a meaningful coping mechanism against negative shocks for self-employed workers, who can more efficiently convert

these inputs into consumption.

Finally, I contribute to the literature on labor organization and economic development. As countries develop, research documents a shift from unpaid to paid work and from independent to salaried jobs (Bandiera et al., 2022b). Self-employment is associated to lower and more volatile earnings (Amodio et al., 2022; Donovan et al., 2018; McCaig and Pavcnik, 2021). From a policy angle, this evidence has fueled policy work seeking to foster productivity increases and wage job expansion in developing countries. Bandiera et al. (2022b) have proposed a meta-analysis of labor policies in Sub-Saharan Africa, finding that many settings qualify as low-equilibrium environments where there is low demand and supply of salaried labor, and recommend big-push policy that shift workers across equilibria, lifting multiple constraints at once — a conclusion that Amodio et al. (2022) also reach, focusing on labor market power as a determinant of policy efficiency. I propose a new reason why policy on similar individuals could have different effects: informal insurance through individual flexibility, making formal arrangements less attractive for individuals that are involved in such solidarity networks. This relates to concrete policy propositions whereby diminishing unprotected firm risk, for example through financial inclusion, can facilitate entry of entire networks into more productive jobs.

The paper proceeds as follows. In section 2, I present the different databases I use. In section 3, I show descriptive evidence of co-movement between spouses' job types and their earnings suggesting the existence of spousal informal insurance for family businesses. In section 4, I incorporate these insights into a model, estimate key parameters and illustrate the implications of the model. In section 5, I test the model's predictions on insurance effects on women's job choice using a case study from the same setting. In section 6, I test the model's predictions for women's job choice directly. Section 7 features model illustration and policy discussions, and section 8 concludes.

2 Data

This paper combines three types of data: time-use surveys, which record activities at the hour level; earnings surveys, which record income and labor inputs at the income-source level; and census microdata, which records occupational choice at the couple level. Table 15 maps each dataset to the variables it supports, their definitions, sample sizes, and where each features in the paper; the remainder of this section describes the three sources in that order.

Time Use surveys

Time-use surveys collect 24-hour diaries from respondents, linking each slot (half-hour or hour) to a category of activity, often following the International Classification of Activities for Time-Use

Statistics (ICATUS). I use every standalone time-use survey from an African country that I could access and that allows me to study couples and occupational choices, dropping those that enumerate only one household member or that lack information on occupational status (from either dedicated questions or a precise activity classification). My final sample includes five country-years: South Africa 2000 and 2010, Ghana 2009, Kenya 2021 and Egypt 2015.

Within each survey, I restrict attention to ordinary weekdays (Monday–Friday for all countries except Egypt, where I use Sunday–Thursday). Because my focus is on monogamous couples, I keep individuals over 18 in monogamous unions, even for stylized facts at the individual level. To form couples, I match the household head to their spouse; where that variable is missing, I pair two individuals of opposite sex who are less than 20 years apart and who both declare to be married. See Table 15 for final sample sizes.

Occupational status at the individual level I build two individual-level occupation variables: whether an individual is self-employed (*is self employed*$_i$) and whether they hold a wage job (*has wage job*$_i$). Many individuals hold several jobs over the year, so these variables are not mutually exclusive. To construct them, I combine answers to two questions, depending on what each survey makes available: whether the respondent performed a given activity (e.g., working for wage or in-kind payment) over the week, and what their primary and secondary jobs were during the year. The resulting concept is at the year level. *Is self-employed*$_i$ covers employers, own-account workers and unpaid family contributors, whereas *has wage job*$_i$ covers those working for wage, in-kind payment or commission. I show how each variable is defined across surveys, and the resulting proportion of each type in the population, in Table 15.

Multitasking Multitasking, which Zaiceva (2023) defines as performing several activities simultaneously, is measurable because most time-use surveys allow several activities to be recorded in the same slot. For all the databases in my sample with hour-level observations, I define it as respondents declaring more than 60 minutes of activity within a given hour. To capture the nature of multitasking as well as its occurrence, I create three variables: i) *Multitasking*$_h$, an indicator for the total minutes allocated in an hour summing to more than 60; ii) *MultitaskingDomCare*$_h$, an interaction of *Multitasking*$_h$ with a dummy signaling that domestic or care work features in that hour; and iii) *MultitaskingDuration*$_h$, the total minutes declared, conditional on multitasking. These variables are only available in the surveys with hour-level observations, which reduces the number of databases I can use (see Table 15).

Classification of type of hours For hour-level regressions, I separate hours into three mutually exclusive types: *wage*, *self-employed* and *other* — unlike the individual-level occupation variables,

which are not exclusive. In most cases only one type of activity occurs in a given hour, and classification follows directly from the ICATUS definition, which distinguishes wage work from own-account work. When multitasking or sequential activities occur, productive work, domestic work, and leisure can appear jointly in the same hour. I handle this with a priority rule: any hour that features wage work falls into the *wage hour*$_h$ category regardless of the other activities appearing in that hour; any hour without wage work in which self-employment appears falls into the *self-employed hour*$_h$ category; and all remaining hours fall into the *other hour*$_h$ category. For sequential activities, I allocate minutes proportionally where they are declared, and otherwise split the slot into as many parts as there are activities.

Earnings surveys

ILRI Ethiopia pastoralists panel

The International Livestock Research Institute (ILRI) collected panel data on 515 households in Borana, southern Ethiopia, from 2012 to 2015. Pastoralist or agro-pastoralist is the primary activity of households in these communities and seasonal migration during the two dry seasons (June-September and December-February) is frequent (Takahashi et al., 2016). The survey was designed to assess the impact of introducing Index-Based Livestock Insurance (IBLI) and of randomized encouragement to enroll in it. Geographical areas were selected to represent a wide range of environments, and pastoralist households were then drawn at random within them, stratified by herd size, an important determinant of shock resilience (Barrett et al., 2024). The survey contains information on income, consumption, time use, and livestock, with a one-year recall.

Throughout the paper, I select monogamous couples from the dataset. The final dataset contains 362 couples at baseline, 1452 couple-rounds, and 1291 husband income streams. Sample sizes across levels and outcomes are specified in Figure 1, and concept-specific sample sizes can be found under each figure.

Occupation: working for wage, working for the pastoral activity, working for farm Because the survey never asks members directly about their involvement in wage, self-employed and domestic work during the year, I combine the income and time use modules to recover a lower bound on that involvement. First, for each income category — livestock, farm, non-farm self-employment, and wage — the income module records the main earner of the household. Second, the time use module identifies each individual's first and second most time-consuming activities, using categories that differ from those of the income module: domestic work appears, and self-employment is split only into farm and non-farm rather than isolating livestock. Combining the two yields the most comprehensive measure possible. For example, the *[gender] has wage work*$_i$ variable equals one

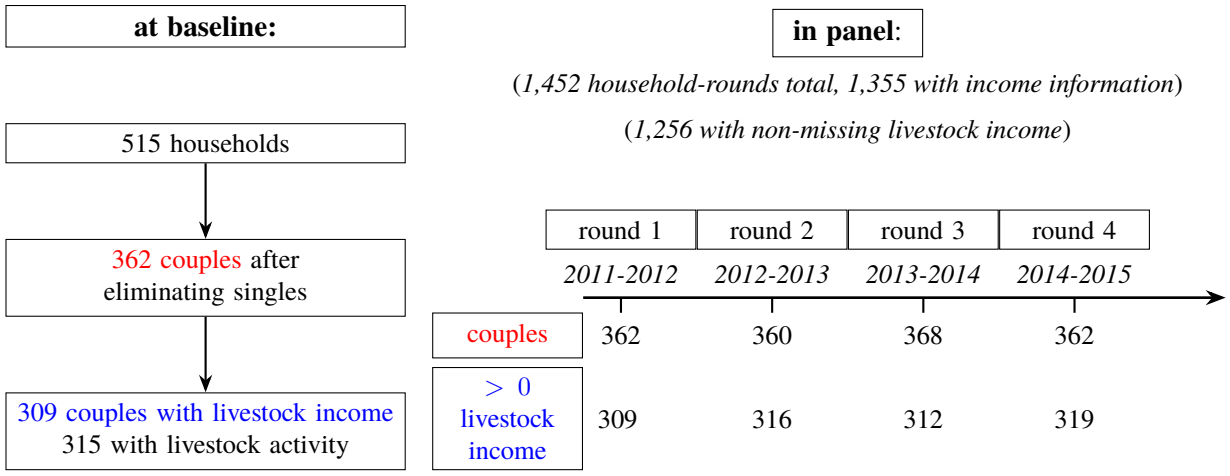


Figure 1: Number of observation across levels and income concept - Ethiopian IBLI panel

if the worker is either the household's main wage earner or reports wage work as their primary or secondary occupation, where domestic work counts among the candidate occupations. Because the time use module does not distinguish livestock from farm self-employment, I use both to define a variable for general involvement in agricultural activities, while collecting income information specific to livestock rather than to farm self-employment. All the occupational variables underestimate actual participation over the year, particularly for activities other than domestic work and farm self-employment — the hegemonic uses of time for household members — and for women, who earn lower wages than men and are thus less likely to appear in the income module as the main wage earner. My *woman has wage work*$_i$ variable, which takes the value one for only 5% of the sample, is therefore a particularly conservative lower bound for wage employment, and can be read as an indicator for women who are heavily invested in their wage work.

Income concept: farm income, non-farm income, wage income For each category of income, I collect yearly nominal earnings from the income module of the survey. Observing earnings at the household level is conditional on someone in the household earning money from that source during the year, and observing them at the individual level is conditional on that individual being the main earner in that category; I therefore attach each income stream to the member designated as the household's main earner for it.

When computing hourly earnings, I control for yearly hours obtained through the time use module. I only observe hours for individuals for whom that category is the primary or secondary use of their time. Yearly hours are built from hours per typical day and months spent on the activity during the year.

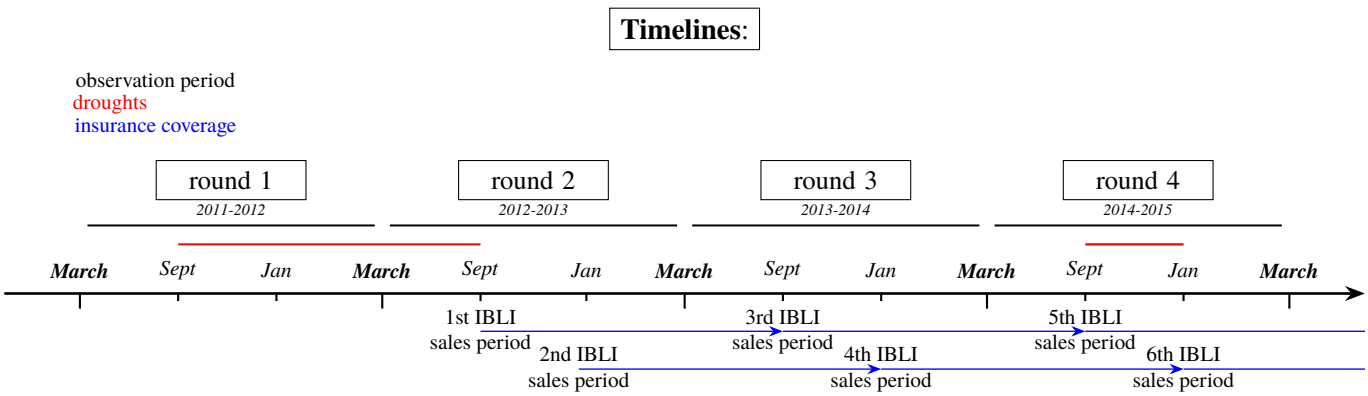


Figure 2: timeline of data collection, insurance sales periods, and droughts

Risk exposure and formal insurance The researchers experimentally introduced insurance and randomized premium discounts from the middle of round 2 onwards, with IBLI sold twice during each subsequent data collection period. Droughts are defined as low rain and forage density events that either triggered payouts from the index insurance product delivered alongside the survey or were mentioned by reports predating the introduction of insurance. They occurred in 3 of the 4 years during which data were collected (red bars in Figure 2).[2] There was a drought in 2011-2012 (the observation periods of rounds 1 and 2), and another one in 2014 that triggered payouts in several study sites (Takahashi et al., 2020). Figure 2 shows how all of these events interact with the data collection timelines.

Other variables The database also collects household-level information on herd size and composition, socio-demographic information (age, education), geography (woreda, study site), and survey weights at the household level.

Summary statistics Table 1 presents summary statistics for my main variables over the 4 years during which the panel data were collected, at the household level, on the 1355 household-years with income information. In line with there being a drought every year except round 3, 75% of observations experience a drought. The "region" variable, created from the *woreda* variable, splits the sample into three geographically coherent areas of roughly equal size. Women are substantially less literate and younger than their husbands. Households are large and one third of them include children. The overwhelming majority of men report some farm self-employed work each year (the

[2] see OXFAM Report for the 2011-12 drought (`https://alnap.org/help-library/resources/evaluation-of-ethiopia-drought-response-20112012-using-oxfam-gbs-global-humanitarian/` : "In 2011, two consecutive seasonal rains failed in Ethiopia. [...] The most severely affected regions were Oromia (1.8 million people affected)". The UN Office for the Coordination of Humanitarian Affairs (OCHA) report stated that there was "no likelihood of improvement until early 2012". Sakketa et al. (2025) and Takahashi et al. (2016) also mention a catastrophic drought the year the survey was launched.

	mean	median	sd	count
Location and drought experience				
Year is a drought	0.75	1	0.43	1355
West (Dillo, Teltele)	0.33	0	0.47	1355
East (Dire, Yabello)	0.31	0	0.46	1355
Center (Arero, Dhas, Moyalle, Miyo)	0.35	0	0.48	1355
Baseline livestock				
Log. herd size	2.50	3	1.49	1355
Socio-demographic characteristics				
Woman is literate	0.02	0	0.15	1355
Man is literate	0.10	0	0.30	1355
Man age	48.54	46	16.88	1355
Woman age	34.72	31	12.61	1355
Household size	6.86	7	2.41	1355
Woman has 0-6 y.o. child at baseline	0.23	0	0.42	1355
Woman has 12-18 y.o. child at baseline	0.12	0	0.33	1355
Income and hours (conditional on non-missing)				
Yearly household income, USD	637.43	350	1827.26	1355
Yearly household livestock income, USD	570.15	300	1838.34	1131
Man works for wage during year	0.20	0	0.40	1355
Woman works for wage during year	0.06	0	0.23	1355
Hours/year in farm SE, man	3102.00	3360	1072.76	1287
Hours/year in farm SE, woman	1333.29	1008	769.50	1035
Hours/year domestic work, man	1346.73	1344	781.29	41
Hours/year domestic work, woman	2643.45	2688	754.51	1286
Hours/year wage work, man	1885.63	2016	1151.75	107
Hours/year wage work, woman	1681.98	1680	773.57	17
Woman yearly wage income, USD	485.27	70	3055.80	67
Insurance discounts and purchase				
Purchased insurance during year (rounds 2-4)	0.34	0	0.47	1015
Mean insurance premium discount rate received (rounds 2-4)	36.69	35	21.42	1015

Table 1: Summary statistics - ILRI Borana pastoralists panel

category that comprises own-account livestock activities), while women are somewhat less likely to report these activities and report domestic work instead. Only 5% of women do wage work during the year, but those who do tend to be heavily involved, with a median of 1680 hours — 32 hours per week with no holidays — in line with the definition being a lower bound. 34% of households purchase insurance in a given year, a relatively high rate for an index-based insurance product, even with discounts (Chantarat et al., 2013).

Viet Nam Household Living Standard Survey (VHLSS)

In the appendix, I supplement the stylized facts from Ethiopia with similar evidence, extended to urban areas and non-farm self-employed sectors from the 2002, 2004, 2012 and 2014 rounds of the VHLSS. The VHLSS are nationally representative and contain farm and non-farm business modules in repeated cross-section, with a smaller panel section. I recover around 1700 couples per round. As in Ethiopia, I construct yearly income and hours variables; unlike my main data source, the VHLSS collects both systematically for every individual. I also collect annual hours worked in each activity, along with a comparable set of controls (details can be found in Appendix section A).

IPUMS

The Integrated Public Use Microdata Series (IPUMS)-International is a collection of national censuses covering around 100 countries across several decades, with harmonized socio-demographic and labor-related variables. I select countries that record occupational status of the primary job and employment status, and whose household and personal identifiers allow information to be linked across spouses. The resulting sample spans 84 countries and 264 country-years across all income levels, and I keep only working-age adults.

My main variable of interest is occupational status, which is directly available from IPUMS. I recode employment and occupational status into four categories describing occupation over the past year: unemployed/inactive, solo self-employed, wage-employed, and self-employed in a family firm (self-employed when the spouse is also in the same industry). I also extract control variables (household size, number of children in the household, number of children under 5, age category, educational attainment, industry of work, and whether urban) and survey weights. Finally, I create a country income variable by matching the GDP per capita of each country-year to the World Bank income classification.

