Implications of the seasonality of labour for rural livelihoods and agricultural supply response

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Abstract:

Agriculture is unique from most other sectors, because of its strong reliance on weather inputs and seasonal requirement for production factors. The seasonality of labour markets is a well-known issue and is particularly relevant for rural livelihoods in developing countries, where a large share of the population relies on labour intensive agriculture. All the more astonishing is the fact, that seasonality of labour markets has hardly been incorporated in economy-wide models such as computable general equilibrium (CGE) models. This study develops the first national CGE model framework with an explicit depiction of seasonal labour markets. In order to demonstrate the relevance of seasonality for model outcomes the model is applied to a case study of Bhutan being affected by an increase in cereal prices. If the seasonality of labour markets is accounted for we find that the price shock results in a substantially lower supply response of the agriculture sector and that ignoring the seasonality of labour markets results in an overestimation of positive welfare effects for farm households. Furthermore, we find that incorporating seasonal labour results in a more accurate understanding of resource constraints, which can benefit the application of models for policy analysis.

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1. Introduction

With a growing world population to feed, farming becomes increasingly more challenging in times of drastic climatic changes and urbanization. Models are frequently employed to simulate exogenous shocks, baselines and policy scenarios ex-ante to understand the mechanisms of the food system. While agriculture is not only different from other economic sectors because of its strong reliance on weather inputs, it is also unique in terms of its requirement of seasonal labour inputs. Economy-wide model frameworks have so far neglected the role of seasonal labour when analysing impacts related to the agricultural sector even though 40% of the developing world's labour force is employed in agriculture (World Bank, 2017). With this study we demonstrate the relevance of seasonal labour markets when simulating the agricultural supply response towards exogenous shocks.

Amartya Sen notes that for "agriculture being a seasonal operation, it is somewhat misleading to speak in terms of a homogeneous unit of labour. A unit of labour at the time of harvesting is not replaceable by a unit of labour at a slack period" (Sen, 1966, p. 440). This simple insight has import implications for the understanding of rural labour markets which are dominated by seasonal activities, such as agriculture. Seasonal labour bottlenecks are identified to be important constraints limiting agricultural output "regardless of the degree of underemployment" that might be observed for the rest of the year (Ruthenberg, 1971, p. 78). Seasonality of labour also cause temporary labour market disequilibria such as seasonal labour surpluses or shortages. Seasonal unemployment has been documented by various empirical studies (Lanjouw and Lanjouw, 2001; Skoufias, 1993). In rural India, for example, involuntary

unemployment was found to more than double between the peak and slack season with disproportionate adverse effects for female labour (Bardhan, 1984). Seasonal labour shortages, on the other hand, are predominantly observed during peak seasons, as for instance in China (Zhang *et al.*, 2011) and even the U.S. (Taylor *et al.*, 2012).

Seasonal labour is particularly relevant for developing countries, where seasonality is considered "an inherent feature of rural livelihoods" due to a high share of the labour force working in agriculture (Ellis, 2000, p. 293). Still, seasonal labour markets are rarely if at all incorporated in simulation models depicting rural labour markets. Furthermore, the interaction between seasonal and non-seasonal labour market segments up to the level of national labour markets has not yet been a research focus. This is surprising, as many relevant questions center around labour market seasonality: How do large-scale agricultural investments impact rural livelihoods if only seasonal employment is provided? What is the potential of promising technologies if they disrupt the traditional seasonal calendar of activities? How can interventions alleviate poverty if they specifically target rural employment problems such as seasonal labour shortage and unemployment?

Modelling seasonal labour requirements in agriculture is a standard feature in farm and multi-agent models (Troost and Berger, 2015). While these models are limited to effects within the agricultural sector, computable general equilibrium (CGE) models are well suited to address simultaneous equilibria on segregated labour markets and their impacts on production, income and livelihoods. Yet, CGE models typically solve on an annual basis and aspects of seasonality have been hardly pursued so far. It is therefore either implicitly assumed that quantities of labour demanded by economic activities and supplied by households are constant across different periods of the year, or alternatively that units of labour are freely allocated within a year. The first assumption contradicts the reality of seasonal labour markets in which field operations such as planting or harvesting have to be done within a specific time period. The

second assumption obviously violates time consistency, as labour supplied in one period cannot be used in another period.

To the best of our knowledge, Finnoff and Tschirhart (2008) and Filipski *et al.* (2017) are the only ones to incorporate seasonal labour in a general equilibrium framework, but do not depict national labour markets. One factor explaining the non-existence of seasonal labour in national economy-wide simulation models might be the data paucity, as data on seasonal labour is difficult to obtain. However, it is also uncertain whether collecting such data is worthwhile, due to the not yet demonstrated influence of depicting labour as seasonal on typical model outcomes such as household welfare, prices and supply response. This study aims at assessing the relevance of labour seasonality by simulating an increase in cereal prices to a default CGE model (without seasonal labour) and an extended CGE model depicting seasonal labour markets using a generic structure. As increasing cereal prices stimulate the output of domestic producers, we are interested in assessing how the seasonality of labour and potential labour bottlenecks affect the supply response. Furthermore, as in the default model setup labour can be sourced for employment in the production of cereals throughout the year, differences in changes of output of activities that are known to have counter-cyclical demand for labour will be analysed in detail.

2. Theoretical foundation

2.1. Labour Supply

According to neoclassical economic theory, individuals maximize utility facing a consumption-leisure trade-off which allows to determine the first-order conditions of an individual's labour supply. Equation (1) describes an individual's utility[1] U as a function of consuming a bundle of goods X and hours of leisure F.

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[1] The utility function is assumed to possess the necessary conditions such as being quasi-concave and continuously differentiable.

$$U = U(X, F) \tag{1}$$

Utility is maximized under the following budget and time constraints:

$$P X \leq wL + V \tag{2.1}$$

$$T = F + L \tag{2.2}$$

where P is the weighted price of consumption bundle X, w is the hourly wage, L is hours worked, V is any non-labour income and T is an individual's total time endowment. Substituting $F = T - L$, we can formulate a constrained maximization function Z which describes an individual's utility maximization under the budget constraint in (2.1).

$$Z = U\big(X, (T - L)\big) + \lambda(wL + V - P X) \tag{3}$$

According to common textbook knowledge in labour economics theory, we substitute $-\frac{\partial U}{\partial L} = \frac{\partial U}{\partial F}$ and derive the equilibrium conditions for a state in which (1) the individual supplies labour $(L > 0)$ or (2) does not participate in the labour force $(L = 0)$:

$$\frac{\frac{\partial U}{\partial F}}{\frac{\partial U}{\partial X}} = \frac{w}{P} \qquad \text{if state (1) } L > 0 \tag{4.1}$$

$$\frac{\frac{\partial U}{\partial F}}{\frac{\partial U}{\partial X}} \geq \frac{w}{P} \qquad \text{if state (2) } L = 0 \tag{4.2}$$