3 Facts on flexibility and shock protection across spouses' occupational choices

This section delineates time-based insurance, distinguishing it conceptually and empirically from other informal insurance mechanisms, in order to ground both a model that incorporates it and an empirical strategy that tests for it. The most widely documented alternative mechanism is the "added worker effect" (Erten and Keskin, 2021): because consumption is produced jointly, a spouse who loses their job makes the other more likely to join the labor force. Self-employed workers, unlike salaried ones, cannot be fired, but they face a range of other risks that their families can help mitigate — notably by supplying productive labor, which becomes a second form of informal insurance (Beegle et al., 2006; Dumas, 2020) and shapes productivity through complementarities within family firms (Adhvaryu and Nyshadham, 2017). The mechanism proposed here differs on two counts: spousal availability is productivity-enhancing rather than consumption-augmenting, which sets it apart from the added-worker effect; and it can operate through time uses *beyond* productive labor. Examples include watching over one's plot (Chen et al., 2025), which reduces the likelihood of losing land tenure, and watching children so that others can focus (Delecourt and Fitzpatrick, 2021) — activities that, whether or not they are classified as productive labor, are easier to provide on a flexible schedule.

This section presents stylized facts that identify which spouses are more flexible and trace the implications of that flexibility, separating the channels of competing informal insurance mechanisms in order to assess the descriptive support for time-based insurance. First, I document individual ability to provide short-notice time-based help, or time-based insurance, across occupational statuses. Second, I explore the effect of wife flexibility on her husband's experience of income shocks, distinguishing shocks suffered at businesses from those suffered at wage jobs. Third, I document intra-household correlations in schedules and occupational choice.

3.1 Individuals: Occupational status and job flexibility

I define job flexibility as the ability to modify parts of one's job — tasks or schedule — at short notice, and I measure it along two dimensions: the ability to modify the tasks performed on the job in response to changing needs (multitasking), and the ability to modify one's schedule (variance). These two measures map onto the delivery of time-based insurance: the first signals the ability to help others while on the job, the second the ability to leave the job momentarily to provide help.
A limitation of my data is that I observe neither exogenous shock occurrence nor panel time use data, which prevents me from directly observing how workers adapt to a shock. My measures are therefore cross-sectional: I compare wage work with self-employed work, at the hour or at the worker level, across the two margins of flexibility. All results should be taken as correlational.

Occupational status and multitasking Using the three time-use surveys with hour-level observations, and for each multitasking outcome (*Multitasking*$_h$, *MultitaskingDomCare*$_h$, *MultitaskingDuration*$_h$, see Data section), I implement the following regression:

$$Y_h = \alpha + \beta \text{wage hour}_h + \epsilon_h$$

Standard errors are clustered at the individual level and survey weights are applied. The specification is a raw difference in means with no controls, so the comparison is entirely between individuals: self-employed and wage-employed workers differ in sector, gender composition and hours, any of which could drive the gap; like all the other stylized facts, this evidence is correlational. The estimation sample is all worked hours, so that α is the self-employed mean and β the difference for wage hours. The Appendix repeats the exercise on all hours, comparing wage hours with all hours regardless of whether they were worked (see Table 17 and Table 18), with stronger results in the same direction.

Table 2 presents results for all worked hours. The constant, which gives the mean for self-employed hours, reveals considerable cross-country variation both in how often multitasking occurs and in what it involves. Self-employed workers in the 2000 round of South Africa and the 2009

	Multitasking$_h$			**MultitaskingDomCare**$_h$			**MultitaskingDuration**$_h$	
	SA2000	SA2010	GH2009	SA2000	SA2010	GH2009	SA2010	GH2009
Wage hour	-0.015	-0.010*	-0.018	-0.005	-0.003***	-0.020***	1.324	-7.740**
	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(1.08)	(2.67)
Constant	0.101***	0.033***	0.104***	0.009***	0.004***	0.030***	114.827***	108.985***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.75)	(1.10)
R2	0.000	0.001	0.001	0.001	0.000	0.002	0.001	0.010
N	43816	105224	28698	43816	105224	28698	2589	2886

* p<0.05, ** p<0.01, *** p<0.001. Sample of worked hours of married 18+ persons in a typical day. s.e. clustered by individual

Table 2: Multitasking occurrence and intensity - women and men, worked hours

round of Ghana multitask in about 10% of their hours, but they combine different activities when they do. In Ghana, about one third of multitasking involves domestic or care duties (constant, col. 6), far less so in South Africa in 2000. Conditional on multitasking, workers declare more than an hour and a half worth of activities in Ghana in 2009 and in South Africa in 2010.
Wage work reduces the occurrence of multitasking in every case, and particularly multitasking involving domestic work, which it drives almost to zero in the three samples (in South Africa in 2000 the result is significant at the 10% level). Results on intensity are mixed, so I cannot conclude that wage work reduces the amount of activity declared conditional on multitasking. The appendix reports the same regressions for women (Table 16), where both the self-employed baseline and the negative wage coefficient are larger.

Occupational status and variance in workday duration Wage workers are less able to combine tasks on the job, but a worker could instead leave work to provide help, in which case multitasking would understate their capacity to deliver informal insurance. I therefore examine the length of the working day and its dispersion by occupational status.[3]

Results are presented in Table 3. In all countries, self-employed workers work much shorter days. The pairwise Levene test rejects equality of variances in four out of five countries, with self-employed variance higher in both South African rounds and in Egypt, lower in Kenya, and equality not rejected in Ghana. Because mean workdays differ so much across the two groups, however, the coefficient of variation is more informative here, and it is considerably higher for the self-employed in all countries, including Kenya.

In conclusion, cross-country micro evidence suggests that wage work is less flexible on both

[3]Occupational categories here are the individual-level, non-mutually-exclusive variables described in the Data section: a worker holding both a wage job and a self-employed activity appears in rows 1 and 2.

Employment status	South Africa 2000	South Africa 2010	Kenya 2021	Ghana 2009	Egypt 2015
Wage work	8.62 (3.73)	8.64 (4.00)	8.09 (3.98)	10.54 (3.70)	6.83 (4.46)
Self-employment	4.95 (4.24)	5.37 (4.37)	6.08 (3.63)	8.99 (3.82)	5.58 (4.55)
No job/other	1.59 (3.13)	0.65 (1.91)	1.15 (1.97)	1.59 (3.16)	0.13 (0.78)
Levene test p-value	0.00	0.00	0.00	0.67	0.00
Coef. of variation wage	0.43	0.46	0.49	0.35	0.65
Coef. of variation SE	0.86	0.81	0.60	0.42	0.82

Format: mean (standard deviation) of total hours of work in ordinary day. Coef. of variation = sd/mean.

Table 3: Variance and coefficient of variation in workdays across occupational status

margins: it allows less multitasking on the job and comes with more rigid schedules. In the remaining stylized facts, I therefore use occupational status as a proxy for flexibility and move from individual- to couple-level observations, using the flexibility measure to ground the model set-up.

3.2 Couples: Wife time flexibility and husband shock resilience

In this section I move away from time use surveys to study earnings, primarily using the Borana pastoralists panel.[4] The aim is to investigate whether, and in which cases, greater wife flexibility correlates with the severity of shocks to her husband's income, distinguishing wage income from business income, which can absorb inputs from third parties.[5] This also serves as a non-parametric, descriptive motivation for the approach used in section 5.

Empirical strategy For each yearly income stream s of a married man (self-employed farm, self-employed non-farm, or wage income), the variable of interest is ε_{it}^s from the following regression, run separately for each income source s:

$$\log(Y_{it}^s) = \alpha + \beta_1^{s'} X_{it}^s + \varepsilon_{it}^s$$

The controls X_{it}^s vary slightly across surveys according to availability. For Ethiopia I include round and study-site fixed effects, husband and wife age and literacy, indicators for the presence of very young and of school-aged children, and household size. For the farm income stream I add baseline herd size and baseline specialization dummies (camel, cattle, goat, sheep, lactating animals, female animals). Labour inputs enter as regressors: for farm income, the log of the husband's annual farm

[4]The same results on Vietnam are showed in section A.

[5]Here, I use wife and husband rather than "spouse" and "spouse" for conciseness, clarity, and because of gendered patterns of occupational choice. The model lends itself to a gender-neutral analysis, and could be repurposed to look at the reciprocal link, although the nexus formed by women business owners and wage-excluded husbands might be a less quantitatively important issue.



Figure 3: Husband income residuals across husband and wife occupational statuses

hours plus the wife's farm hours, to allow for joint production; for wage income, only the husband's log annual wage hours. The Ethiopian non-farm self-employment stream has too few observations to plot.

Figure 3 shows results for Ethiopia. Because yearly incomes are regressed on inputs (livestock, man and woman labor), the residuals represent variation in realised income not explained by these inputs, such as productivity shocks. The x axis can be read as a multiplication of expected income by e^x: a deviation of -0.5 would mean that, for unexplained reasons, income was only 60% of its predicted value. Results indicate that farm households experience considerable unexplained shocks to their productivity, but that not all categories are equally exposed. There is a missing mass to the left for households where the wife does not work for wage: they have lower density in the left tail of the distribution, without the entire distribution shifting. I implement the Kolmogorov-Smirnov test separately on the two halves of the distribution. The test rejects equality on the negative side at $p = 0.05$ — households whose wife works for wage have a more negative distribution below zero — but fails to reject equality of distributions for positive residuals. Replicating this with household fixed effects and controls interacted with round dummies — which shifts the meaning of unexplained shocks from across similar farms to within a given farm across rounds — leaves a smaller but still visible missing mass, though the KS test is no longer significant (section A).

A missing left tail means something different from an entire shift in the distribution or a change in its variance: it signals that wives not participating in wage labor correlate with fewer negative productivity shocks. That pattern is in line with an insurance mechanism rather than with a uniform productivity boost from the inputs of more available wives and labor complementarity, or with assortative matching — both of which would shift the distribution at all levels — or with a reduction in uncertainty, which would reduce variance overall.

The picture changes drastically for wage-earning households, 75% of which also appear in the farm self-employed earnings panel, so that the population overlap is significant: for them, wage-earning

wives are if anything correlated with less severe unexplained hourly income shocks, although the KS test is non-significant on both sides. Taken together, these results suggest that wife flexibility is associated with protection of business income but not of wage income, which is conceptually coherent: inputs from third parties can convert into income for family businesses, but not at wage jobs. In the Appendix, the Vietnam figures indicate that the same patterns occur among urban, non-farm self-employed households; the list of controls and the results can be found in section A.

3.3 Couples: Husband occupational status and wife time flexibility

My first set of facts shows that wife flexibility correlates with her occupational status; my second set suggests that wife flexibility is more valuable under certain *husband* occupational statuses. Together these imply correlation in occupational choices at the couple level, which the added worker effect could not explain. This section documents these correlations at the intensive margin (time allocation during the day) and at the extensive margin (occupational choice).

Intensive margin: wife workweek flexibility over husband occupational choice Using the harmonized database of time use surveys from African countries, I show that the intersection of husband and wife occupational choice conditions women's schedules. I map the ICATUS classification of each hour to a flexibility scale in which wage employment is non-flexible, self-employed activities are semi-flexible, leisure and domestic work are flexible, and sleep is its own category (see appendix section A for the mapping and for country-level graphs of time allocation without controls). The mapping turns on whether a third party has authority over the timing of the activity (as in wage employment) and on whether the activity is done to generate goods (as in market labor); it is justified empirically by the individual-level stylized facts, which found that on several dimensions wage work allowed less short-notice flexibility than either self-employment or leisure. I build four scores for hours spent in each category; by construction, they sum to 24. For each category Y_i I implement the following regression, controlling for region, woman and man age and education, and number of children under 6 and under 18, and applying survey weights:

$$Y_i = \alpha + \text{SE husband}_i + \text{Wage-working wife}_i + \text{SE husband}_i \times \text{Wage-working wife}_i + \beta_i^{'} X_i + \varepsilon_i$$

Table 4 to Table 7 show results for each time category. Holding a wage job raises a woman's non-flexible time substantially, as expected (Table 4). But in every country, wage-working women reduce their non-flexible time when their husband is self-employed: the interaction is negative in all five samples and significant in three at conventional levels. That time does not go into the family business – the interaction terms on semi-flexible time in Table 5 are small, of inconsistent sign and never significant. It goes instead into flexible time and self-care (Table 6, Table 7), in

	Number of non-flexible hours in a typical weekday				
	Ghana 2009	Kenya 2021	Egypt 2015	S.A. 2000	S.A. 2010
SE husband	0.157	0.192**	0.069	0.246	0.005
	(0.12)	(0.07)	(0.04)	(0.34)	(0.12)
Wage-working wife	6.719***	4.671***	4.380***	7.543***	7.316***
	(1.06)	(0.36)	(0.46)	(0.34)	(0.25)
SE husband x Wage-working wife	-4.747**	-0.489	-1.146	-1.952*	-1.636**
	(1.48)	(0.46)	(0.67)	(0.89)	(0.53)
R2	0.718	0.501	0.570	0.677	0.650
N	687	2449	1305	733	2125

* p<0.05, ** p<0.01, *** p<0.001. s.e. in parentheses
Sample of hours of married couples where both are >18yo in a typical weekday.

Table 4: Wife schedule allocation across own and husband occupation - non-flexible time

	Number of semi-flexible hours in a typical weekday				
	Ghana 2009	Kenya 2021	Egypt 2015	S.A. 2000	S.A. 2010
SE husband	0.776	0.629**	0.635***	0.952***	1.084***
	(0.61)	(0.20)	(0.14)	(0.26)	(0.22)
Wage-working wife	-1.871	-1.547***	0.727**	-0.305**	-0.268***
	(1.17)	(0.22)	(0.27)	(0.10)	(0.08)
SE husband x Wage-working wife	1.311	-0.114	0.447	-0.277	-0.288
	(1.65)	(0.30)	(0.49)	(0.52)	(0.34)
R2	0.186	0.211	0.093	0.185	0.116
N	687	2449	1305	733	2125

* p<0.05, ** p<0.01, *** p<0.001. s.e. in parentheses
Sample of hours of married couples where both are >18yo in a typical weekday.

Table 5: Wife schedule allocation across own and husband occupation - semi-flexible time

	Number of flexible hours in a typical weekday				
	Ghana 2009	Kenya 2021	Egypt 2015	S.A. 2000	S.A. 2010
SE husband	-0.795	-0.543**	-0.652***	-0.808*	-0.804**
	(0.59)	(0.20)	(0.19)	(0.40)	(0.26)
Wage-working wife	-3.694***	-2.842***	-4.121***	-6.121***	-5.912***
	(1.01)	(0.37)	(0.44)	(0.34)	(0.23)
SE husband x Wage-working wife	1.734	0.457	0.525	1.296	1.526**
	(1.32)	(0.48)	(0.63)	(0.86)	(0.50)
R2	0.120	0.228	0.237	0.526	0.483
N	687	2449	1305	733	2125

* p<0.05, ** p<0.01, *** p<0.001. s.e. in parentheses
Sample of hours of married couples where both are >18yo in a typical weekday.

Table 6: Wife schedule allocation across own and husband occupation - leisure time

	Number of sleep hours in a typical weekday				
	Ghana 2009	Kenya 2021	Egypt 2015	S.A. 2000	S.A. 2010
SE husband	-0.138	-0.299**	-0.050	-0.390	-0.285
	(0.27)	(0.09)	(0.15)	(0.26)	(0.15)
Wage-working wife	-1.154**	-0.277*	-0.939***	-1.117***	-1.136***
	(0.42)	(0.14)	(0.28)	(0.18)	(0.12)
SE husband x Wage-working wife	1.701*	0.151	0.170	0.932*	0.399
	(0.71)	(0.20)	(0.39)	(0.40)	(0.24)
R2	0.171	0.187	0.093	0.197	0.204
N	687	2449	1305	733	2125

* p<0.05, ** p<0.01, *** p<0.001. s.e. in parentheses.
Sample of hours of married couples where both are > 18yo in a typical weekday.

Table 7: Wife schedule allocation across own and husband occupation - sleep time

proportions that vary by country. Because the effect appears within a given wife job status, and survives the controls, it is unlikely to be caused by assortative matching. Taken together with the previous stylized facts, these results suggest that the higher value of spousal flexibility for the self-employed might generate co-movement between spouses' schedules that is not caused by the need for productive labor or by assortative matching.

Extensive margin: wife occupational choice across husband occupational choice

I now investigate the extensive margin of correlation in women's and men's time allocation: occupational choice. Using the IPUMS data, I first show the raw correlation in spouses' job status graphically, using only survey weights. Figure 4 presents these results. At all income levels, wives of self-employed husbands — *husband has a business* — are much less likely to work for wage and much more likely to be self-employed in their husband's industry, which I read as an upper bound on the prevalence of joint family firms. The correlation with inactivity varies with income: in low-income countries wives of self-employed husbands are more likely to be inactive, there is no correlation in middle-income countries, and the sign reverses at high income. To check how much of these effects are caused by income effects and assortative matching, I estimate, for each occupational outcome:

$$OccChoiceWife_i = \beta_1 HusbandHasBusiness_i + \beta_2 Controls_i + FE_{country-year} + \varepsilon_i$$

Controls include household size, number of children, number of children under 5, age category, educational attainment, industry of work if applicable, and whether urban. Survey weights are applied.

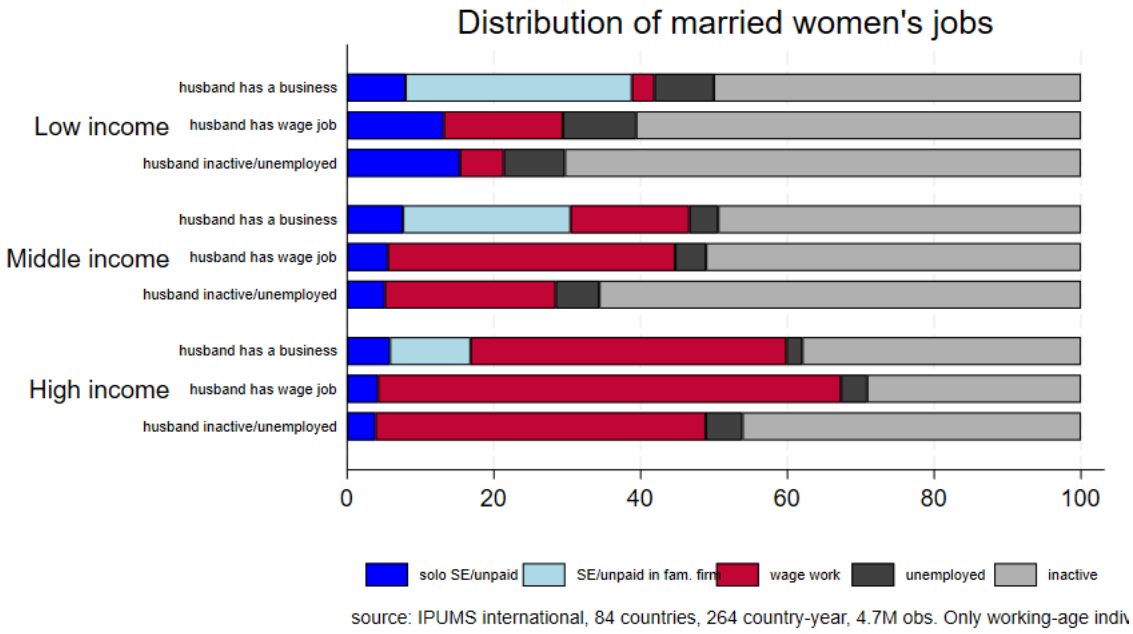


Figure 4: Correlation across spouses between occupational statuses in primary jobs

	Wage	Solo SE	Joint SE	Unemployed/inactive
Husband is self-employed	-0.086***	-0.122***	0.215***	-0.004***
Baseline mean	0.287	0.111	0.006	0.584
Observations	2933915	2933915	2933915	2933915

* p<0.05, ** p<0.01, *** p<0.001. s.e. in parentheses

Table 8: Correlation across spouses occupational statuses - all countries

	Wage	Solo SE	Joint SE	Unemployed/inactive
Husband is self-employed	-0.076***	-0.223***	0.302***	0.001*
	(0.00)	(0.00)	(0.00)	(0.00)
Baseline mean	0.143	0.225	0.013	0.605
Observations	1019070	1019070	1019070	1019070

* p<0.05, ** p<0.01, *** p<0.001. s.e. in parentheses

Table 9: Correlations across spouses occupational statuses - low-income countries

Table 8 presents results for all countries, while Table 9 does so for the subset of low-income countries. When their husbands hold self-employed primary jobs, women everywhere are less likely to work for wage, less likely to run a separate business, and sharply more likely to be self-employed in their husband's industry. In lower-income countries, where wage work is more frequently casual or daily, this descriptive result suggests that wage work might still prevent short-notice help. Once controls are added, wives with business-owning husbands are no more likely to be inactive, indicating that the negative raw correlation in Figure 4 was driven by an income effect.

Conclusion from stylized facts The evidence in this section reveals significant interactions between wife job choice, wife flexibility, and protection of the family firm, which generate co-movement between wife and husband job choice. Holding a wage job reduces a worker's capacity to provide help at short notice, whether on the job or by adjusting the length of the day. When wives hold one, their reduced flexibility, proxied by wage work, correlates with more severe negative shocks to husbands' business income, but not to their wage income. Finally, spouses' schedules and occupations co-move even after accounting for income effects and observable assortative matching: women married to business owners do less wage work, both extensively, by not entering the occupation, and intensively, by supplying fewer wage hours when they do. Together these suggest that time-based insurance — the ability to supply it and the value of receiving it — may be a quantitatively meaningful determinant of occupational choice within households. The next section provides a theoretical characterization of these dynamics.

4 Model

I build a model of joint occupational choice by incorporating risk, commitment to wage work and the possibility of time-based insurance into a standard time allocation model. The model has three primary objectives: (i) to rationalize the descriptive evidence presented in the previous section, (ii) to guide the empirical estimation and (iii) to propose novel implications for labor policy through a numerical illustration.

Two features are added to the standard model to allow time-based insurance to emerge and be tested empirically. First, the model incorporates an insurance framework: it has two periods, with family firm risk realized only in period 2. Second, it introduces an insurance role to women's availability. In period 1, before risk is resolved, the wife commits to a wage contract for period 2, aware that this commitment will have a risk-dependent effect on family income.

Incorporating time-based insurance modifies the trade-off households face when deciding whether the wife commits to wage work. The direction in which the tradeoff shifts depends on whether parameters meet certain conditions (on partial derivatives and sign of differences). The goal of the

model is to isolate these conditions in a way that is empirically testable, and to make predictions about the decision-making trade-off as a function of whether these conditions are met.

Discrete commitment The wife's period-1 decision is modeled as a discrete choice: whether or not to hold a wage job in period 2, rather than how many wage hours to supply. Formally, the wage contract specifies a fixed number of hours $\bar{h} \in (0, 1)$, and the household chooses only whether to accept it, $e \in \{0, 1\}$, so that realized wage hours are $e\,\bar{h}$.[6]

Model setup The model extends a standard time allocation framework where agents (f for female, m for male) allocate time between leisure (l), family firm work (f), and wage work (h). The model has two periods. In the first period, the wife decides whether she will work for wages in the second period, by choosing $e \in \{0, 1\}$ where $e = 1$ implies committing $e\bar{h}$ hours of wage labor. To test for direct effects of availability on the production function, e enters π as an argument, meaning π is a function of f^f, f^m risk s and wife wage work choice e. In period 2, all other supplies are chosen, which is why they carry the subscript 2, and discrete risk $s \in [r, R], \pi(f^f, f^m, e, R) < \pi(f^f, f^m, e, r)\ \forall\ (f^f, f^m, e) \in [0, 1]$ realizes, with $\mathbb{P}(s = R) = p$. The household can also receive income Y from other sources (savings, informal insurance...). The household solves its maximization problem through backward induction:

- Utility in **Period 2**, when e is locked and uncertainty is resolved, is:

$$\max_{h_2^m, f_2^f, f_2^m} U(C) + v(l^f) + z(l^m) \quad \text{s.t.} \quad C = w^m h_2^m + w^f \bar{h} e + Y + \pi(f_2^m, f_2^f, e, s)$$

$$l^m + h_2^m + f_2^m = 1, \quad f_2^f + l^f = 1 - \bar{h}e, \quad s \in r, R, \quad h_2^m, f_2^m, f_2^f \in [0, 1].$$

- In **Period 1**, risk is uncertain; the household chooses whether to take the wage contract, with $U^*(e, s)$ the value function:

$$\max_{e \in \{0,1\}} \mathbb{E}\left[U^*(e, R)\right] = \max_{e \in \{0,1\}} \Big(p\, U^*(e, R) + (1 - p)\, U^*(e, r)\Big)$$

I assume additively separable utility. In contrast with a standard time allocation model (without, risk, commitment, or wife wage work as the profit function), this framework generates an asymmetry between the spouses' constraints: the husband's wage supply h_2^m remains continuous and is

[6]Choosing to model discrete, rather than continuous, hours reflects the fact that wage contracts in these settings - whether salaried or casual daily - come with schedules set by the employer, which is the loss of short-notice help-giving ability documented in the stylized facts. It also allows me to make predictions for wives who do not participate in wage labor, which represents 95% of my sample.

chosen after the shock, which is what makes him the margin of adjustment in the added worker effect discussed below, while the wife is locked into her contract. I first show the first-order conditions for the inner problem of period 2, before turning to the participation decision in period 1.

Period 2 problem Conditional on e and s, the Lagrangian for Period 2 is

$$\mathcal{L}(C, f_2^f, f_2^m, h_2^m, \lambda) = U\big(C,\ 1-\bar{h}e-f_2^f,\ 1-h_2^m-f_2^m\big)+\lambda\left(C - w^m h_2^m - w^f \bar{h}e - \pi(f_2^f, f_2^m, e, s)\right)$$

with the following first-order conditions:

$$\frac{\partial \mathcal{L}}{\partial C} = U_C + \lambda = 0 \quad \Rightarrow \quad \boxed{U_C = -\lambda} \tag{1}$$

$$\frac{\partial \mathcal{L}}{\partial f_2^f} = -U_{l^f} - \lambda \frac{\partial \pi}{\partial f_2^f} = 0 \quad \Rightarrow \quad \boxed{U_{l^f} = -\lambda \frac{\partial \pi}{\partial f_2^f}} \tag{2}$$

$$\frac{\partial \mathcal{L}}{\partial f_2^m} = -U_{l^m} - \lambda \frac{\partial \pi}{\partial f_2^m} = 0 \quad \Rightarrow \quad \boxed{U_{l^m} = -\lambda \frac{\partial \pi}{\partial f_2^m}} \tag{3}$$

$$\frac{\partial \mathcal{L}}{\partial h_2^m} = -U_{l^m} - \lambda w^m = 0 \quad \Rightarrow \quad \boxed{U_{l^m} = -\lambda w^m} \tag{4}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = C - w^m h_2^m - w^f \bar{h}e - \pi(f_2^f, f_2^m, e, s) = 0 \quad \Rightarrow \quad \boxed{C = w^m h_2^m + w^f \bar{h}e + \pi(f_2^f, f_2^m, e, s)} \tag{5}$$

substituting $\lambda = -U_C$ throughout and assuming interiority for all inputs, I find:

$$\frac{\partial \pi}{\partial f_2^m} = w^m \tag{6}$$

$$\frac{U_{l^f}}{U_{l^m}} = \frac{\partial \pi / \partial f_2^f}{w^m} \tag{7}$$

$$U_{l^f} = U_C \frac{\partial \pi}{\partial f_2^f} \quad \Rightarrow \quad \frac{U_{l^f}}{U_C} = \frac{\partial \pi}{\partial f_2^f}, \frac{U_{l^m}}{U_C} = \frac{\partial \pi}{\partial f_2^m} \tag{8}$$

In contrast to the standard model, where both sources' labor supply is flexible, marginal productivity equalization only occurs for husbands. Marginal productivity at the firm is not equated to the wage for the wife because she cannot adjust wage hours at the margin in period 2, and because e enters $\pi(\cdot)$ directly, modifying the partial derivatives associated with wage time.

Characterization of time-based insurance With a discrete choice, the object of interest is the difference in profit across the wage participation choice e. Writing $\pi_0(f^f, f^m, s) = \pi(e{=}0, f^f, f^m, s)$ and $\pi_1(f^f, f^m, s) \equiv \pi(e{=}1, f^f, f^m, s)$ for the profit function under the two regimes, the total effect

of the wife taking the wage job on period-2 profit, in state s, is

$$\Delta\pi(s) \;=\; \pi_1\big(f_2^{f*}(1,s), f_2^{m*}(1,s), s\big) - \pi_0\big(f_2^{f*}(0,s), f_2^{m*}(0,s), s\big),$$

which can be decomposed as

$$\underbrace{\Big[\pi_1\big(f_2^{f*}(0,s), f_2^{m*}(0,s), s\big) - \pi_0\big(f_2^{f*}(0,s), f_2^{m*}(0,s), s\big)\Big]}_{D(s) \;=\; \text{direct effect of time-based insurance}} + \underbrace{\Big[\pi_1\big(f_2^{f*}(1,s), f_2^{m*}(1,s), s\big) - \pi_1\big(f_2^{f*}(0,s), f_2^{m*}(0,s), s\big)\Big]}_{\text{reallocation of productive labor}} \tag{9}$$

$D(s)$ holds both spouses' productive labor supply to the firm fixed and isolates the effect of the wife's wage commitment as a shift in the profit function. The second term collects the effect operating through changes in the labor the two spouses supply to the firm. The direct effect can be interpreted as an effect of e on total factor productivity, and the reallocation term as its compensated impact through the reallocation of productive labor.[7] D(s) can be positive or negative, but time-based insurance manifests through the combination of two conditions: i) $D(R) < 0$ — when shocks realize, spousal availability, which decreases with commitment to wage work, is valuable to the firm, holding firm hours fixed — and ii) $D(R) < D(r)$ — wife availability is more valuable in the bad state than in the good one.

Other, well-documented informal insurance mechanisms do not manifest with condition i) and ii), but in the model's parameter values. The added worker effect arises due to the joint production of consumption, and can generate increases in hours worked from household members when the livelihood of another member is hit by a shock (usually job loss). Here, this effect would manifest if in response to the shock, hours worked by the husband (hours of the wife being already fixed) at the wage job increased. In contrast with the conditions above for time-based insurance, this effect would not show through production of the firm, holding hours constant. More productive labor could go to the firm even if a shock decreases its productivity, for example if consumption constraints are binding; however, this would appear in the reallocation term, not in D. Informal cash transfers from networks could generate $Y(R) > Y(r)$ if risk-dependent, but would also not affect the firm's production, holding hours constant, except if it is re-invested in the firm in a manner that is dependent on wife wage choice, a departure from how money-based informal insurance is described in the literature which would also amount to e featuring in π. Finally, the reinvestment of wage income in production would produce the opposite sign, $D(s) > 0$, so finding $D(R) <$

[7] No piece in this expression represents the cost of not being able to optimize hours of wage labor based on risk: this cost stems directly from wage work being committed in period 1, and comparison with a counterfactual, one-period model would be needed to make it appear. The cost that is related to commitment to wage hours reducing the number of hours available is factored in the reallocation term.

0, $D(R) - D(r) < 0$ signals time-based insurance *despite*, rather than because of, any reinvestment effect.

The model therefore delivers a clear signal for quantitatively meaningful time-based insurance. To obtain empirically testable predictions on the effect of e on wage participation in period 1, I must assume that, within each state, the sign of $D(s|f^f, f^m)$ does not change for any feasible choice of f^f and f^m. This rules out any instance where, in the same state, e harms the firm at low levels of (f^f, f^m) but helps it at high levels.

Period 1 problem In period 1 the household compares the expected value of the two regimes and takes the wage contract if and only if

$$p\,\Delta U^*(R) + (1-p)\,\Delta U^*(r) \;\geq\; 0, \qquad \text{where } \Delta U^*(s) \equiv U^*(1,s) - U^*(0,s). \tag{10}$$

To isolate the contribution of time-based insurance, I define the counterfactual value function

$$\widehat{U}^*(1,s) \;\equiv\; \max_{h_2^m, f_2^f, f_2^m} U(C) + v(l^f) + z(l^m) \quad \text{s.t.} \quad C = w^m h_2^m + w^f \bar{h} + Y + \pi_{\mathbf{0}}(f_2^f, f_2^m, s),$$

subject to the same time constraints as the $e = 1$ problem, as $\bar{h}$ is fixed even if technology is π_0. This is the value the household would have attained by taking the wife's wage contract if the firm's technology did *not* respond to that commitment. Equivalently, it is the value function from a model in which wives have to commit to working for wages before the shock, but where that commitment leaves firm technology untouched. We can then write:

$$\Delta U^*(s) \;=\; \underbrace{\left[\widehat{U}^*(1,s) - U^*(0,s)\right]}_{\text{Standard}(s):\ \text{wage income vs. time cost}} \;+\; \underbrace{\left[U^*(1,s) - \widehat{U}^*(1,s)\right]}_{\text{TBI(s)}:\ \text{shift due to Time Based Insurance}}. \tag{11}$$

The first term is the tradeoff a standard model would evaluate, with commitment and risk: the wife gains $w^f \bar{h}$ of income and gives up $\bar{h}$ of time that would otherwise go to leisure or to the firm, with the household re-optimizing f_2^f, f_2^m and h_2^m around the new constraint differently depending on whether risk realizes. The second term is present only because e enters π. Going back to Equation 10 using Equation 11, we can then write

$$\begin{aligned} &e = 1 \Leftrightarrow p\,\Delta U^*(R) + (1-p)\,\Delta U^*(r) \;\geq\; 0 \\ &\Leftrightarrow p(Standard(R)) + (1-p)Standard(r) + p(TBI(R)) + (1-p)TBI(r) > 0 \end{aligned} \tag{12}$$

The signs of these two new terms determine whether time-based insurance changes participation decisions, compared to a standard case where e does not factor in π. For households that are indif-

ferent to the wife working for wage in the standard case, $p\,Standard(R)+(1-p)\,Standard(r)=0$, and with the new, TBI(s) piece, we obtain

$$\begin{aligned} e=1|\mathbb{E}(Standard(s))=0 &\Leftrightarrow p(TBI(R))+(1-p)TBI(r)>0 \\ &\Leftrightarrow TBI(R)>\frac{p-1}{p}TBI(r) \end{aligned} \tag{13}$$

Implications for wage work participation at the margin The term above designates the part of household's tradeoff that is added as a result of e being a part of the firm's profit function, or in other words, how accounting for time-based insurance changes the households' decisions if they were indifferent to the wife wage work in a counterfactual model where the wife commits to wage work in period 1, but e does not appear in π. I now investigate what each of these terms contains. First, $\frac{p-1}{p}<0$ and increases, getting closer to 0, with risk p: the more likely R is, the more important $TBI(R)$ is for women's choice compared to $TBI(r)$.