To incorporate seasons, we subdivide the scalar T into a j dimensional vector T'_t such that $T = \sum_{t=1}^{j} T'_t$ – where set t denotes a period and j the number of periods. The Lagrangian utility maximization function for such a model with $j = 2$ is presented in equation (5):

$$Z = U\big(X, (T'_1 - L_1), (T'_2 - L_2)\big) + \lambda(w_1 L_1 + w_2 L_2 + V - P X) \tag{5}$$

Analogous to equation (4.1), we can obtain the equilibrium conditions under which a household supplies labour, however this time for labour supplied in each period subject to the seasonal wage w_t.

$$\frac{\frac{\partial U}{\partial F_1}}{\frac{\partial U}{\partial x}} = \frac{w_1}{P} \qquad \text{if } L_1 > 0 \tag{6.1}$$

$$\frac{\frac{\partial U}{\partial F_2}}{\frac{\partial U}{\partial x}} = \frac{w_2}{P} \qquad \text{if } L_2 > 0 \tag{6.2}$$

As the marginal utility of consumption and the price of the consumption bundle is equal across both equations, it becomes directly obvious that for each period t the marginal utility of leisure needs to equal the respective seasonal wage. The pointwise separability of seasonal leisure and annual consumption in equation (5) is problematic as we assume households to maximize utility over time horizon T, thus for the sake of time-consistency we assume non-separability of leisure consumption. Using a nested structure, leisure from each period t is aggregated to composite leisure $\bar{F}$ and households maximize utility consuming composite leisure and goods. Composite leisure $\bar{F}$ is specified through a constant elasticity of substitution (CES) function with constant returns as presented below.

$$\bar{F}(F_t) = A\left[\sum_{t=1}^{j} \delta_t F_t^{-\rho}\right]^{-\frac{1}{\rho}} \tag{7.1}$$

$$\bar{F}(T'_t - L_t) = A\left[\sum_{t=1}^{j} \delta_t (T'_t - L_t)^{-\rho}\right]^{-\frac{1}{\rho}} \tag{7.2}$$

where A is a shift parameter, δ is a calibrated share parameter and ρ is the substitution parameter. In equation 7.2, we substituted leisure again with the difference between total time endowment and labour supply. The degree of substitution of seasonal leisure depends on substitution parameter ρ, which is determined by elasticity of substitution σ, as $\rho = \frac{1}{\sigma} - 1$ reflecting an individual's preferences regarding the intertemporal distribution of leisure.

Assuming non-separability for seasonal leisure thus allows for substitution of leisure from different periods.

2.2. Labour demand

For simplicity reasons, we disregard the role of intermediate inputs and assume a CES production function with constant returns producing the output X using production factors L and K, representing labour and capital:

$$X(L, K) = A\left[\delta L^{-\rho} + (1 - \delta)K^{-\rho}\right]^{-\frac{1}{\rho}} \tag{8}$$

It is straightforward extending this function by a nest for composite labour L aggregating seasonal labour from periods t:

$$L(L_t) = A\left[\sum_{t=1}^{j} \delta_t L_t^{-\rho}\right]^{-\frac{1}{\rho}} \tag{9}$$

Under profit maximizing conditions, a factor is demanded until its marginal revenue product MRP_F equals the factor price. Setting $j = 2$ we consider seasonal labour for two periods. By partially differentiating, for example with respect to seasonal labour in period 1, we obtain $\frac{\partial x}{\partial L_1}$, which equals the marginal productivity (MPP_{L_1}). As $MPP_{L_1} = \frac{MRP_{L_1}}{P}$ and $w_1 = MRP_{L_1}$, we can derive the first order-condition from the partial differential:

$$w_1 = P A \left[\delta_1 L_1^{-\rho} + \delta_2 L_2^{-\rho}\right]^{-\frac{1}{\rho}-1}\left[\delta_1 L_1^{-\rho-1}\right] \tag{10}$$

This shows that changes in seasonal wages depend on the substitutability of factors, being governed by the substitution parameter ρ, which is a transformation of the elasticity of substitution σ. In a model without seasonal labour, perfect substitution possibilities between seasonal labour would be implicitly assumed making a separate nest redundant. In a model with seasonal labour, the elasticity of substitution strongly depends on the nature of the economic activity. A cropping activity such as paddy cultivation has a very low σ as the labour

requirement for the various field operations such as ploughing, planting and harvesting follow a rigid pattern.

There are further interesting aspects such as the role of seasonal input of capital which can only substitute labour during certain periods of the year (e.g. agricultural machinery such as harvesting devices). On the other hand, the annual stock of capital might limit the substitution of labour across periods as for example as there is only so much weaving machinery available workers could utilize in a given point of time. However, such nuanced aspects go beyond the scope of this study as the objective is to address the general relevance of the depiction of seasonal labour markets.

3. Data

Social accounting matrices (SAMs) are widely used as databases for CGE models and are usually developed on an annual basis. Building on a 2012 SAM for Bhutan, we develop to the best of our knowledge the first national SAM with seasonal labour markets using data from a nationally representative 2012 agricultural sample survey (MoAF, 2013) in combination with information from various crop budget and cost of production studies and crop calendars.

The seasonal 2012 SAM disaggregates labour between farm and non-farm labour. Farm labour is further disaggregated according to Bhutan's three major agroecological zones (AEZ), which are classified according to altitude.[2] Farm labour is supplied by farm and landless households and is mostly demanded by agricultural activities, but also by post-harvest and other activities, such as textile-weaving. Non-farm labour is disaggregated into unskilled and skilled labour which is demanded by manufacturing and service activities. Farm labour is disaggregated according to 12 regular seasonal periods (i.e. each period represents one month) and in the

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[2] AEZ1 is the humid, sub-tropical zone at altitudes below 1,200 meters above sea level (masl). AEZ2 is the dry-subtropical AEZ in altitudes between 1,200 and 1,800 masl. AEZ3 is the temperate zone in altitudes above 1,800 masl.

following, each activity that employs seasonal labour is referred to as a seasonal activity. In addition to the labour accounts, there are four land accounts (rainfed, irrigated, pasture and forest land) which are all disaggregated by each AEZ. Capital is disaggregated in two livestock accounts (cattle and other animals), unincorporated and incorporated capital. Unincorporated capital is exclusively owned by farm and landless households.