Second, the two $TBI(s)$ terms represent the shift in utility attributable to the inclusion of e in the profit function, relative to a counterfactual model where women commit to working for wage before shocks realize but this choice has no direct effect on the firm. Within each TBI, $U^*(1,s)$ and $\widehat{U}^*(1,s)$ share the same choice set — the commitment still limits wives' available time in period 2 if they took up the contract — and the only factor that changes from one to the other is the technology. With the assumption above that $D(s)$ is single-signed over all feasible time inputs, e shifts the budget set in the same direction across the whole parametric space. Because utility is strictly increasing in consumption, e has a uniform effect on the value function, and thus $sign(TBI(s))=sign(D(s))$.[8] Predictions are summarized in the table below.

When both signs are aligned, the predictions read as if the wife's wage work were simply an omitted firm productivity shifter, with the participation decision adjusting accordingly. In the positive case, this could arise if wages are reinvested in the family firm and support productivity regardless of the state of the world. In the negative case, it could arise if the wife's absence harms productivity in either state—for instance, if she is away at her wage job rather than watching over farm or business assets, or if she is not available to supervise children, who distract the family firm's other workers.

[8]Because no reallocation effort can overturn the sign of the impact of a productivity change at one of the household's income sources, but only mitigate or amplify it, the second term in the decomposition of profit does not change the sign of the effect of e on utility. In TBI, $U^*(1,s)$ and $\widehat{U}^*(1,s)$ optimize over the same choice set, but with different technologies. If we assume that technology 1 is better in state s (meaning $\pi_1(s,i,j)-\pi_0(s,i,j)>0$ for any $i,j\in(0,1)^2$), then households switching from technology 0, with maximizing inputs x_0, to technology 1, with maximizing inputs x_1, have $U^*(x_0)\geq\widehat{U}^*(x_0)$: they gain from the technology change even at fixed inputs, and factor reallocation only serves to amplify those gains: $U^*(x_1)\geq U^*(x_0)\geq\widehat{U}^*(x_0)$. The opposite holds if technology 1 is worse, where reallocation mitigates losses but cannot make the value function higher than its counterfactual with the better technology.

How does adding wife wage work decision e in profit π affect the period 1 trade-off for e ? *(relative to counterfactual with commitment to e, without e not in π)*		
Sign of $D(r) \rightarrow$	**–**	**+**
	Wife wage work *harms*	Wife wage work *benefits*
Sign of $D(R) \downarrow$	π in good state	π in good state
–		
Wife wage work *harms*	$\Pr(e^* = 1) \downarrow$	$\Pr(e^* = 1) \downarrow$ if $\lvert TBI(R)\rvert > \lvert\frac{p-1}{p}\rvert TBI(r)$
π in bad state		
+	**–**	**+**
Wife wage work *benefits*	$\Pr(e^* = 1) \downarrow$ if $TBI(R) < \frac{p-1}{p} TBI(r)$	$\Pr(e^* = 1) \uparrow$
π in bad state		

p = probability of risk in period 2. TBI(s) = net effect on utility in state s from adding e as a parameter in π relative to counterfactual with commitment to wage work, but no direct effect of wage work on π. D(s) : direct effect of e on π, all hours held constant

Table 10: Model predictions for wife wage take-up e^* across values for $D(s)$

The conditional cases are the ones that justify the two-period structure and the attention to risk, and they are the ones in which participation responds to the risk environment rather than to average productivity and outside options alone. If the firm benefits from the wife's wage work in good times but is harmed by her unavailability in bad times (upper-right case), households will decline the wage contract only where bad shocks are likely and where there are few alternative sources of consumption in period 2—conditions under which a shock causes a large drop in consumption and its associated utility. The mirror-image logic applies to the bottom-left case.

Model discussion This section rests on key assumptions, which I now discuss in more detail. First, there are assumptions that are related to the specificity of the time-based insurance mechanism to family businesses. The model does not model for shocks at men's wage work, nor does it allow for women's availability to be a parameter in observed wages. This does not necessarily mean that no time-based insurance can be provided at wage jobs, but rather, that given conceptual differences in pay structure and in line with the descriptive work, wage workers are less able to efficiently convert help received into consumption. It is beyond the scope of this paper but a potentially interesting avenue for research to consider time-based insurance for wage workers in the long-run, notably through its effect on likelihood of being promoted (Kleven et al., 2025).

Another two assumptions are required to deliver predictions without specifying a functional form: that utility is additively separable, and that $D(R)$ and $D(r)$ are single-signed over the feasible set of input choices within a given state s and wage choice e. Both are discussed within the model above. The model also has to assume that men work for wage any year to discipline time allocations and be tractable. This is a limitation, as only about 20% of men work for wage each year.

The remaining two assumptions the functioning of women's wage labor market and serve to map the model to the setting I use. The strongest hypothesis is that wives have to commit to working for wage during the year, meaning they have to decide before the shock occurs and cannot exit during the year. Conceptually, this is what generates the insurance dimension of women's flexibility, and the empirical estimation of the signs of $D(R)$ and $D(r)$ also relies on it, as it allows me to treat wage work as exogenous to shocks within a given round. This can be understood as the extreme of a situation where working for wage takes organization and fixed costs (transport, domestic arrangements, childcare) which are difficult to change afterwards, and where exiting has high costs — for example, a social cost that would prevent finding employment the next year. It could alternatively be modeled as a high exit fee in a multi-period version of the model. The second assumption is that contracts have fixed hours, which allows me to map the model to the data, since the data only collect wage hours for women who work for wage as their primary or secondary occupation. For the women who are the main wage-earner in their household I do observe the occupation: most fall under temporary off-farm work or building and renovation work, whose temporary nature suggests a ceiling on total hours during the year, while absenteeism and early exit costs provide a floor. An alternative model where wives commit to a number of hours, with firm shock protection depending on those hours, delivers the same prediction: below a certain threshold, time-based insurance can make the optimal number of wage hours go down.

The next section tests the model mechanism by estimating the sign of $D(R) - D(r)$ from firm income regressions, using random productivity shocks and plausibly exogenous variation in the wife's wage participation while controlling for both spouses' labor inputs, which isolates the direct effect from the reallocation term.

5 Test of model mechanism: risk coping and time-based insurance

5.1 Empirical strategy

The joint occupational choice model defines a region — whose size depends on risk frequency, risk severity, and outside options — in which women may optimally forgo higher wages to insure the family firm against shocks. Relative to a counterfactual model where households commit to wage work before shock realization but that commitment leaves firm technology unchanged, the wife's unavailability shifts the technology of the firm (production with inputs held constant); if that shift is very negative and risk is likely ($D(R) << 0, 1 > p >> 0$), wives will be ready to forgo external wages even with a high opportunity cost of staying home. This section maps the model

predictions to estimating equations, with the primary objective of identifying the signs of $D(R)$ and $D(r)$, which section 4 showed determine the effect of time-based insurance on the wife's wage work participation decision.

Parametrization In line with the model, utility is additively separable in consumption and in the leisure of each spouse. To get at the sign of $D(r)$, I must assume that e and s affect all inputs the same way (Hicks neutrality) and that the effects of s and e are multiplicatively separable. I also choose a translog production function for the family firm, which avoids assuming a particular substitutability pattern. The resulting equation becomes

$$\pi(e, s, f^f, f^m) = A(e, s)G(f^m, f^f) = (Aa^e b^s c^{es})(d \log f^f + e \log f^m + g \log(f^f) \times \log(f^m))$$

Which, when put in log, gives:

$$\begin{aligned}
\log(\pi(e, s, f^f, f^m)) &= \log(A(e, s)) + \log(G(f^m, f^f)) \\
&= \log(A) + e\beta_1 + s\beta_2 + e \times s\beta_3 + \log(G(f^m, f^f)), \\
\beta_1 &= \log(a), \beta_2 = \log(b), \beta_3 = \log(c) \\
\log(A(1, 0)) - \log(A(0, 0)) &= \log A + \beta_1 - \log A = \beta_1 \\
\log(A(1, 1)) - \log(A(0, 1)) &= \log A + \beta_1 + \beta_2 + \beta_3 - \log A - \beta_2 = \beta_3 + \beta_1
\end{aligned}$$

I define $d(s) = ln(A(1, s)) - ln(A(0, s))$. As logs are increasing functions, $sign(d(s)) = sign(D(s))$. Under my functional form assumptions, we get $\beta_1 = d(r)$ and $\beta_1 + \beta_3 = d(R)$. The Borana panel contains a counterpart for each object in the model: household livestock income stands in for profit (implicitly assuming that households are price-takers), household fixed effects for the individual part of productivity, indicators for drought and for the wife's wage take-up for s and e, and each spouse's labor at the firm for their respective inputs. The specification must nonetheless fulfill several econometric conditions, notably that e and s are exogenous and that inputs f^f and f^m move only because of the shock, conditional on controls. I implement the following changes to the estimating equation in order to address these concerns.

Labor inputs As inputs at the firm are correlated with unobservables and subject to reverse causality, using them as such would bias the estimation of β_1 and β_3. I instrument log labor for men, women, and their interaction with the man's and the woman's sick days and their squares. I allow labor inputs to equal 0 for women (25% do not declare self-employed agricultural hours) and men (3%) by using $\log(f^g + 1)$. F-values and coefficients are documented in Table 20: the F-values are between 2.5 and 5, which can be attributed to the low number of observations. Adding house-

hold fixed effects to the instrumentation of labor inputs weakens the instruments further, but leaves results unchanged in all specifications. Moving from the non-instrumented to the instrumented version also leaves results unchanged, both qualitatively and in terms of significance.

Exogeneity of s and e Droughts are plausibly exogenous, as is the *drought year*$_t$ variable, which is equal to one for any round other than 3. The impact of droughts, however, is not exogenous, and dynamic effects of household characteristics are not fully absorbed by the household fixed effects. I therefore include interactions of the drought dummy with baseline livestock specialization and with baseline log herd size, both documented determinants of shock resilience (Barrett et al., 2024).
Choosing to work for wage is not exogenous either: it depends on unobservable characteristics and opportunities. I show summary statistics based on whether the wife has a wage job in subsection B.1.[9] Wage-working wives differ from the rest: they are less likely to be located in the eastern *woredas*, and belong to households with less livestock at baseline. Their husbands are more likely to be literate and to have worked for wage during the year, which reduces their hours in farm self-employment, although they still participate with the same frequency. However, these households do not have significantly different mean yearly livestock income, suggesting assortative matching or positive effects from having wage-working spouses for business owners. While household fixed effects account for the time-invariant effect of these differences, these characteristics could shift the dynamics of shock resilience — if, for example, regional opportunities are correlated with the severity of the shock. To address this, on top of household fixed effects, I control for the interaction of the drought dummy with variables that were either imbalanced or can plausibly influence domestic duties and local job opportunities: log herd size at baseline, the region indicator, wife literacy, whether the wife has a very young child at baseline (0-6) and whether she has a school-aged child at baseline (6-18).
A further concern is that very few women are identified as doing wage work (around 5% of the sample each year), and panel equations identify variation from switchers alone, which reduces the sample further. In the data, however, around 80% of women who ever have a wage job have it in only one year, so much of the identifying variation is still used for estimation.

Simultaneous changes to household problem Insurance was introduced in round 2 and delivered payouts in round 4. Because these equations concern the ex-post effect of insurance, and the delivery of payouts changes the data-generating process, I drop round 4 from these estimations. Even without payouts, however, having insurance could influence e if insurance is a substitute for

[9]The number of hours per year in domestic work for men is not collected here, in contrast to summary statistics, because no men whose wife has a wage job declared any - consistent with the fact that respondents can only declare hours for the two most time-consuming activities and husbands of wage-working wives are much more likely to have wage work on top of their pastoralist activity.

(all Ys in log form)	HH livestock inc.	HH inc.	Livestock, qty	Livestock, value
Year is a drought	-0.467**	-0.362**	-0.040	-0.024
	(0.04)	(0.07)	(0.30)	(0.26)
Wife works for wage	0.323	0.800**	0.019	-0.029
	(0.14)	(0.07)	(0.02)	(0.03)
Drought * Wife wage	-0.367*	-0.495	-0.055	-0.054
	(0.12)	(0.18)	(0.10)	(0.10)
Nb Obs.	890	890	887	888
r2	0.68	0.67	0.89	0.90
Y mean without drought/wage	8.7	8.9	3.4	11
Controls	Y	Y	Y	Y
HH FE	Y	Y	Y	Y

* p<0.1, ** p<0.05, *** p<0.001. s.e. clustered by round.

Table 11: Effect of a drought across wife wage participation e

time-based insurance. I thus instrument insurance purchase with the randomized mean discounts on the insurance premium received by a household over the year as part of the IBLI experiment; that instrument is very strong (see Table 20). With these adjustments, the final equation estimated on couples with non-null livestock income in rounds 1-3 becomes:

$$\begin{aligned}&\text{HH Livestock inc.}_{it} = \alpha + \beta_1 WageWife_{it} + \beta_2 Drought_t + \beta_3 Drought_t \times WageWife_{it} + \\ &\beta_4 \widehat{\log(ff+1)} + \beta_5 \widehat{\log(f^m+1)} + \beta_6 \log(f^m+1) \times \widehat{\log(f^f+1)} + \beta_7 \widehat{InsDemand}_{it} + \beta_c' X_i \times Drought_t + \gamma_i + \varepsilon_{it} \\ &\text{each labor input } \widehat{Y} \text{ instrumented from:} \\ &Y_{it} = a_0 + a_1 \text{sick days}_{it}^m + b_1 \text{sick days}_{it}^f + c_1(\text{sick days}_{it}^m)^2 + d_1(\text{sick days}_{it}^f)^2 + \varepsilon_{it} \\ &\text{insurance demand instrumented from:} \\ &InsDemand_{it} = b_0 + b_1 Discount_{it} + \varepsilon_{it}\end{aligned} \tag{14}$$

Standard errors are clustered by round and X_{it} comprises region (groupings of 3 *woredas*), an indicator for whether the woman has a child below 6 and one between 6 and 18, indicators for household baseline livestock specialization and baseline herd size, and woman literacy, all interacted with the drought dummy.

5.2 Results

Results are presented in Table 11. The first column comes directly from the model, while the rest serves to explore mechanisms. Droughts have catastrophic effects on households: they cut

livestock income by 37% ($e^{-0.467} = 0.63$). As I control for hours, the estimates of droughts and wages can be interpreted as effects on productivity itself - ie income generated while accounting for all inputs. Furthermore, livestock in quantity and in value, does not seem affected, which reinforces the interpretation of estimates as effects on productivity, as other inputs are not shifting as a result of the shock.

While droughts have large effects on all households, they do not harm them uniformly: households where the wife works for wage are subject to a double burden, meaning that instead of falling by 37%, their income falls to less than half of its non-drought value ($e^{-0.467} \times e^{-0.367} = 0.63 \times 0.69 = 0.43$). Under the assumptions made in the empirical strategy, rows 2 and 3 of column 1, $\beta_1 + \beta_3$, represent $d(R)$, while $d(r)$ can be found in row 2 only (β_1). These estimates carry the same sign as $D(s), s \in r, R$ and thus tie directly to the predictions made in section 4. With the estimate for β_1 statistically insignificant, they suggest $D(R) < 0, D(R) - D(r) < 0$, the parametric signature of time-based insurance, and thus tie to the model prediction from the upper-right cell of the table. The effect of having a wife work for wage without a shock is not significantly different from 0, but it is close (p-value~ 0.15): even if statistically significant, it would be of lower magnitude than β_3, meaning that the result above would be unchanged, although where the modal household sits within the predicted decision threshold would.

Results on household overall income, although not directly related to the model, allows me to investigate whether wage-working wives reallocate time to another earning source, which would appear as a decrease in farm productivity while still smoothing household consumption. Household income per round behaves in line with expectations: it is significantly affected by droughts, although less so than livestock income, indicating that households do not have a climate-proof, alternative employment option that allows them to reallocate well. Wives working for wage increase it mechanically. However, wives do not seem to generate more wage income when shock hits: although the estimate of β_3 is insignificant, its p-value is 0.11 which provides suggestive evidence that the negative effect of wage-working wives is more negative for total income that for livestock income. This could indicate that time-based insurance is even more needed in other wage-generating activities, such as non-farm self-employment, or alternatively, that the absence of the wife prevents other family members from reallocating to more productive activities.

Finally, although not shown here, coefficients on hours inputs are positive and larger for men's hours than for women's, though neither is significant at traditional levels. Coefficients on the interaction are negative, which would suggest substitution, but their sign varies across outcomes and they are not significant either. In a separate regression, I check actual hours responses to the shock and do not find effect either of droughts or on wages either on men's or women's hours in farm self-employment, domestic work, or non-farm self-employment.

Robustness checks If wage opportunities are very spatially concentrated, then results could be heavily driven by a single *woreda*. In Figure 7, I check and confirm that this is not the case by running my main specification on livestock income, leaving out each *woreda* in turn, although some β_3 estimates lose significance.

Second, if women who participate in wage work pass their productive labor to the firm as domestic labor instead, all inputs might not be fixed when estimating the change in technology associated with e, biasing estimates of $d(s)$. I re-estimate my equations on household livestock and total income adding wives' domestic work into the controls in Table 21. Results are of very similar magnitude for the effect of drought and of having a wife who works for wage; β_3, the negative effect of a wage-working wife in case of drought is more marked and becomes significant for total household income, indicating that non-wage-working wives might be supplying domestic labor that serves as an input to the firm. There is a caveat to this finding, however: domestic labor might react to the realization of the shock, which is why I only use it as a check and not in the main specification.

Competing narratives Before attributing the estimates to time-based insurance, I investigate other channels that could produce the same results. First, women may differ in the extent to which their labor is substitutable. If they have older children (12–18 in my specification), these children might occasionally take care of domestic or productive duties (e.g., fetching water or watching over livestock; see Dehouck (2026) and Barrett et al. (2024)). If having substitutable household members correlates with resilience to shocks and wage take-up, these effects could be unrelated to my proposed mechanism of time-based insurance. To investigate this possibility, I run two heterogeneity analyses: I allow for heterogeneity in the effects of having a larger household than the median of 6 members and of having a child between 12 and 18 years old. Results are presented in Table 22. The negative significant coefficient on the effect of drought persists in all specifications, but concurring signs allow for more detail on the channels through which time-based insurance circulates. The heterogeneity test on women having 12-18 years old children signals that the burden associated with wage work in case of droughts is concentrated on women with such children. On the contrary, holding presence of children constant through the controls, estimates from the heterogeneity study on belonging to a large household indicates that women who belong to large households, presence of children held constant, do not harm firm productivity as much as the rest when they work for wages during droughts. Taken together (and with a grain of salt, as some of these estimates are not significant at traditional levels), these results could indicate that having children increases demand for wife flexibility, in line with childcare duties, even at these ages, while having other household members that are not children reduces demand for wife flexibility.

Beyond showing that the time-based insurance story resists alternative explanations, the finding that other substitutable household members lighten the pressure on women's availability supports

and generalizes it as a mechanism that applies to entire households, and by extension to solidarity networks, not only to spouses.

Having tested the model mechanism, the next section examines its key prediction directly by looking at how wives' wage entry responds to the provision of a risk product that is an alternative to time-based insurance.

6 Test of model prediction: risk protection and wage work take-up

In the previous section, I obtained signs of $D(R)$ and $D(r)$ that map to one prediction cell of Table 10: when wife unavailability harms the firm in the bad state more than it helps it in the good state, households at the margin may decline wage work that they would have accepted in the absence of time-based insurance. In this section, I use experimental variation in the alternative risk management strategies available in that setting to test the model predictions and clarify which side of the threshold this particular setting is on.

At baseline, the setting is characterized by the absence of other risk-mitigation products, leaving households to deal with risk informally. Risk mitigation strategies are seldom independent from one another, and a sizable literature already documents substitutability between informal risk management strategies and formal insurance products, generating crowding-out mechanisms whereby adopting insurance leads to the abandonment of former strategies such as herding small, liquid animals (Barrett et al., 2024) or farming safer, lower-yield crops (Karlan et al., 2014; Mobarak and Rosenzweig, 2013). If the payout is a substitute for activities that might have been performed by available wives, then enrollment would reduce the cost of wife wage work to the firm in the bad state. Does introducing alternative risk mitigation products undo some of the co-movement in spouses' occupational choice that is induced by time-based insurance?

Setting Index-Based Livestock Insurance (IBLI) links pre-specified payouts to subregional forage density indices falling below a predefined trigger, unlike traditional indemnity-based insurance, where payouts are linked to documented individual losses. IBLI products were subject to randomized encouragement trials during the 2010s to assess their impact (see, for example, Takahashi et al. (2020); Matsuda et al. (2019); Takahashi et al. (2019); Jensen et al. (2025); Sakketa et al. (2025) in the Ethiopian case and Jensen et al. (2016) in the Kenyan case).

In Ethiopia, IBLI triggered payouts when forage density dropped below its 15th percentile (1980–present), an event with about a 25% probability during the 2010s. Payouts depended on the amount by which

the index exceeded the trigger value (severity of the shock) and on the number of animals insured. Premiums varied across geographic regions, based on drought-related mortality risk, and with the number of animals insured (Takahashi et al., 2020). To estimate the effect of insurance provision while overcoming the problem of endogenous take-up, the researchers introduced two random encouragement schemes, one with subsidies and the other with an information treatment; only subsidies were shown to directly influence demand in Takahashi et al. (2020). The precise designs are available in the original papers, and I include key dates of the intervention in Figure 2.

Empirical Strategy As in the parameter estimation, I use the panel data on Ethiopian pastoralists, with a new outcome of interest: whether women work for wage during the year. In the model, women commit before shocks realize, so insurance paying out in round 4 is no longer a threat to identification and I can now include all rounds in the estimation where the experiment took place, meaning I only exclude round 1. As in the section above, I instrument insurance take-up with the average subsidies received on the insurance premium over the two selling periods of the year.

Threats to identification The model predicts that if women's flexible work serves as a time-based insurance product substitutable for formal insurance, then introducing formal insurance will alter women's sectoral choices. However, this effect might operate through other channels. By changing shock severity, insurance shifts expected TFP upwards; as women can participate in the firm whose TFP is affected, insurance introduction could influence labor and job choice via channels unrelated to wage exit. Estimating this model on women in pastoralist households, regardless of whether they work at the family firm, will therefore not identify the effect of insurance introduction on wage entry through the time-insurance mechanism if wage labor participation can change through these other channels.

To isolate the effect, I exploit the heterogeneous activation of these channels across subpopulations of women. Women whose husbands are pastoralists should in any case be subjected to the time-based insurance channel — their flexibility serves a firm-level insurance purpose, which the product substitutes for. However, only women who also participate in the livestock activity should get the TFP channel on top of it. To implement this distinction, I ensure as much as I can that there is no unobservable variables determining wife participation in the pastoralist activity by implementing household and round fixed effects and the same controls as with the previous section (region, having a child below 6, baseline herd size and specialization, literacy and age of man and woman), interacted with round dummies. To avoid reverse causality, I set my participation in livestock to its

Outcome	*Wife wage work*			*Husband wage work*
Sample	All women	Wives of pastoralists		All men
		Wife has livestock activity?		
		No	Yes	
Purchased insurance	0.204**	0.102*	0.226**	0.198
	(0.01)	(0.03)	(0.05)	(0.11)
Nb. obs.	1090	314	557	1090
r2	0.44	0.42	0.46	0.53
Y mean without discount	.057	0	.03	.11
Controls	Y	Y	Y	Y
HH FE	Y	Y	Y	Y

* p<0.1, ** p<0.05, *** p<0.001. s.e. clustered by round. Sample excludes round 1.

Table 12: Effects of providing insurance on women's work take-up

baseline values for both husband and wives. For household i at time t, I thus estimate

$$\begin{aligned}\text{Woman works for wage during year}_{it} &= \alpha + \beta_1 \widehat{\text{Any insurance purchase in hh}_{it}} + \beta_2 X_i \gamma_t + \gamma_i + \gamma_t + \varepsilon_{it} \\ \text{Any insurance purchase in hh}_{it} &= a + b\text{Discount rate}_{it} + u_{it}\end{aligned} \tag{15}$$

And I perform these regressions separately on two sub-populations from the sample of women married to men with non-null time spent in pastoralism at baseline : women who also participate in the livestock activity, and women who do not, also at baseline. I implement the regression on rounds 2-4 where insurance was offered. Under these assumptions, the effect on wage take-up of insurance that only circulates through the time-based insurance can be isolated by comparing effects across wives of pastoralists across own involvement in the pastoralist activity.

Results Table 12 presents the estimated effect of formal insurance on women (col. 1) and men's (col. 4) wage employment during the year, and on wives of pastoralists who do not (col. 2) and who do (col. 3) participate in the livestock activity. The effects of insurance on wage entry are visible on the full population of women, which is not the case for men. Purchasing at least one insurance policy over the year, as instrumented by the average discount rate received over the two periods, raises women's chance of being in a wage job that year by 20.4 percentage points, nearly four times the baseline mean. This estimate, which is sizable, can be interpreted as the local average treatment effect on households who purchased insurance because they got a discount ; is not the effect that would be observed simply by comparing households who got a discount to the rest of the population.

To check whether this effect is caused by reduced demand on time-based insurance delivered by flexible women, I select the sub-sample of wives of pastoralists and I separate women according to whether they also participate in the livestock activity versus not. Women who participate in the livestock activity and thus benefit from insurance both through an expected TFP channel, and the time-based insurance substitution channel, enter the wage labor force more than the rest. However, the effect remains positive, sizable and significant for those who do not benefit from the TFP channel, indicating that in this setting, time-based insurance could be a meaningful impediment to women's wage labor market entry.

Discussion and robustness In this section, I examine several alternative narratives that might explain my results instead of the time-based insurance mechanism. First, although they do not participate in the production process, spouses without a livestock activity might still benefit from it from a consumption standpoint — although these results precede any insurance payout because insurance only pays out in round 4 and wage work decisions are taken before the shock in the model, so this channel would work only through expected consumption. More expected income could allow for better job search, which would have increased both men's and women's participation rates, and this we do not see in Table 12. Alternatively, more resources could translate into an increased ability to pay for school or childcare. I thus test whether the results are specific to women with children of a given age: children aged 6-18 can be at school, while children aged up to 6 might need childcare. Results are presented in Table 13. They remain significant for all populations, but difference in effect size is informative on how the mechanism circulates: effects are stronger for mothers, which as we have seen in the robustness checks of the model mechanism test, is the population that suffers the most from droughts when women is absent, signaling high value for informal time-based insurance through childcare. If this is the case, then a substitute would generate more entry from previously constrained women, as seen above. However, the effects survive for other populations, indicating other explanations beyond childcare-related channels.

Another alternative explanation for the baseline results is that insurance fueled a reallocation of livestock away from smaller animals such as goats, a result found notably in the long term for both Ethiopia and Kenya by Barrett et al. (2024). If wives have a stronger effective or perceived comparative advantage in the animals that insurance makes households shift away from, this would also modify the trade-off between non-wage and wage work for unrelated reasons. I check whether results hold across baseline livestock specialization, measured as a household having a ratio of a certain livestock type (camel, goat, cattle, sheep) over its total livestock above the 75th percentile of the whole population. Results are always positive no matter the specialization. In particular, goat-specialized households, whose herd composition changed the most as a result of getting insurance according to the literature, are not the only one who get positive and significant effects. The fact

Y = Wife wage entry	No 6-18 child	6-18 child	No 0-6 child	0-6 child
Purchased insurance	0.135*	0.248**	0.160**	0.224**
	(0.04)	(0.01)	(0.01)	(0.01)
Nb. obs.	435	655	288	802
r2	0.53	0.39	0.57	0.42
Y mean without discount	.074	.029	.043	.062
Controls	Y	Y	Y	Y
HH FE	Y	Y	Y	Y

* p<0.1, ** p<0.05, *** p<0.001. s.e. clustered by round. Sample excludes round 1

Table 13: Robustness - results across baseline age of children

Y = Wife wage entry	Camel	Cattle	Goat	Sheep
pred_ins	0.140	0.406**	0.256	0.338**
	(0.08)	(0.09)	(0.14)	(0.02)
Nb. obs.	278	245	308	215
r2	0.49	0.43	0.43	0.58
Y mean without discount	0	0	0	.067
Controls	Y	Y	Y	Y
HH FE	Y	Y	Y	Y

* p<0.1, ** p<0.05, *** p<0.001. s.e. clustered by round. Sample excludes round 1

Table 14: Robustness - results across baseline livestock specialization

that they are not significantly positive and of smaller magnitudes than cattle might reflect women's perceived comparative advantage in this form of livestock, which prevented them from leaving for wage work even when a risk alternative was presented, as they were seen as more productive in this particular production.

Together, the results and robustness checks suggest that time-based insurance is one of the channels through which formal insurance can generate wage work participation from married women. Robustness checks suggest that women might be particularly constrained, and thus responsive to policy, in households where their domestic and childcare work has higher value and when they do not have a strong perceived comparative advantage in the business production. Beyond supporting the model and showing the promise of risk alleviation for the take-up of profitable jobs, finding quantitatively meaningful time-based insurance that responds to policy has implications for the scale at which policy is implemented: since occupational choices are interdependent, policies targeting one household member's job status will have heterogeneous effects depending on the occupation of other members. I expand on this prediction and examine other policies in the next

section.

7 Discussion and numerical illustration

Observing households' risk coping strategies after risk realization — in other words, their period 2 problem — provided evidence of quantitatively meaningful time-based insurance. In turn, this mapped to the prediction from the model that wage entry might decrease at the margin if risk is likely enough, if wife unavailability harms the firm enough, and if employment alternatives are too low to prevent utility from dropping when risk realizes. Testing the model predictions revealed that many households were close to that threshold, as introducing formal insurance generated significant entry of wives into wage work. These findings provide two policy insights: first, where costly coping mechanisms include exit from profitable labor markets, financial inclusion can constitute a labor policy tool; second, if time-based insurance generates causal co-movements between jobs within households, policy that affects only one individual of these solidarity networks — for example, subsidies for highly gendered industries — might be less efficient than policy targeting two spouses at once.

The aim of this section is to expand on these results by suggesting other predictions related to policies that have been implemented in similar contexts. First, I choose other parameters to illustrate the model numerically, showing that time-based insurance affects reservation wages, with consequences for the efficiency of subsidy policies. Second, I use the model illustration to show theoretically how model parameters, particularly those that can be mapped to policy making changing women's work landscape, changes these predictions. This exercise is illustrative rather than an estimation of structural parameters: while the sign of $d(r)$ and $d(R)$ is estimated in subsection 5.2, the remaining parameters are assigned, so the illustration should be read as showing the direction and rough shape of the implied response in women's wage participation, not its magnitude.

7.1 Model numerical illustration - reservation wages

To illustrate the model, I must now make full functional form assumptions. In line with the theoretical model, I choose a log-additive utility function in consumption and leisure. In line with the empirical results suggesting labor substitutability, I take a CES family firm production function with $\rho \in [0, 1]$. In state s, given the wife's period-1 commitment $e \in \{0, 1\}$, households solve the following inner problem:

$$\max \ \ln C + b \ln l^f + d \ln l^m$$

$$\text{s.t.} \quad C = w_m h^m + Y_e + \pi, \qquad \pi = A(e, s) \left[\delta \left(f^f \right)^\rho + (1 - \delta) \left(f^m \right)^\rho \right]^{\frac{1}{\rho}},$$

$$l^m + h^m + f^m = 1, \qquad l^f + f^f = 1 - \bar{h}e,$$

with $Y_e \equiv \bar{Y} + w^f \bar{h}e$, $\delta \in (0,1)$, $\rho < 1$, and elasticity of substitution $\sigma = 1/(1-\rho)$.

The model is solved analytically in Appendix D. I now illustrate the model predictions for the outer problem by plotting utilities for every state of the world s and participation choice e. I set parameters for drought severity and additional burden associated to wage-working wives in droughts to β_2 and β_3 from section 5. I set $A(0,0)$, productivity in the good state without wage work, so that, given the other parameters, the model has interior solutions for all inputs and for the other values of A. Some interiority conditions do not have closed-form solutions, so I search over the interval defined by those that do for values of $A(0,0)$, $A(0,1) = e^{\beta_2} A(0,0)$ and $A(1,1) = e^{\beta_3} e^{\beta_2} A(0,0)$ that deliver interior solutions for all labor inputs. As β_1 is insignificant, in the main model illustration I use $A(1,0) = A(0,0)$.