Table 1 shows the seasonal activities represented in the SAM. The cropping activities maize, vegetables and potato are further disaggregated into an early and a late growing period. Column one and two show the share of each seasonal activity in total output value and person-days. All cropping activities account for 44.9% of total output value and 49.3% of total person-days. In total, there are 26.0 million person-days, which are provided by 141,230 workers translating to an average 184 working days per person. This might seem to be low at first sight, however, other activities such as child rearing, cooking, house maintenance, etc. are not included. Overall, seasonal labour represents 43.9% of Bhutan's total labour force. If employment in agriculture is taken as a proxy for seasonal work, this share is comparable to most South Asian countries, where in 2010 on average 50.4% of the total labour force was employed in agriculture (World Bank, 2017).

The last column shows the assumed substitution elasticity of seasonal labour among different periods within the model's production structure. Cropping activities are known to have a rigid demand for seasonal labour and the substitution elasticity of seasonal labour across time periods is set low ($\sigma = 0.1$). Other activities are considered to have a flexible demand for seasonal labour, for which varying degrees of substitution across periods are assumed.

Table 1 - Seasonal activities represented in SAM

Activity	Share in total seasonal output	Person-days (in thousand)	Seasonal labour substitution elasticity (σ)
Paddy	10.0%	4,414	0.1
Maize - first season	1.6%	937	0.1
Maize - second season	4.7%	2,525	0.1
Other cereals and oilseeds	2.2%	935	0.1
Vegetables - first season	4.1%	668	0.1
Vegetables - second season	4.1%	941	0.1
Potato - first season	5.3%	1,199	0.1
Potato - second season	0.2%	82	0.1
Spices	3.9%	385	0.1
Fruits	9.1%	877	0.1
Total cropping activities	**45.3%**	**12,964**	
Cattle husbandry	8.7%	1,195	0.1
Other animals	4.9%	1,330	0.1
Dairy production	11.4%	3,327	0.1
Total livestock activities	**25.0%**	**5,852**	
Paddy milling	10.7%	741	0.75
Cereal milling	0.9%	124	0.75
Cereal processing	2.4%	293	0.75
Ara* production	3.6%	668	0.75
Total post-harvest activities	**17.6%**	**1,826**	
Community forestry	7.8%	3,539	1.5
Textile weaving	4.4%	1,805	1.5
Total off-farm activities	**12.2%**	**5,344**	
Total seasonal activities	**100.0%**	**25,986**	
Share of seasonal activities in total output/employment	**9.3%**		

Please note: Each seasonal activity is further disaggregated by agroecological zone
* Ara is a traditional home-brewed alcoholic beverage made from cereals

Figure 1 shows the aggregated distribution of person-days across the 12 time periods for the three AEZs. Within each time period the amount of person-days required by rigid and flexible demand is presented. Paddy cultivation, comprising about a quarter of all labour demanded by cropping activities, has a strong influence on the rigid demand for seasonal labour. This is due to the high labour intensity of paddy cultivation, which requires on average about 250 person-days per hectare – about twice as much as labour as needed by Maize. The peaks of rigid demand and the potential seasonal labour bottlenecks are thus largely determined by the paddy transplanting and harvesting seasons, which in AEZ1 for example take place in June-July and November-December, respectively.

Off-farm activities account for 20.6% of total seasonal labour. As seasonal labour employed by off-farm activities follows a counter-cyclical pattern, the share of seasonal labour employed by activities with flexible demand is lowest during peak periods and in contrast highest during lean seasons, such as during the winter months in AEZ3.
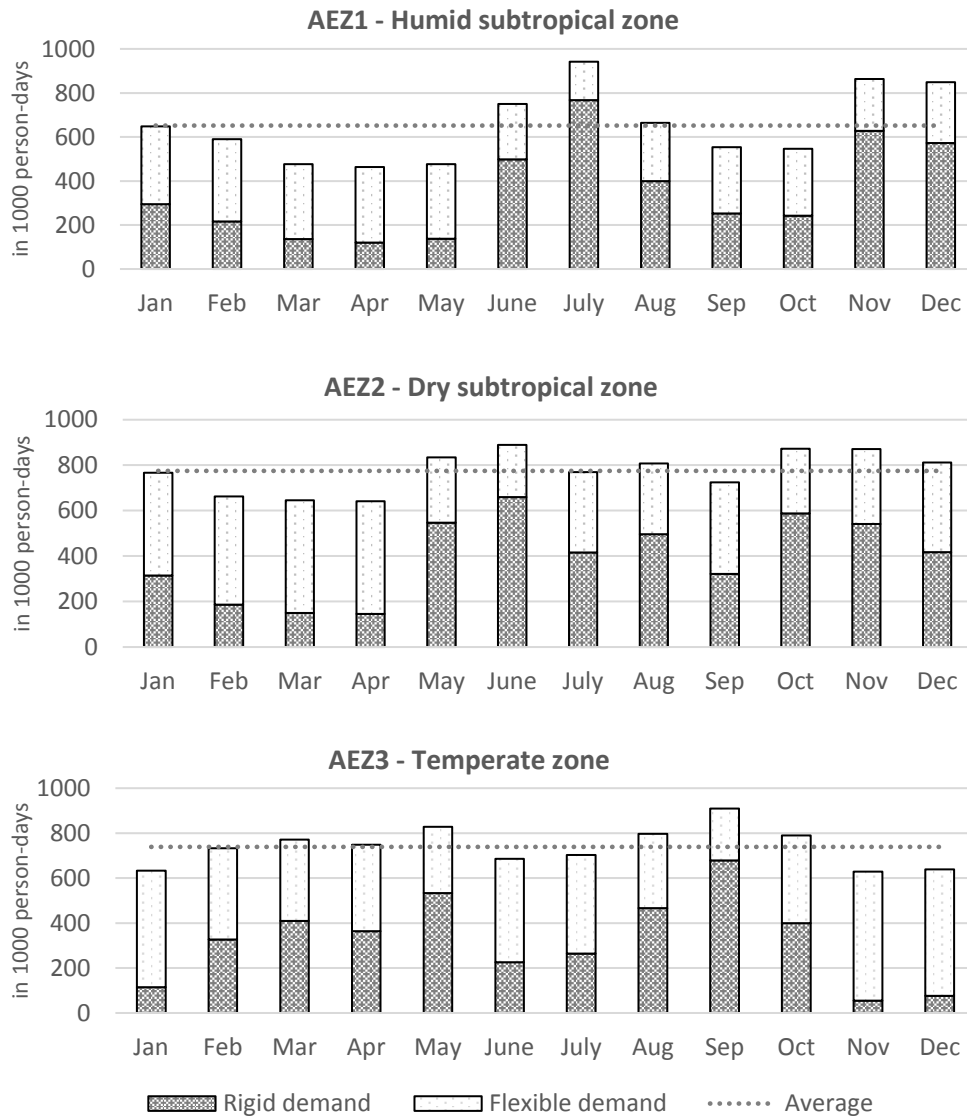

Figure 1 - Aggregated distribution of seasonal labour demand in 1000 person-days per month across AEZs

4. Model framework

The CGE model adapted for this study is the single country, comparative-static STAGE2 model which is comprehensively described in McDonald and Thierfelder (2015). The production structure in STAGE2 is modified to adequately incorporate seasonal labour. Non-seasonal

activities only use the light-shaded nests in Figure 2. At nest L1, we assume that intermediate inputs and value added components are aggregated according to Leontief technology. Fixed shares also hold for the aggregation of intermediate inputs at L2.1. The value added nest at L2.2 and factor aggregates below (L3.2 and 3.3) are CES aggregates using elasticities equal to 0.24 and 1.5, respectively (Hertel, 1997; Hertel *et al.*, 2016).