Parametrization Because of the large negative estimates found for β_2 and β_3, the range across which $A(e,s)$ varies is wide: the highest value of A is 2.5 times its lowest, which constrains the space in which the other parameters can be set while still delivering interior solutions. I impose a number of supplementary conditions on parameters to fit the setting. In line with the results, I impose ρ positive to signal substitution. I keep h below 0.2 to fit the summary statistics, which show that even women who are most involved in wage work, for whom it is the primary or secondary activity, do not spend more than 20% of their available time during the year doing it. I keep $\delta < 0.5$ to reflect the fact that livestock is a male-intensive activity. Because the key object of interest is reservation wages, I allow women's wages w_f to vary from 0 to men's wages w_m. The remaining parameters are chosen to enable interior solutions for all values of $A(e,s)$ given these conditions, which notably results in much higher utility weights for men's leisure d than for women's b. Finally, when computing expected utilities, I set the probability of risk p to 20%. This is lower than actual drought occurrence during the period, but fits the extreme NDVI values of recent decades — which, in line with the insurance product introduced in the sample I use, I define as NDVI going below the 15th percentile of its distribution since 1980 (see (Chantarat et al., 2013) for more details on product design), and which I observe using Figure 8 from the World Bank.[10] Choosing this value, which covers more years, brings it closer to the probabilities households would have expected while solving their inner problem, and understates the importance of the bad state, meaning it is a lower bound for the importance of time-based insurance. Parameter values are the same throughout graphs and are noted under each.

Model illustration The left panel of Figure 5 represents utilities when the wife does not participate in the wage labor market (black) versus when she commits to participating (red), across levels

[10] https://documents1.worldbank.org/curated/en/099701012222213301/pdf/P17570400835c405709e490b364512ba5a1.pdf

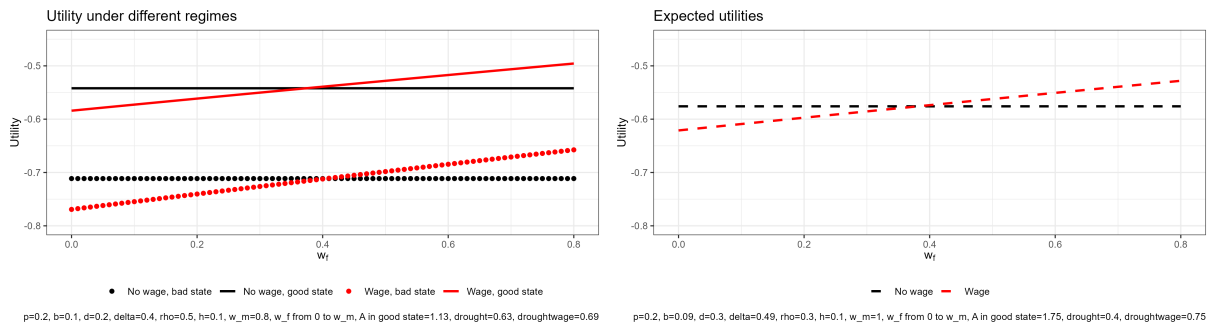


Figure 5: Utilities under different regimes

of w_f. Lines represent the good state while dots represent the bad state. The aim of this first exercise is to illustrate how adding time-based insurance changes women's reservation wage — the wage at which they are indifferent in expectation between $e = 0$ and $e = 1$. The difference between the black curves represents the loss of utility driven by droughts decreasing firm productivity; these lines are flat because, as the wife does not participate in the wage labor market, utility is indifferent to wages. Compared to the black lines, the red curves cumulate several different channels: time-based insurance means that productivity drops more, and commitment to wage work means that, in any state of the world, wage-working women have less available time in period 2. This is reflected in the fact that, at low levels of wage, utility is lower for wage-working women than for non-wage-working women. Whether reservation wages are more costly in the good or in the bad state depends on the relative weights of consumption and women's leisure: if consumption is relatively more important, having little time in the good state when the firm is productive will be costlier, all else equal. In the bad state, there are two competing effects: commitment to wage work is not as costly in terms of time, because the opportunity cost of working at the firm goes down, but it is costly in terms utility loss driven by additional negative effects on productivity compared to non-wage households.

With these two channels taken into account, the right panel of Figure 5: shows reservation wages stand at about half of men's wages. To separate the two mechanisms, I study a counterfactual wage job that takes commitment and has fixed hours, but does not affect family firm productivity.

7.2 Policy implications: wage job flexibility

To what extent are reservation wages in that framework determined by high, costly commitment to wage work before the shock, and to what extent are they attributable to drops in productivity related to unavailability of wage-working spouses in case of shocks at the firm? The answer highlights very different routes for policymakers looking to generate entry into wage work. To distinguish responses driven by time-based insurance from those driven by commitment to fixed-hour wage

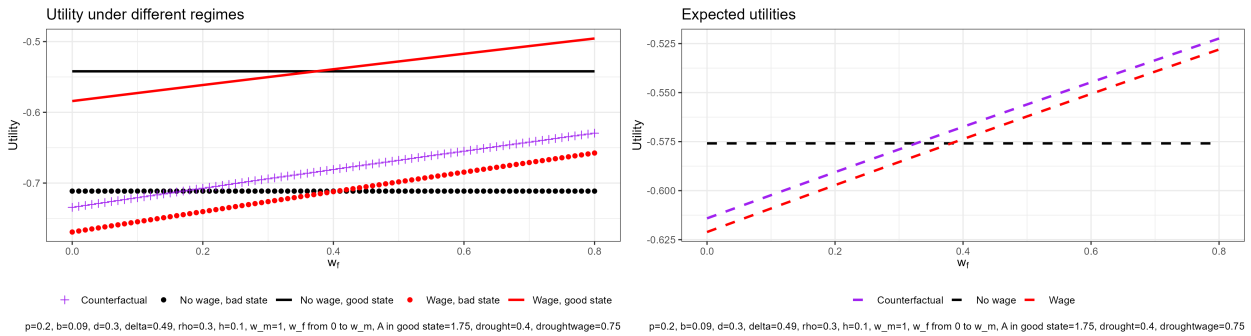


Figure 6: Utilities and expectation, adding flexible wage work counterfactual

work, I plot a counterfactual curve (purple) that represents utility in the bad state when $D(R) = 0$ — $\widehat{U(1,R)}$ in the model. This utility corresponds to the case where there is risk at the firm and commitment to wage work, but where the resulting spousal unavailability does not influence family firm productivity in bad times — a case without time-based insurance. In real life, this reflects wage work not diminishing the availability of the wife, and maps to contemporary evolutions of jobs in low- and high-income countries, where remote work is softening the assertion that wage work is less flexible, by allowing domestic duties to be taken care of and interruptions to be absorbed more easily than at a factory job. Importantly, the opposite situation (direct effect, no commitment to wage work) corresponds to a model where h_w is shifted back into period 2 with the rest of the inputs - not a model where $\bar{h}$ decreases, which would correspond to decreases from a full-time to contracts with lower hours, but still imply as much commitment.

Figure 6 presents the change in predictions with this counterfactual type of wage work (purple curve). Because wage work commitment does not have an effect on firm productivity in the good state, the good-state value for this counterfactual is the red curve. Households face the same commitment and wage contract length as those on the red curve, so the residual variation is entirely attributable to time-based insurance. The households at the margin in the model are those at the intersection of the purple and black curves in the graph. With these parameters, making wage-working women more flexible generates about 15% reduction in their reservation wages.

It is important to distinguish what comes from arbitrary parameters and what comes from the empirical estimation. Here, I find that throughout the distribution of women's wages, time-based insurance increases reservation wages. While the magnitude of these results is driven by arbitrary coefficients (risk probability, love for leisure vs. consumption, marginal productivities and complementarity at the firm), here, reservation wages always decrease in the counterfactual where e does not affect firm productivity. This directly stems from the null coefficient on β_1 (effect of wage-working wives on the firm in the good state) in the empirical estimation (Table 11). If, in the good state, wage workers reach higher firm productivity than the rest because of investments from the

wife's wage income, reservation wages for wage-working women become lower - lower than the counterfactual flexible wage work curve for certain parameters.

Under these parameters, time-based insurance increases women's reservation wages, meaning that policymakers envisioning wage subsidies will have to make them higher to draw women in. Alternatively, this means that policymakers who strive to design wage jobs adapted to the constraints of households with family firms -either by decreasing the level of ex-ante commitment through work on infrastructure or contract design, or reducing the level of on-the-job rigidity by implementing amenities that allow women to take care of short-notice demands on their time - would succeed in generating wage entry.

8 Conclusion

The creation of good jobs has been a key policy objective for development and gender equality in low-income countries, where many individuals operate at low-income, high volatility jobs. In this paper, I argue that risk, and the possibility to benefit from help in coping with it, might be creating complementarities in occupational choice between those delivering and those benefiting from, time-based insurance. By tying together occupational choice at the level of spouses, and by extension solidarity networks, this mechanism could modify policy *efficiency*, by making high-productivity jobs more costly to take up than without these linkages, and it could shift its *incidence*, making its efficiency on otherwise similar workers dependent on the prevalence of risky jobs in a given network. I draw on new stylized facts, a model of joint occupational choice with commitment and risk, empirical evidence from Ethiopia, and numerical illustration of the model predictions to argue that time-based insurance could be a quantitatively meaningful determinant of labor market trajectories and policy impact.

The implications of this mechanism are broad in terms of actors and settings. Beyond providing insight into wage work entry, time-based insurance also has implications for firm creation and death, with misallocation driven by ability to benefit from time inputs by available relatives. Finally, this paper focuses on developing countries, but its findings extend beyond these settings. Occupational choices are still very correlated across spouses in high-income countries, and recent shifts — remote work, zero-hour contracts, marital tax reforms — are changing the commitment and rigidity associated with wage work, while the nature of jobs and risk is also evolving rapidly. This makes for an interesting research agenda for the future.

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A Data: concepts and sample sizes

	Hour-level diary	Wage work concept	Self-emp. concept	Earnings	Nb. couples	Used in
Time-use surveys						
South Africa 2000	✓	Worked for wage last week	had farm/business/help unpaid at fam business last week		742	Descriptives (multitasking, , variance, schedules)
South Africa 2010	✓	Worked for wage last week	Declares business/unpaid help in fam.business or to be on own account		2125	Descriptives (multitasking) , variance, schedules)
Ghana 2009	✓	Employment in primary occupation is employee	Primary job is self-employed or contributing fam. worker		697	Descriptives (multitasking, , variance, schedules)
Kenya 2021		Employee the past week or has employee primary/secondary job	has self-emp./fam. contributor activity last week or as 1st/2nd job		2449	Descriptives (variance, schedules)
Egypt 2015		Main job is employee or or declares wage activity	has self-emp./fam. contributor job or is head of hh with a fam. business		1305	Descriptives (variance, schedules)
Earnings surveys						
Ethiopia IBLI 2012–15		Is main wage-earner in hh or 1st/2nd most time-consuming activity is wage	Same as with wage	✓	∼330/year	Descriptives (earnings) + model calibration
Vietnam VHLSS (02,04,12,14 rounds)		Has wage job during year	Has business during year	✓	∼ 2700	Descriptives (earnings)
Census microdata						
IPUMS-I, 84 countries					2.9Ms	Descriptives (occupational choice correlations)

Table 15: Concepts, data sources and coverage

	Multitasking$_h$			**MultitaskingDomCare**$_h$			**MultitaskingDuration**$_h$	
	SA2000	SA2010	GH2009	SA2000	SA2010	GH2009	SA2010	GH2009
Wage hour	-0.037	-0.018**	-0.023	-0.007	-0.006***	-0.018*	1.503	-6.873
	(0.02)	(0.01)	(0.02)	(0.01)	(0.00)	(0.01)	(1.69)	(6.23)
Constant	0.121***	0.044***	0.126***	0.017***	0.009***	0.051***	114.731***	108.281***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.86)	(1.39)
R2	0.003	0.002	0.000	0.001	0.002	0.001	0.001	0.004
N	15125	37720	13457	15125	37720	13457	1099	1673

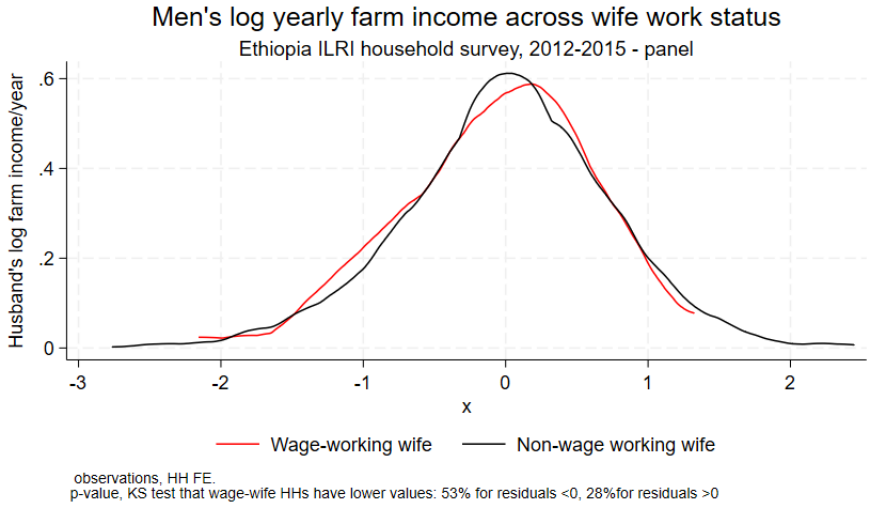
* p<0.05, ** p<0.01, *** p<0.001. Sample of worked hours of married 18+ women in a typical day. s.e. clustered by individual

Table 16: Multitasking occurrence and intensity - women, worked hours

Occupational status and job flexibility

Couples: Wife time flexibility and husband shock resilience

Ethiopian figures



Vietnam figures

For Vietnam 2012-2014 and 2002-2004, the income concept is yearly profit (earnings - expenses). Controls include sector-relevant yearly log hours (separate controls for men and women's self-employed hours in that sector for farm and non-farm, with women's hours in log(x+1) form to allow for null values, only men's hours for wage work), household size, urban*tinh (district) fixed effects, age and square age of the woman and man, education of the woman and man and main industry for that income source for 2012-2014, and the

	Multitasking$_h$			**MultitaskingDomCare**$_h$			**MultitaskingDuration**$_h$	
	SA2000	SA2010	GH2009	SA2000	SA2010	GH2009	SA2010	GH2009
Wage hour	-0.115***	-0.059***	-0.033**	-0.057***	-0.027***	-0.038***	-3.363***	-5.005*
	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.80)	(2.48)
Constant	0.201***	0.083***	0.119***	0.061***	0.029***	0.049***	119.514***	106.250***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.28)	(0.60)
R2	0.017	0.010	0.001	0.013	0.006	0.003	0.003	0.002
N	138046	366658	56259	138046	366658	56259	23065	6866

* p<0.05, ** p<0.01, *** p<0.001. Sample of hours of married 18+ persons in a typical day.
s.e. clustered by individual

Table 17: Multitasking occurrence and intensity - women and men , all hours

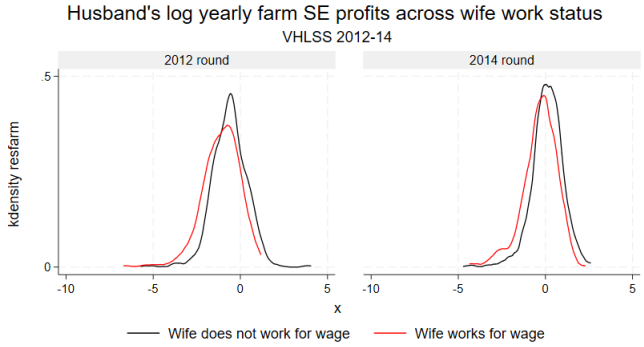
	Multitasking$_h$			**MultitaskingDomCare**$_h$			**MultitaskingDuration**$_h$	
	SA2000	SA2010	GH2009	SA2000	SA2010	GH2009	SA2010	GH2009
Wage hour	-0.116***	-0.060***	-0.028	-0.007	-0.006***	-0.018*	1.503	-6.873
	(0.01)	(0.00)	(0.02)	(0.01)	(0.00)	(0.01)	(1.69)	(6.23)
Constant	0.200***	0.085***	0.131***	0.017***	0.009***	0.051***	114.731***	108.281***
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.86)	(1.39)
R2	0.012	0.007	0.000	0.001	0.002	0.001	0.001	0.004
N	69875	189312	29865	15125	37720	13457	1099	1673

* p<0.05, ** p<0.01, *** p<0.001. Sample of hours of married 18+ women in a typical day.
s.e. clustered by individual

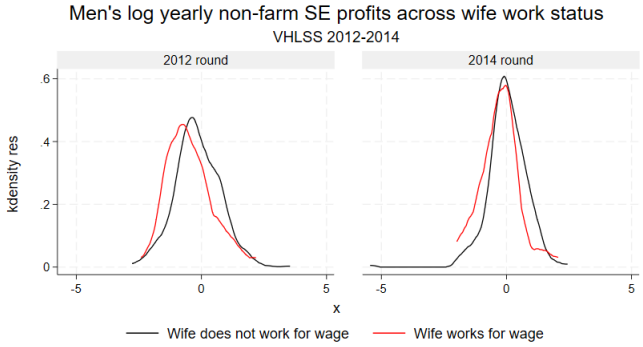
Table 18: Multitasking occurrence and intensity - women, all hours

same without the urban indicator, which is unavailable, in 2002-2004.