Seasonal activities also use the dark-shaded nests. At level L3.1, cultivated area and fertilization are aggregated using an elasticity of 0.4, as assumed by Bouët *et al.* (2010) in the context of developing countries. At nest L4.2 fertilizers, animal manure and chemical fertilizer, are aggregated using an elasticity of 0.8, which is within the range of 0.523 and 1.327 of Ali und Parikh (1992). Cultivated area (L4.1) is a CES composite consisting of aggregated seasonal labour (L5.1) and land. The elasticity is set quite low (0.5) to reflect the fact that an increase in land also requires a similar increase in labour required to cultivate that land. At level 5.1, seasonal labour from the 12 time period enters the production structure.
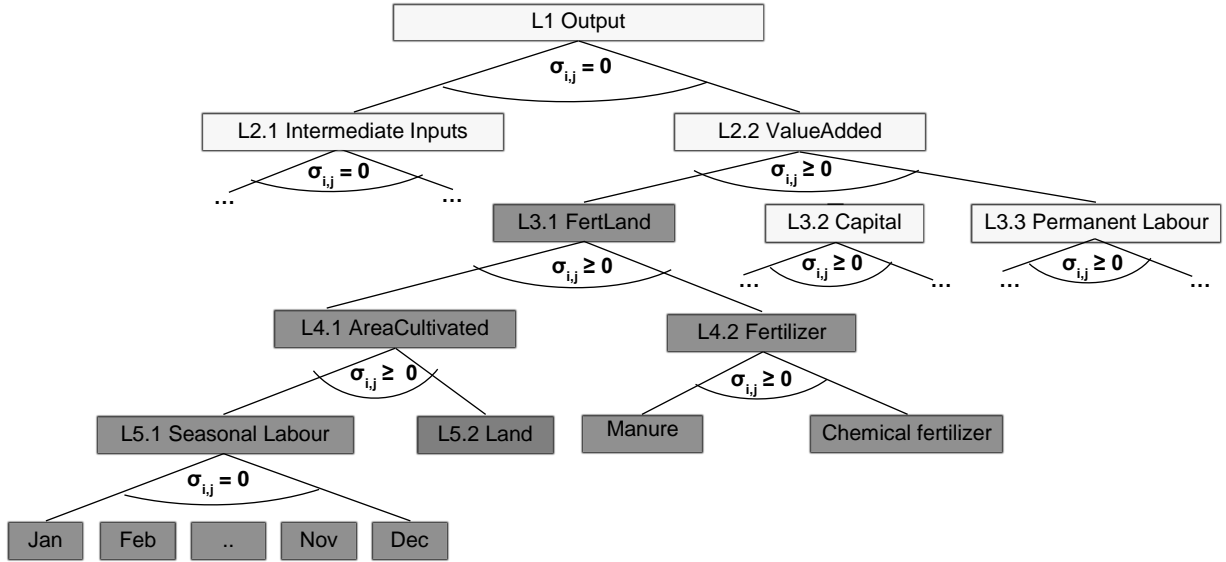

Figure 2 - Production structure incorporating seasonal labour

Our model uses the small country assumption, i.e. world market prices are fixed and we further assume that the external balance is cleared by an adjusting exchange rate. The model is savings-driven (savings are fixed in real terms) and investment level adjusts. Government consumption

and savings are fixed in real terms and sales taxes are variable to balance the government account. Capital supply is constant and assumed to be immobile and activity specific as we consider a medium term adjustment horizon. All labour accounts, skilled, unskilled and seasonal labour are perfectly mobile across those activities in which they were demanded in the base period, however they are segmented according to their characteristics (skill-level, AEZ and time period) which cannot be altered (i.e. no labour mobility across characteristics). Land is imperfectly mobile across cropping activities and allocated using a CET specification. Due to high prevalence of fallow land in Bhutan, we implement a land supply curve as specified in Eickhout *et al.* (2009). Land supply is dependent on the land rental rate and approaches an asymptote of maximum land supply as the factor price for land goes towards infinity. Due to the absence of specific estimates for Bhutan, we assume a moderate elastic price elasticity for the supply of land of $\varepsilon_n = 1.2$.

4.1. Labour-leisure trade-off

The model incorporates a labour-leisure choice through which households consume aggregate leisure and aggregate commodity groups according to a Linear Expenditure System. The income elasticities of commodity groups were estimated using cross-sectional secondary household data from the 2012 Bhutan Living Standard Survey. Each commodity group is comprised of similar commodities which are aggregated using a CES specification.

Following Boeters and Savard (2013), we calibrate the total time endowment per factor type such that we arrive at an empirically plausible total-income elasticity of labour supply $\varepsilon_{L,Y}$ of -0.1. This leaves us with a "time-endowment ratio" of about 1.1 labour supply, in other words leisure comprises about 10% of total time, which corresponds to an uncompensated income elasticity of leisure $\varepsilon_{F,Y}$ of 1.0 (Ballard, 2000). Aggregate leisure is determined by a CES nest in which leisure can be substituted from all labour types and seasons. For a household endowed

with both permanent and seasonal labour, the model thus allows to substitute leisure hours of the former with seasonal leisure in one or more periods of the latter.

The degree of leisure substitution is governed by the parameter σ. Grounded within the life-cycle labour supply theory (Lucas Jr and Rapping, 1969), various intertemporal elasticities of substitution (IES) have been empirically estimated, however mostly in high-income countries with formal labour markets. Skoufias (1996) is one rare exception, estimating IES for seasonal labour in rural India. He finds significant IES for female workers to range between 0.075 and 0.085, but finds no evidence for male workers. Given the absence of estimates for Bhutan and the generally low level of estimated IES in literature, we therefore assume an IES of 0.1.

4.2. Model scenario

During the food price crisis in 2007-08, India has imposed export bans on rice and wheat in order to stabilized domestic prices and exempted only a few countries, including Bhutan (Bhutan Observer, 2010). The privilege of being exempted from India's export bans and the high dependency on India to ensure food supplies is also perceived as a potential risk through which India could exert political influence. Just shortly before the second free elections in July 2013, India provoked by Bhutan's diplomatic advances towards China cut subsidies on kerosene cooking fuels exported to Bhutan, which caused turmoil and contributed to the very unexpected victory of the opposition party in (Taneija, 2013).

Bhutan is landlocked and does not have any border crossing with its Northern neighbour, China. Hence, any imports would either need to come via land through India or via air. According to the World Bank (2017), the average import cost per ton to Bhutan is estimated to be 117 USD/ton, which in the following is assumed to be the absolute mark-up on the import cost that Bhutan would face if it needed to source cereal imports from the world market instead of India.

As virtually all cereals are imported from India (Table 2), depending on the absolute unit price of imports in 2012 the cost of imported cereals would increase between 15.5% and 51.7%.

Table 2 - Overview of simulated changes in import cost of cereals (Source: Bhutan SAM 2012)

Commodity	Import Unit Price (2012)	Quantity imported (2012)	% imported from India	% price increase
	(USD/ton)	Tons		
Milled rice	324.9	72,297	99.99%	35.9%
Maize	225.4	2,257	100.00%	51.7%
Other cereals*	276.8	5,967	99.99%	24.8%
Grain-mill products	751.1	66,888	97.24%	15.5%
Animal feed	663.9	1,405	99.82%	17.5%

* Wheat makes up 74.5% of imported other cereals

The hypothetical scenario of Bhutan importing cereals from the world market is simulated using two model setups, a seasonal and a default model. The seasonal model depicts seasonality as described in the model structure. The default model mimics the model structure identical to the one presented above, however, instead of 12 seasonal labour accounts per AEZ there is one farm labour account in nest L5.1. This is the only difference between the model setups.

The transmission of the price shock is endogenous in the model, as imported goods are imperfect substitutes of domestic goods and vice versa for exported goods. The Armington elasticity determines the ease of substitution of foreign and domestically produced goods and its magnitude has a large influence on the price transmission and thus model results. As paddy is not traded in the model, the weighted average of the GTAP Armington elasticities (Hertel *et al.*, 2016) for paddy and processed rice is used , which is equal to 4.23.

5. Results

The increased import cost of cereals stimulates Bhutan's production of agricultural products and cereals in particular, resulting into a modest increase in real GDP of about 0.01% according to both model setups (Table 3). As cereal prices increase (Table 4), households need to spend a larger share of their income to purchase food. This loss of purchasing power causes total household consumption to decline by 2.4 and 2.5%, respectively. The decline in household consumption is compensated by higher investment and a reduction in the country's current account deficit. The latter is largely due to a substitution of imported cereals by increased domestic cereal output, resulting into an increase in cereal self-sufficiency from 65.2% to 77.5% and 75.6%, respectively. Unlike in the default model, exports increase when accounting for seasonal labour, because exports of forest products and textiles drop at much lower rates. The increase in cereal prices could lead to more positive macroeconomic results, if it was not for the appreciation of the Bhutanese currency.

Table 3 - Macroeconomic results for the world cereal price shocks

	Base Year	Change from base year (%)	
	Share of GDP (%)	Default	Seasonal
GDP	100.00	0.01	0.01
Absorption (C+I+G)	128.51	-0.60	-0.61
Consumption (C)	45.23	-2.42	-2.52
Investment (I)	67.03	0.49	0.54
Government (G)	16.25	0.00	0.00
Exports (E)	34.66	-0.01	0.08
Imports (M)	66.15	-1.18	-1.16
%-change in exchange rate (Domestic currency/ foreign currency)		-3.25	-3.26
Cereal self-sufficiency (%)	65.15	77.53	75.63

Total cereal production increases by 13.9% in the default model, but the supply response is markedly lower at 9.6% when seasonality of labour is accounted for (Table 4). The increase is domestic cereal production results in an increase of overall agricultural goods of 0.9% in the

default model, which is only 0.1% under the seasonal model. While production of rice and other cereals increases strongly, the output response of Maize is low, because only 3.1% of domestic maize demand is imported and because of lacking export linkages. Therefore, the price transmission to the domestic market is relatively small. The spike in world market prices is buffered through the increase in domestic cereal output. As the default model results in higher total cereal output, cereal producer prices increase only by 10.0% compared to 12.8% under the seasonal model. The difference in results for cereal output is especially evident in case of paddy, for which the default model reports a 41.8% higher increase in output.

Table 4 - Percent changes in output, producer prices, purchaser prices and trade for world cereal price shocks

SAM sectors	Sector or group name	% change purchaser price		% change domestic production		% change imports		% change exports	
		Default	Seasonal	Default	Seasonal	Default	Seasonal	Default	Seasonal
1-14	Agriculture	2.5	3.1	0.9	0.1	0.6	0.2	-7.5	-6.8
1-3	Cereals	10.0	12.8	13.9	9.6	-38.2*	-33.5*	-7.5*	-16.7*
1	Paddy	11.6	15.8	22.0	15.6				
2	Maize	7.7	9.0	1.4	1.5	-32.2	-31.0		
3	Other cereals	8.8	9.3	2.8	3.8	-18.3	-16.7	-18.8	-18.6
4-7	Other crops	-1.0	-1.1	-3.8	-3.6	3.8	3.2	-7.5	-6.8
8-10	Livestock	0.2	-0.2	-4.4	-4.0	2.1	1.5	-13.1	-11.7
11-14	Post-harvest	6.0	7.1	2.9	0.7	-16.9	-15.4	-23.8	-25.1
11	Milled rice	10.3	14.0	22.4	15.8	10.5	2.9	-5.6	-16.4
15-16	Forestry	1.1	-2.1	-2.2	-0.5	10.5	2.9	-10.3	-2.7
17	Mining	-3.1	-3.1	1.0	1.0	0.7	0.8	1.1	1.2
18-23	Manufacturing	-3.1	-3.2	0.4	0.8	0.1	0.0	1.0	1.2
18-20	Food processing	1.4	1.6	-3.3	-3.5	-6.5	-6.5	-14.0	-14.5
22-23	Textile weaving	-1.8	-3.3	-5.1	-2.3	0.6	-2.4	-7.6	-1.8
24	Electricity	-3.2	-3.2	0.0	0.0	1.1	1.2	-0.2	-0.2
25	Construction	-3.5	-3.6	0.5	0.6	-0.0	-0.1		
26-32	Services	-4.1	-4.2	-0.2	-0.2	-1.5	-1.6	0.1	0.1

* Paddy is not traded, thus changes of paddy as well as aggregated crops and cereals in domestic demand, import and export do instead refer to changes in milled rice.