Log profits



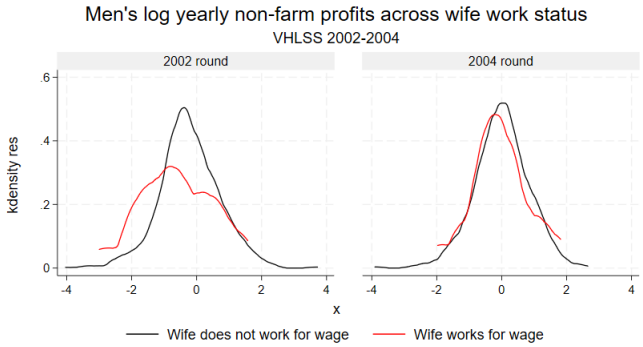
~1650 obs each year. Log farm self-employed profits. Weighted on hh weights in residual-making regression and plot
p-value, KS test that wage-wife HHs have lower values: 0% for residuals <0, 4% for residuals >0



~560 obs each year. Log non-farm self-employed profits. Weighted on hh weights in residual-making regression and plot
p-value, KS test that wage-wife HHs have lower values: 1% for residuals <0, 25% for residuals >0

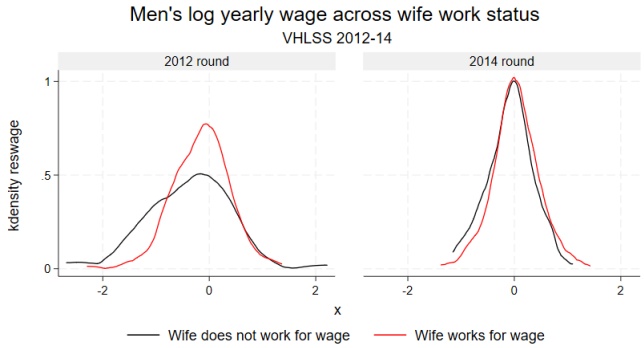


~1800 obs each year. Log farm self-employed profits. Weighted on hh weights in residual-making regression and plot.
P-value, KS test that wage-wife HHs have lower values: 0% for residuals <0, 83% for residuals>0.

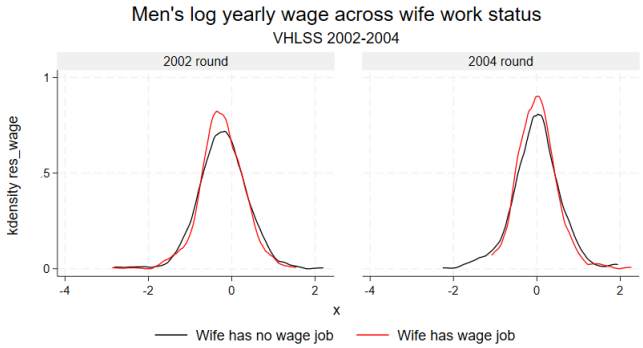


~460 obs each year. Log non-farm self-employed profits. Weighted on hh weights in residual-making regression and plot
p-value, KS test that wage-wife HHs have higher values: 8% for residuals <0, 57% for residuals >0

Log wages



around 330 observations each year. Log wage income. Weighted on hh weights in residual-making regression and plot
p-value, KS test that wage-wife HHs have higher values: 3% for residuals <0, 41% for residuals >0



~760 obs/year. log wage income. Weighted on hh weights in residual-making regression and plot
P-value, KS test that wage-wife HHs have lower values: 78% for residuals <0, 7% for residuals>0.

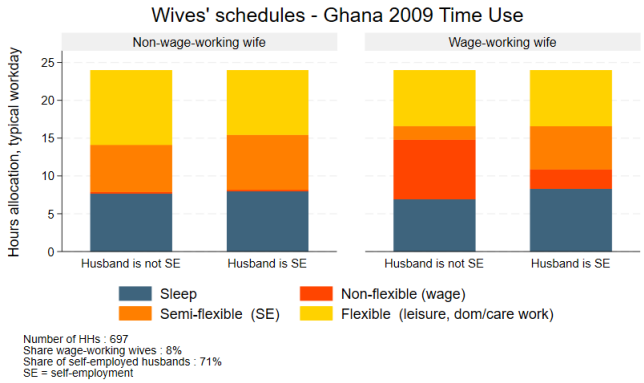
ICATUS activity	Classification
1 Employment and related activities	Non-flexible if wage Semi-flexible if SE
2 Production of goods for own final use	Semi-flexible
3 Unpaid domestic services [...]	Flexible
4 Unpaid caregiving services [...]	Flexible
5 Unpaid volunteer, trainee and other	Flexible
6 Learning	Flexible
7 Socializing communication	Flexible
Community participation, religious practice	
8 Culture, leisure, mass-media and sports	Flexible
9 Self-care and maintenance	Sleep

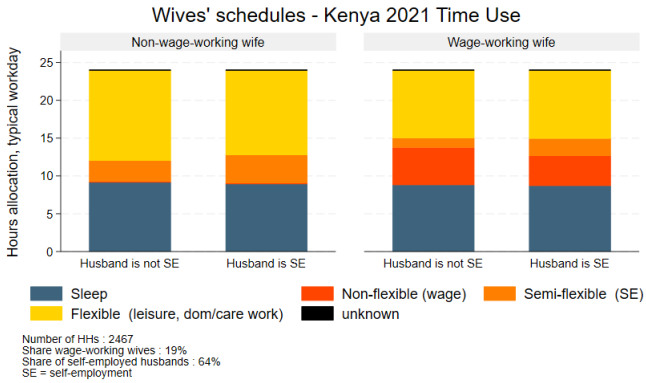
Table 19: Mapping from ICATUS classification to flexibility score

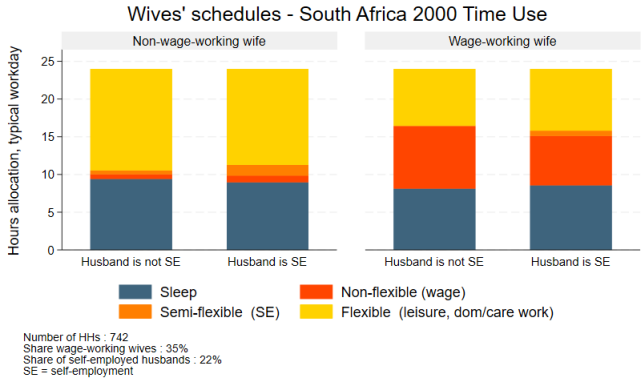
Couples: Husbands' occupational status and wife time flexibility

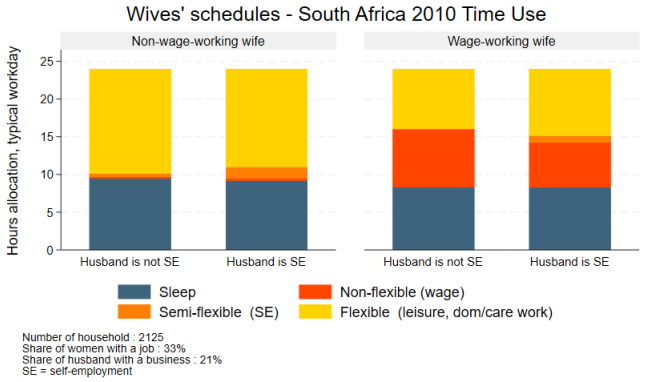
Mapping from ICATUS classification to flexibility score

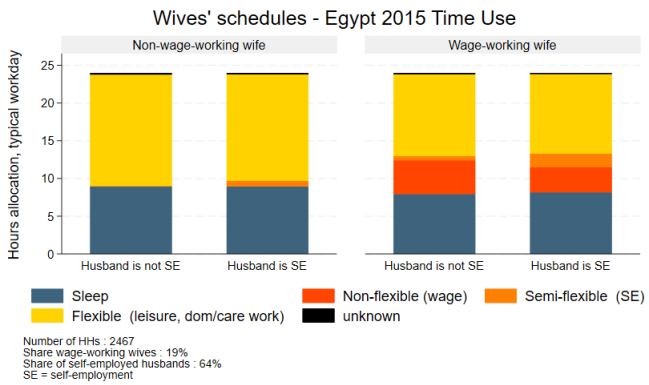
Country-level graphs of workday allocation










Wives' schedules - Egypt 2015 Time Use
Non-wage-working wife
Wage-working wife
Hours allocation, typical workday
25
20
15
10
5
0
Husband is not SE
Husband is SE
Husband is not SE
Husband is SE
Sleep
Flexible (leisure, dom/care work)
Non-flexible (wage)
unknown
Semi-flexible (SE)
Number of HHs : 2467
Share wage-working wives : 19%
Share of self-employed husbands : 64%
SE = self-employment

B Model calibration: additional results

B.1 Balance test on wives having wage jobs

	mean	sd	count	mean	sd	count	p
Location and drought experience							
Year is a drought	0.75	0.43	1279	0.79	0.41	76	0.43
West (Dillo, Teltele)	0.33	0.47	1279	0.41	0.49	76	0.16
East (Dire, Yabello)	0.32	0.47	1279	0.13	0.34	76	0.00***
Center (Arero, Dhas, Moyalle, Miyo)	0.35	0.48	1279	0.46	0.50	76	0.04*
Baseline livestock							
Log. herd size	2.53	1.48	1279	1.90	1.58	76	0.00***
Socio-demographic characteristics							
Woman is literate	0.02	0.15	1279	0.00	0.00	76	0.17
Man is literate	0.11	0.31	1279	0.03	0.16	76	0.02*
Man age	48.38	16.87	1279	51.20	16.91	76	0.16
Woman age	34.77	12.76	1279	33.89	9.90	76	0.56
Household size	6.88	2.43	1279	6.47	1.99	76	0.15
Woman has 0-6 y.o. child at baseline	0.23	0.42	1279	0.21	0.41	76	0.70
Woman has 12-18 y.o. child at baseline	0.12	0.33	1279	0.13	0.34	76	0.79
Income and hours (conditional on non-missing)							
Yearly household income, USD	627.70	1747.69	1279	801.18	2863.87	76	0.42
Yearly household livestock income, USD	582.88	1879.93	1079	306.01	320.07	52	0.29
Man works for wage during year	0.19	0.39	1279	0.49	0.50	76	0.00***
Hours/year in farm SE, man	3116.78	1067.35	1217	2844.96	1140.35	70	0.04*
Hours/year in farm SE, woman	1333.60	779.28	989	1326.47	522.15	46	0.95
Hours/year domestic work, woman	2644.93	752.64	1213	2618.96	789.90	73	0.78
Hours/year wage work, man	1952.42	1203.55	82	1666.56	951.19	25	0.28
Insurance discounts and purchase							
Purchased insurance when introduced (rounds 2-4)	0.35	0.48	958	0.26	0.44	57	0.20
Mean insurance premium discount rate received (round !=1)	36.46	21.41	958	40.53	21.37	57	0.16

B.2 Instruments

B.3 Robustness checks on estimates of $d(s)$

Leave-one woreda out

Controls for domestic hours and wage income

Heterogeneity: older child and large household

	log farm SE hours + 1			*Insurance purchase*
	Men	Women	Men x Women	
man sick_days	-0.015	-0.020	-0.022*	
	(0.01)	(0.02)	(0.01)	
woman sick_days	-0.035**	0.008	-0.024**	
	(0.01)	(0.02)	(0.01)	
sick days sq woman	0.000**	-0.000	0.000**	
	(0.00)	(0.00)	(0.00)	
sick days sq man	0.000	0.000	0.000	
	(0.00)	(0.00)	(0.00)	
(mean) discount_rate				0.007***
				(0.00)
Nb Obs.	890	890	890	890
F-statistic	3.04	4.76	2.47	163.16
Baseline Y mean	7.8	5.5	8.2	.026
Controls	N	N	N	N
HH FE	N	N	N	N

* p<0.1, ** p<0.05, *** p<0.001

Table 20: Instruments for farm profit regressions

all Ys in log form	HH livestock inc.	HH inc.
Year is a drought	-0.461**	-0.349**
	(0.05)	(0.07)
Wife works for wage	0.329	0.813**
	(0.14)	(0.07)
Drought * Wife wage	-0.379*	-0.521*
	(0.11)	(0.17)
Nb. Obs.	890	890
r2	0.68	0.67
Mean Y without drought/wage	8.7	8.9
Control dom hours	Y	Y
Controls	Y	Y
HH FE	Y	Y

* p<0.1, ** p<0.05, *** p<0.001. s.e. clustered by round

Table 21: $d(s)$ - robustness with domestic work

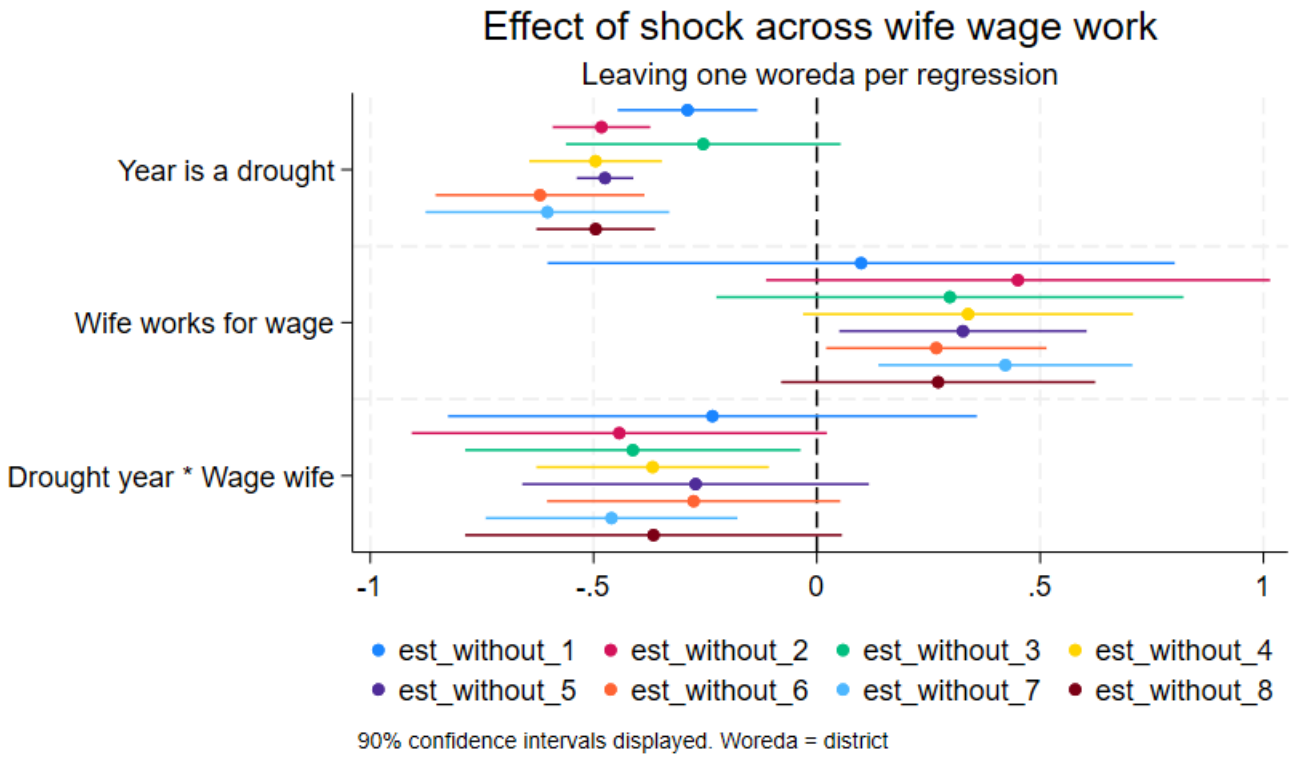


Figure 7: Results replication, leaving one district out in turn

	log. HH livestock income		log. HH income	
Year is a drought	-0.465**	-0.439**	-0.378**	-0.343*
	(0.04)	(0.06)	(0.06)	(0.09)
Wife works for wage	-0.393	0.823*	-0.153	0.981*
	(0.26)	(0.28)	(0.24)	(0.28)
Drought * Wife wage	0.210	-1.063**	0.371	-0.797
	(0.39)	(0.20)	(0.31)	(0.32)
Drought* Wife Wage * 12-18 child	-0.450		-0.879	
	(0.50)		(0.44)	
Drought* Wife Wage * Large hh		1.051		0.515
		(0.40)		(0.49)
Nb. Obs.	890	890	890	890
r2	0.68	0.68	0.67	0.67
Mean Y without drought/wage	8.6	8.5	8.9	8.7
Controls	Y	Y	Y	Y
HH FE	Y	Y	Y	Y

* p<0.1, ** p<0.05, *** p<0.001. s.e. clustered by round. "Without treatment" reflects outcome means for women without old children or living in small households.

Table 22: Heterogeneity in drought effects along margins of substitution to women's absence

C Empirical exercise: test of model predictions

D Resolution of household inner problem with CES

In state s, given the wife's period-1 commitment $e \in \{0,1\}$:

$$\max \ \ln C + b \ln l^f + d \ln l^m$$

$$\text{s.t.} \quad C = w_m h^m + Y_e + \pi, \qquad \pi = A(e,s)\left[\delta\,(f^f)^\rho + (1-\delta)\,(f^m)^\rho\right]^{\frac{1}{\rho}},$$

$$l^m + h^m + f^m = 1, \qquad l^f + f^f = 1 - \bar{h}e,$$

with $Y_e \equiv \bar{Y} + w^f \bar{h} e$, $\delta \in (0,1)$, $\rho < 1$, and elasticity of substitution $\sigma = 1/(1-\rho)$.

Lagrangian

$$\mathcal{L} = \ln C + b \ln l^f + d \ln l^m + \lambda\Big[w_m h^m + Y_e + A\big(\delta(f^f)^\rho + (1-\delta)(f^m)^\rho\big)^{1/\rho} - C\Big]$$
$$+ \mu^m\Big[1 - h^m - f^m - l^m\Big] \ + \ \mu^f\Big[1 - \bar{h}e - f^f - l^f\Big]$$

First-order conditions

$$\frac{\partial \mathcal{L}}{\partial C} = 0 \Rightarrow \tfrac{1}{C} = \lambda \tag{16}$$
$$\frac{\partial \mathcal{L}}{\partial l^f} = 0 \Rightarrow \tfrac{b}{l^f} = \mu^f \tag{17}$$
$$\frac{\partial \mathcal{L}}{\partial l^m} = 0 \Rightarrow \tfrac{d}{l^m} = \mu^m \tag{18}$$
$$\frac{\partial \mathcal{L}}{\partial h^m} = 0 \Rightarrow \lambda w_m = \mu^m \tag{19}$$
$$\frac{\partial \mathcal{L}}{\partial f^f} = 0 \Rightarrow \lambda\delta\, A\,(f^f)^{\rho-1}\big(\delta(f^f)^\rho + (1-\delta)(f^m)^\rho\big)^{\frac{1-\rho}{\rho}} = \mu^f \tag{20}$$
$$\frac{\partial \mathcal{L}}{\partial f^m} = 0 \Rightarrow \lambda\,(1-\delta)\,A\,(f^m)^{\rho-1}\big(\delta(f^f)^\rho + (1-\delta)(f^m)^\rho\big)^{\frac{1-\rho}{\rho}} = \mu^m \tag{21}$$
$$\frac{\partial \mathcal{L}}{\partial \lambda} = 0 \Rightarrow C = w_m h^m + Y_e + \pi \tag{22}$$
$$\frac{\partial \mathcal{L}}{\partial \mu^f} = 0 \Rightarrow l^f + f^f = 1 - \bar{h}e \tag{23}$$
$$\frac{\partial \mathcal{L}}{\partial \mu^m} = 0 \Rightarrow l^m + f^m + h^m = 1 \tag{24}$$

Resolution

$$\text{(17) and (18):} \quad \frac{\lambda w_m l^m}{d} = 1 \ \Leftrightarrow \ \text{(from (15))} \quad \frac{w_m l^m}{d} = C \tag{25}$$

Defining π_m and π_f as $\frac{\partial \pi}{\partial m}$ and π_f $\frac{\partial \pi}{\partial f}$ respectively, using (20) and (17) we get:

$$\begin{aligned}
&\Leftrightarrow w_m = \pi_m = (1-\delta)(f^m)^{\rho-1}A(e,s)[\delta(f^f)^\rho + (1-\delta)(f^m)^\rho]^{\frac{1-\rho}{\rho}} \\
&\Leftrightarrow w^m = (1-\delta)(f^m)^{\rho-1}A(e,s)[\frac{\pi}{A(e,s,)}]^{1-\rho} \\
&\Leftrightarrow (f^m)^{1-\rho} = \frac{(1-\delta)A(e,s)}{w_m}[\frac{\pi}{A(e,s)}]^{1-\rho} \Leftrightarrow f^m = \big[\frac{(1-\delta)(A(e,s))^\rho}{w_m}\big]^{\frac{1}{1-\rho}}\pi
\end{aligned} \tag{26}$$

$$\frac{(17)}{(16)} = \frac{(18)}{(19)} \Leftrightarrow \frac{dl^f}{bl^m} = \frac{w_m}{\pi_f} \Leftrightarrow l^m = \frac{dl^f \pi_f}{bw_m} \tag{27}$$

Which we can substitute into the expression of $\pi = A(e,s)(\delta(f^f)^\rho + (1-\delta)(f^m)^\rho)^{\frac{1}{\rho}}$ so

$$\begin{aligned}
&\Leftrightarrow \pi = A(e,s)(\delta(f^f)^\rho + (1-\delta)(f^m)^\rho)^{\frac{1}{\rho}} \\
&\Leftrightarrow \pi^\rho = (A(e,s))^\rho\Big(\delta(f^f)^\rho + (1-\delta)\big[\frac{(1-\delta)(A(e,s))^\rho}{w_m}\big]^{\frac{\rho}{1-\rho}}\pi^\rho\Big) \\
&\Leftrightarrow \pi^\rho(1 - A(e,s)^\rho(1-\delta)[\frac{(1-\delta)(A(e,s))^\rho}{w_m}\big]^{\frac{\rho}{1-\rho}}) = (A(e,s))^\rho\delta(f^f)^\rho \\
&\Leftrightarrow \pi = \Big[(1 - A(e,s)^\rho(1-\delta)[\frac{(1-\delta)(A(e,s))^\rho}{w_m}\big]^{\frac{\rho}{1-\rho}})^{-1}(A(e,s))^\rho\delta(f^f)^\rho\Big]^{\frac{1}{\rho}} \\
&\Leftrightarrow \pi = (1 - A(e,s)^\rho(1-\delta)[\frac{(1-\delta)(A(e,s))^\rho}{w_m}\big]^{\frac{\rho}{1-\rho}})^{\frac{-1}{\rho}}(A(e,s))\delta^{\frac{1}{\rho}}(f^f) \\
&\pi = (1 - w_m^{\frac{-\rho}{1-\rho}}(1-\delta)^{\frac{1}{1-\rho}}(A(e,s))^{\frac{\rho}{1-\rho}})^{\frac{-1}{\rho}}(A(e,s))\delta^{\frac{1}{\rho}}(f^f)
\end{aligned} \tag{28}$$

I define $X = (1 - w_m^{\frac{-\rho}{1-\rho}}(1-\delta)^{\frac{1}{1-\rho}}(A(e,s))^{\frac{\rho}{1-\rho}})^{\frac{-1}{\rho}}(A(e,s))\delta^{\frac{1}{\rho}}, \pi = Xf^f$. Then we get :

$$\pi_f = \delta A(e,s)(f^f)^{\rho-1}[\frac{\pi}{A(e,s)}]^{1-\rho} = \delta A(e,s)(f^f)^{\rho-1}[\frac{Xf^f}{A(e,s)}]^{1-\rho} = \delta A(e,s)^\rho X^{1-\rho} \tag{29}$$

We can then substitute back into the consumption constraint:

$$
\begin{aligned}
&C = w_m h_m + Y_e + \pi \Leftrightarrow \text{ (24) and (23) } \frac{w_m l^m}{d} = w_m(1 - l^m - f^m) + Y_e + \pi \\
&l^m w_m(\frac{1+d}{d}) = w_m - w_m f^m + Y_e + \pi = \text{ (25) } w_m(1 - \big[\frac{(1-\delta)(A(e,s))^\rho}{w_m}\big]^{\frac{1}{1-\rho}}\pi) + Y_e + \pi \\
&\Leftrightarrow \frac{\pi_f l^f (1+d)}{b} = w_m + Y_e + \pi(1 - w_m[\frac{(1-\delta)(A(e,s))^\rho}{w_m}]^{\frac{1}{1-\rho}}) \\
&\Leftrightarrow \frac{\pi_f l^f (1+d)}{b} = w_m + Y_e + \pi X^{-\rho} A(e,s)^\rho \delta \\
&\Leftrightarrow \text{(26) } \delta A(e,s)^\rho X^{1-\rho}(1 - h_e - f^f)\frac{(1+d)}{b} = w_m + Y_e + X f^f X^{-\rho} A(e,s)^\rho \delta = w_m + Y_e + f^f X^{1-\rho} A(e,s)^\rho \delta \\
&\Leftrightarrow \text{(28)} \frac{(1-h_e)\delta A(e,s)^\rho X^{1-\rho}(1+d)}{b} - w_m - Y_e = X^{1-\rho} f^f A(e,s)^\rho \delta (1 + \frac{(1+d)}{b}) \\
&\Leftrightarrow f^f = \frac{\frac{(1-h_e)\delta A(e,s)^\rho X^{1-\rho}(1+d)}{b} - w_m - Y_e}{X^{1-\rho} A(e,s)^\rho \delta (1 + \frac{(1+d)}{b})} = \frac{\frac{(1-h_e)\delta A(e,s)^\rho X^{1-\rho}(1+d)}{b} - w_m - Y_e}{X^{1-\rho} A(e,s)^\rho \delta \frac{(1+d+b)}{b}} \\
&\Leftrightarrow f^f = \frac{(1-h_e)\delta A(e,s)^\rho X^{1-\rho}(1+d) - b w_m - b Y_e}{X^{1-\rho} A(e,s)^\rho \delta (1+d+b)} = \frac{(1-h_e)\pi_f (1+d) - b w_m - b Y_e}{\pi_f (1+d+b)}
\end{aligned}
\tag{30}
$$

And then we have all other terms as functions of f^f:

$$
\begin{aligned}
l^f &= 1 - \bar{h}e - f^f \\
f^m &= \big[\frac{(1-\delta)(A(e,s))^\rho}{w_m}\big]^{\frac{1}{1-\rho}} X f^f \\
l^m &= \frac{d l^f \pi_f}{b w_m} \\
h^m &= 1 - l^m - f^m \\
C &= \frac{w_m l^m}{d} \\
U &= \ln C + b \ln l^f + d \ln l^m
\end{aligned}
\tag{31}
$$

D.1 Interiority conditions

$$\pi > 0 \Leftrightarrow X > 0 \Leftrightarrow w_m^{\frac{-\rho}{1-\rho}}(1-\delta)^{\frac{1}{1-\rho}}(A(e,s))^{\frac{\rho}{1-\rho}} < 1 \Leftrightarrow A(e,s) < [w_m^{\frac{\rho}{1-\rho}}(1-\delta)^{\frac{-1}{1-\rho}}]^{\frac{1-\rho}{\rho}} = w_m(1-\delta)^{\frac{-1}{\rho}}$$

$$f^f > 0 \Leftrightarrow \frac{(1-h_e)\delta A(e,s)^\rho X^{1-\rho}(1+d) - bw_m - bY_e}{X^{1-\rho}A(e,s)^\rho\delta(1+d+b)} > 0$$

$$\text{(with X> 0)} \Leftrightarrow (1-h_e)\delta A(e,s)^\rho X^{1-\rho}(1+d) - bw_m - bY_e > 0 \Leftrightarrow (1-h_e)\delta A(e,s)^\rho X^{1-\rho}(1+d) > b(w_m+Y_e)$$

$$\Leftrightarrow (1-h_e)\delta A(e,s)^\rho[(1-w_m^{\frac{-\rho}{1-\rho}}(1-\delta)^{\frac{1}{1-\rho}}(A(e,s))^{\frac{\rho}{1-\rho}})^{\frac{-1}{\rho}}(A(e,s))\delta^{\frac{1}{\rho}}]^{1-\rho}(1+d) > b(w_m+Y_e)$$

$$\Leftrightarrow (1-h_e)\delta A(e,s)[(1-w_m^{\frac{-\rho}{1-\rho}}(1-\delta)^{\frac{1}{1-\rho}}(A(e,s))^{\frac{\rho}{1-\rho}})^{\frac{-1}{\rho}}\delta^{\frac{1}{\rho}}]^{1-\rho} > b(w_m+Y_e)$$

$$\Leftrightarrow A(e,s)[(1-w_m^{\frac{-\rho}{1-\rho}}(1-\delta)^{\frac{1}{1-\rho}}(A(e,s))^{\frac{\rho}{1-\rho}})^{\frac{-1}{\rho}}\delta^{\frac{1}{\rho}}]^{1-\rho} > \frac{b(w_m+Y_e)}{(1-h_e)\delta(1+d)}$$

$$A(e,s)^{\frac{1}{1-\rho}}(1-w_m^{\frac{-\rho}{1-\rho}}(1-\delta)^{\frac{1}{1-\rho}}(A(e,s))^{\frac{\rho}{1-\rho}})^{\frac{-1}{\rho}} > \big[\frac{b(w_m+Y_e)}{(1-h_e)\delta(1+d)\delta^{\frac{1-\rho}{\rho}}}\big]^{\frac{1}{1-\rho}}$$

$$A(e,s)^{\frac{-\rho}{1-\rho}}(1-w_m^{\frac{-\rho}{1-\rho}}(1-\delta)^{\frac{1}{1-\rho}}(A(e,s))^{\frac{\rho}{1-\rho}}) < \big[\frac{b(w_m+Y_e)}{(1-h_e)\delta(1+d)\delta^{\frac{1-\rho}{\rho}}}\big]^{\frac{-\rho}{1-\rho}}$$

$$A(e,s)^{\frac{-\rho}{1-\rho}} - w_m^{\frac{-\rho}{1-\rho}}(1-\delta)^{\frac{1}{1-\rho}} < \big[\frac{b(w_m+Y_e)}{(1-h_e)\delta(1+d)\delta^{\frac{1-\rho}{\rho}}}\big]^{\frac{-\rho}{1-\rho}}$$

$$A(e,s) > \Big[\big[\frac{b(w_m+Y_e)}{(1-h_e)\delta(1+d)\delta^{\frac{1-\rho}{\rho}}}\big]^{\frac{-\rho}{1-\rho}} + w_m^{\frac{-\rho}{1-\rho}}(1-\delta)^{\frac{1}{1-\rho}}\Big]^{\frac{1-\rho}{-\rho}} \tag{32}$$

$$f^f < 1-\bar{h}e \Leftrightarrow \frac{(1-h_e)\delta A(e,s)^\rho X^{1-\rho}(1+d) - bw_m - bY_e}{X^{1-\rho}A(e,s)^\rho\delta(1+d+b)} < 1-\bar{h}e$$

$$\text{(with X> 0)} \Leftrightarrow (1-h_e)\delta A(e,s)^\rho X^{1-\rho}(1+d) - bw_m - bY_e < (1-\bar{h}e)(X^{1-\rho}A(e,s)^\rho\delta(1+d+b))$$

$$\Leftrightarrow (1-h_e)\delta A(e,s)^\rho X^{1-\rho}(1+d-1-d-b) < b(w_m+Y_e)$$

$$\Leftrightarrow (1-h_e)\delta A(e,s)^\rho X^{1-\rho} > -(w_m+Y_e) \tag{33}$$

Which automatically holds if $X > 0$. I make the assumption that $\rho \geq 0$ bcs we see substitutability in the results.

$$l^f > 0 \Leftrightarrow f^f < 1-\bar{h}e,\ l^f < 1-\bar{h}e \Leftrightarrow f^f > 0 \tag{34}$$

$$f^m > 0 \Leftrightarrow \big[\frac{(1-\delta)(A(e,s))^\rho}{w_m}\big]^{\frac{1}{1-\rho}} X f^f > 0 \tag{35}$$

Which follows if $X > 0$. $f^m, l^m > 0$ also follow from $X > 0$ but for $h^m > 0, h_m < 1, l^m < 1, f^m < 1$, the exponents do not cancel out and where I must find the condition on $A(e,s)$ numerically.

$$f^m < 1 \Leftrightarrow \big[\frac{(1-\delta)(A(e,s))^\rho}{w_m}\big]^{\frac{1}{1-\rho}} X f^f < 1 \tag{36}$$

Figure 2.4: Modelled cattle population with and without droughts (DI = 0).

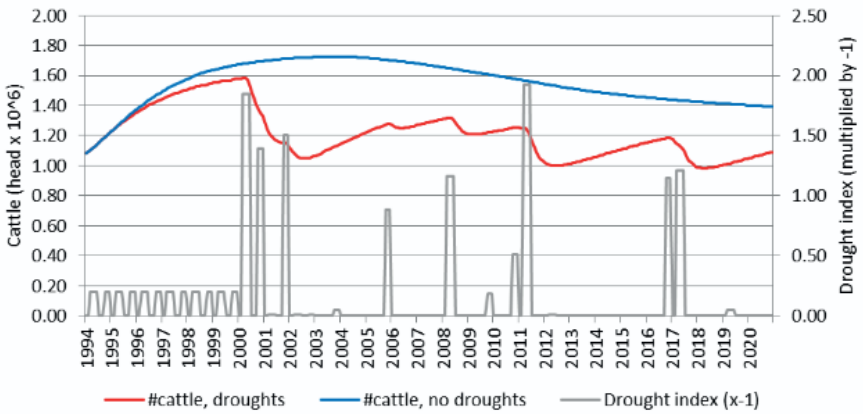


Figure 8: Drought index over different time periods World Bank)

Which I need to solve numerically to find the expression for A(e,s)

E Model illustration