Differences in agricultural output changes between both model setups are highest for AEZ1 and AEZ3 (Table 5). In AEZ 1, total agricultural output changes from a slight increase to a decline of -0.9%, which is due to the more pronounced labour bottleneck during the paddy transplanting period in that zone. This is also why AEZ1 faces the strongest increases of seasonal wages (Figure 4). Hence, the cereal supply response in AEZ1 is most constrained by seasonality, where the cereal output increase is reduced from 11.7% to 6.8%. Yet, seasonality reduces the cereal supply response across all AEZs. For AEZ1 and AEZ2, output of other crops falls less strongly in return, which underlines the lower flexibility of the agricultural system in these zones once seasonal labour is considered.

The composition of cereal supply also changes markedly when incorporating seasonal labour. The output of *other cereals* increases at higher rates in both AEZ1 and AEZ2, as they are predominantly cultivated in the winter season and thus do not directly compete for labour needed for paddy and maize cultivation. In AEZ1 harvest of the early maize and planting of the late maize both coincide with the time of paddy transplanting, while there is no such collision in AEZ2. Consequently, in AEZ1 maize output decreases stronger while in AEZ2 output change swings from no change to an increase of 6.1% (Table 5). In AEZ3, maize cultivation is only done once a year and overlaps largely with paddy and thus the output increase is reduced from 6.7% to 1.9%.

Livestock has quite regular demand for seasonal labour and the seasonal model only allows for a small substitution elasticity, thus less labour can be released from livestock in the seasonal model resulting into a lower decline in output across all AEZs. The difference in model results are most obvious for changes in output of community forest and textile weaving. In the seasonal model, these activities mostly absorb labour during the winter (lean season) months and cannot

release labour units to be employed for cropping activities. Consequently, in the seasonal model the output decline of those activities is substantially lower than in the default model.[3]

Table 5 - Changes in domestic production across agro-ecological zones

SAM sectors	Sector or group name	%-share in base output			% - change in domestic production					
					Default model			Seasonal model		
		AEZ1	AEZ2	AEZ3	AEZ1	AEZ2	AEZ3	AEZ1	AEZ2	AEZ3
1-14	Agriculture	30.7	32.7	36.5	0.0	1.2	1.4	-0.9	0.5	0.5
1-7	Crops	30.8	40.2	29.0	1.7	3.2	2.6	0.3	2.1	1.4
1-3	Cereals	30.6	40.6	28.8	11.7	11.8	16.3	6.8	9.4	13.0
1	Paddy*	29.9	42.1	28.1	22.2	19.9	25.2	14.3	12.4	21.8
2	Maize	34.5	39.2	26.3	-0.9	0.0	6.7	-3.8	6.1	1.9
3	Other cereals	25.3	34.0	40.7	1.1	2.0	4.5	4.8	3.0	4.0
4-7	Other crops	30.6	27.7	41.7	-4.4	-4.3	-3.1	-3.6	-4.1	-3.3
8-10	Livestock	31.0	33.9	35.1	-5.4	-5.1	-2.9	-4.8	-4.6	-2.8
15	Community forestry	19.6	35.6	44.8	3.7	2.7	2.2	2.5	-0.8	0.1
22	Textiles - farm HHs	16.7	31.9	51.4	-5.9	-2.9	-3.7	0.0	-0.6	-1.8

The difference in cereal supply response is directly linked to how agricultural labour is allocated among farm activities. Figure 3 shows the allocation of agricultural labour aggregated at the national level. Even though agricultural labour is perfectly mobile across farm activities within each AEZ, only 4.4% and 2.8% of total agricultural labour is reallocated in the default and seasonal model, respectively. Labour previously employed in counter-cyclical activities like forestry and textile activities plays a relevant role for why the models differ. In the default model, 42% of reallocated labour is released by these activities compared to only 16% in the seasonal model. In the seasonal model also less labour can be mobilized from other crop and livestock activities. In total, labour allocated to cereals increases by 14.1% under the default model, while seasonal constraints limit this allocation to 8.8%.

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[3] Both forest and textile products are additionally produced by non-seasonal activities (Commercial forestry and textiles by urban households). The output of these sectors increases under the default model and thus the difference in the aggregate output is lower than if only the output of the farm activities is considered.
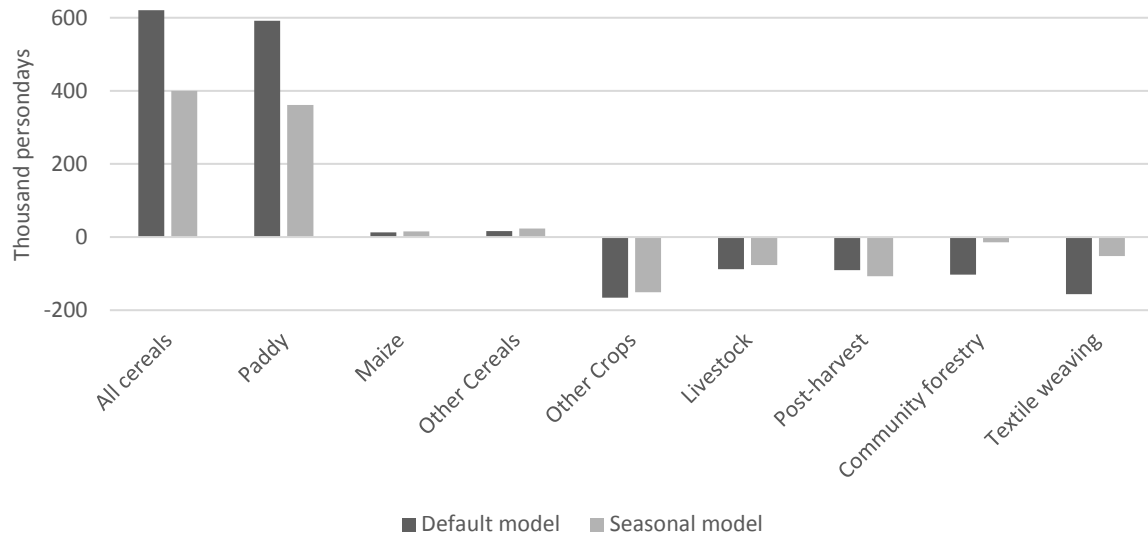
Figure 3 - Re-allocation of farm labour

As the shock only affects cereals, the changes in seasonal wages are asymmetric (Figure 4) and strong increases in wages are particularly recorded for those months in which most of labour is demanded by paddy cultivation. In AEZ1 paddy transplanting takes place in June-July and harvesting in November and December, which are the periods where wages increase by 12.6 – 38.2% and 11.2 – 14.8%, respectively. Due to the colder climate, transplanting and harvesting take place a month earlier in AEZ2 vis-à-vis AEZ1, and another month earlier in AEZ3. Seasonal increases in wages also coincide with the transplanting and harvesting periods in these AEZs. Overall the results for the seasonal increases in wages are in line with field observations and records of farmers complaining about labour shortages in the paddy transplanting and harvesting season. In contrast, seasonal wages also decrease during some periods, as activities benefitting from the increase in cereals prices crowd out other activities that compete for labour during the cultivation periods. These activities, however, will then also need to reduce demand for labour in slack periods, as they require a bundle of labour units from various periods with low substitution possibilities.
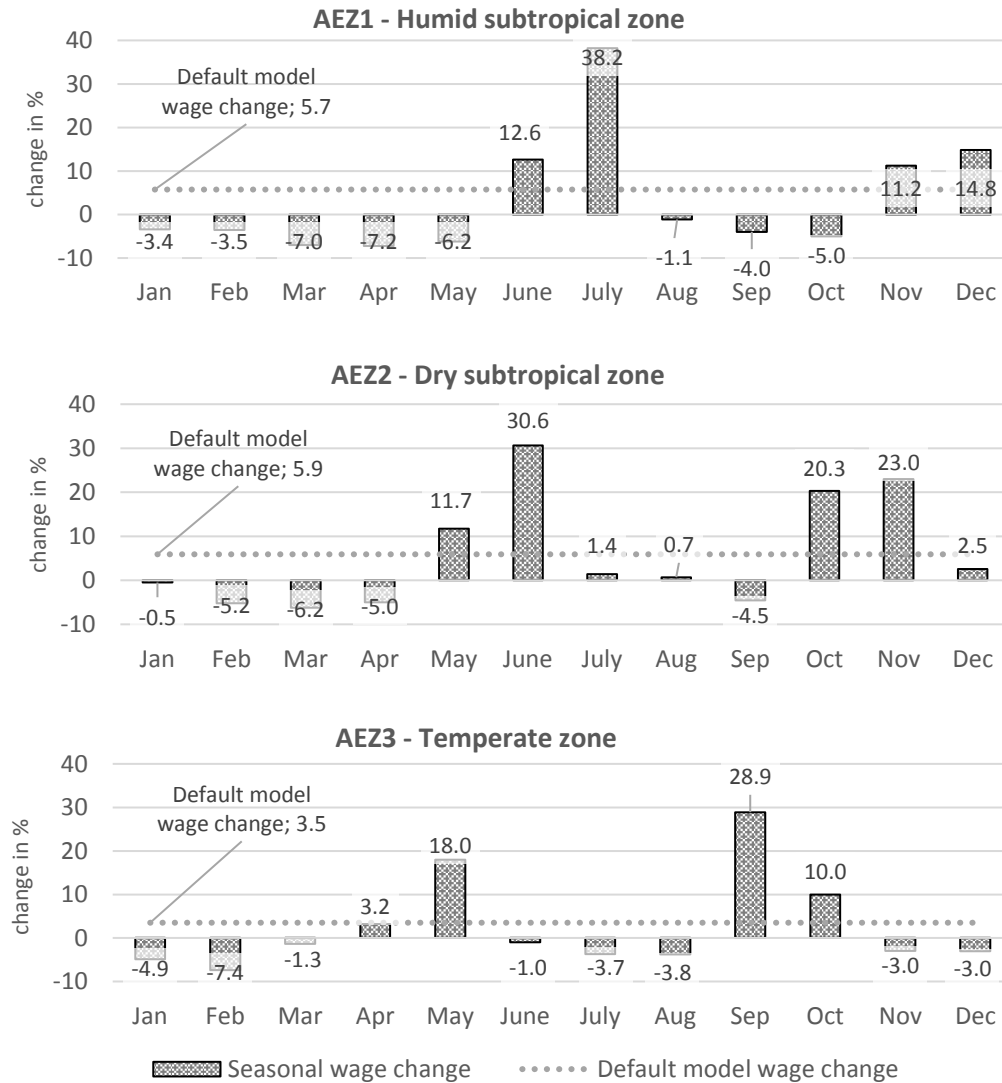
Figure 4 - Seasonal wage changes within each agroecological zone (Source: Own simulation results)

Changes in prices and supply of the remaining factors are presented in Table 6. Wages of formal labour and incorporated capital decrease as domestic aggregate demand drops, which in turn benefits export oriented sectors such as mining, manufacturing and electricity generation. As the rise in cereal production leads to higher demand for agricultural machinery and draught animals for land preparation, the price for unincorporated capital and livestock increases. The price of pasture land falls at a higher rate under the default model. This can be explained by the lower output of the livestock sector, but also because of falling fodder prices, which are a by-product of cereal production and a substitute to pasture land.

The labour-leisure allows for flexible labour supply along the intensive-margin (working hours). The price of leisure is equal to its opportunity cost, the wage, and a household's labour supply is determined by a substitution (leisure versus consumption) and an income effect. Due to decreasing income of non-farm households and lower wages the supply of skilled and unskilled labour increases at similar rates in both models. In case of supply of farm labour, there is a slight increase across all AEZs in the default model. In the seasonal model, however, farm labour supply either remains stagnant or drops, because most additional labour is needed during the peak labour seasons, when there is much less seasonal leisure left over than during lean season periods.

Table 6 – Factor price results for world cereal price shocks

	Change in factor price (%)		Changes in factor supply (%)	
	Default	Seasonal	Default	Seasonal
Skilled labour	-4.6	-4.7	0.2	0.2
Unskilled labour	-4.1	-4.2	0.2	0.2
Farm labour - national	5.0	4.8	0.1	-0.0
Farm labour - AEZ1	5.7	5.3	0.2	0.0
Farm labour - AEZ2	5.9	6.2	0.1	-0.1
Farm labour - AEZ3	3.5	3.1	0.2	0.1
Arable land national	1.0	0.6	1.1	0.9
Rainfed land - national	-2.1	-1.9	-2.6	-2.4
Rainfed land - AEZ1	-2.5	-2.1	-3.2	-1.7
Rainfed land - AEZ2	-2.1	-1.9	-1.5	-1.4
Rainfed land - AEZ3	-1.6	-1.8	-1.1	-1.3
Irrigated land - national	25.5	20.4	14.2	12.8
Irrigated land - AEZ1	21.5	16.6	15.8	13.5
Irrigated land - AEZ2	25.7	18.5	12.4	11.0
Irrigated land - AEZ3	30.5	28.7	15.0	14.7
Pasture land - national	-6.9	-5.4		
Livestock - national	4.4	1.6		
Unincorporated capital	13.1	8.8		
Incorporated capital	-2.4	-2.2		

The supply of rainfed land decreases as this is mostly used for the cultivation of non-cereal crops. In contrast, the boost in demand for domestically produced rice makes the factor price of irrigated land, which is only used for paddy cultivation, to increase at the highest rate. The

increase in supply of irrigated land even outweighs the reduction of cultivated rainfed land resulting in an overall expansion of arable land.

In the default model, all agricultural activities within one AEZ face the same change in agricultural wages, but in the seasonal model, each activity demands different shares of labour across the periods. As changes in seasonal wages differ it follows that each activity faces a specific price change of its composite labour. Composite price changes of agricultural labour are highest for activities that largely depend on labour supplied during bottleneck periods. For AEZ1 this applies for paddy and both for first and second season cultivation of maize (Figure 4). Activities that predominantly demand labour during periods counter-cyclically to the cultivation of paddy and maize (i.e. community forestry and textile weaving) even benefit from a falling composite price of seasonal labour. Consequently, in the seasonal model the decline of aggregate output of forest products (0.5%) and textiles (2.3%) is substantially lower compared to the decline in the default model (2.2% and 5.1%, respectively).
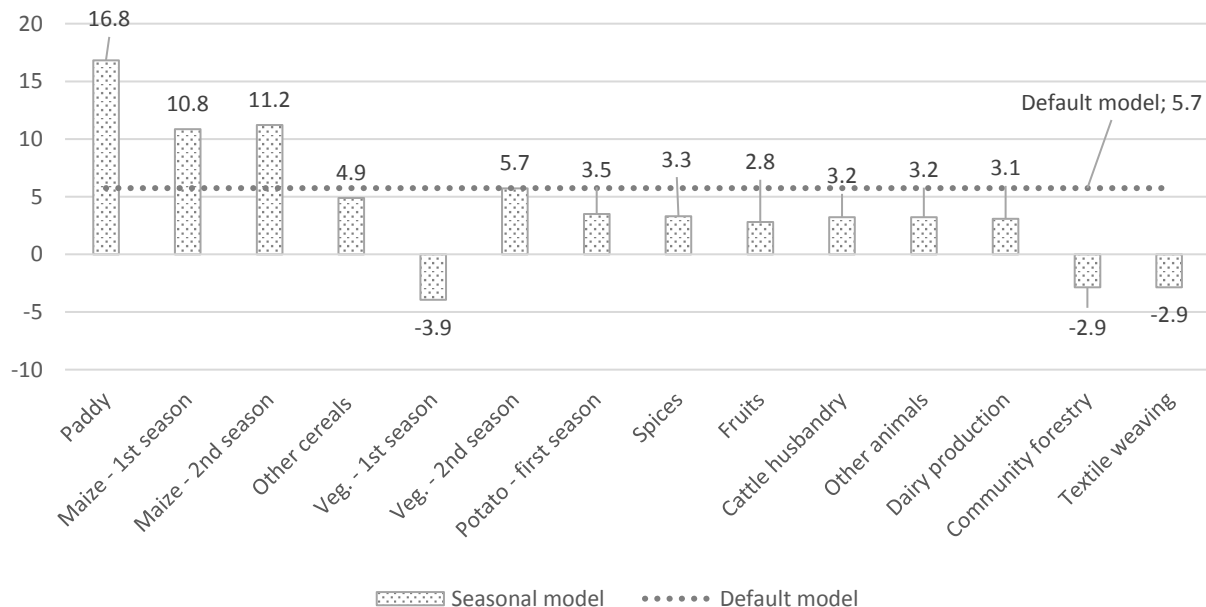

Figure 5 - Change in the activity specific composite price of seasonal labour within AEZ1

In the exemplary case of paddy, it is worthwhile to take a closer look at how the model differ in terms of factor use at the activity level across AEZs (Figure 6). The labour intensity of paddy

measured in person-days per acre increases across all AEZs in the default model, because land gets relatively more expensive as composite agricultural labour. This is quite the opposite for AEZ1 and AEZ2, because the price of aggregate seasonal labour increases at higher rates than land prices. Hence, seasonality is important to assess the actual determinants of changes in production, as for the largest share of Bhutanese farmers availability of labour is the actual production constraint.
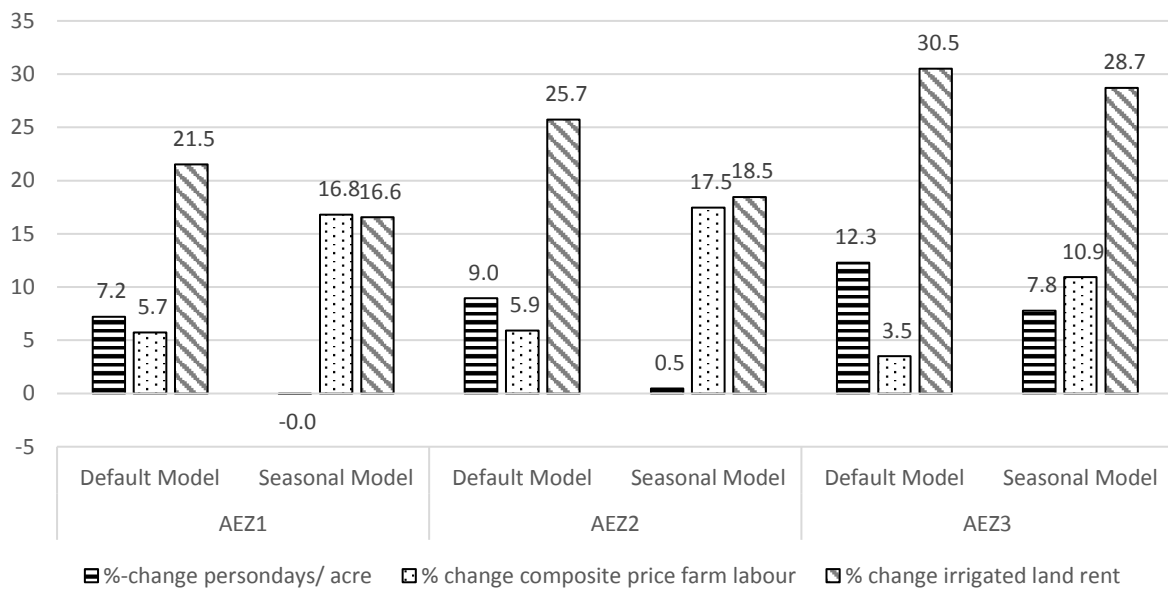

Figure 6 - Change in labour intensity, labour and land prices for paddy cultivation across agro-ecological zones (Source: Own simulation results)

Income of all farm household increases mostly due to higher labour wages and less because of increasing rents of irrigated land (Figure 7). In AEZ1, the decrease in income from rainfed land outweighs the increase in income from irrigated land. The value productivity of plots cultivated with vegetables, spices and fruits is substantially higher in all AEZs. However, in AEZ1 cereal yields are especially low, which is reflected as a low value productivity in the model and thus the income lost from the previous cultivation of rainfed land outweighs the increase in income from irrigated land. In the other two zones the difference in productivity is smaller and farm households have slightly higher income from aggregate land. Most of Bhutan's rice is produced in AEZ2 (42.1%) and as most irrigated land is owned by farmers in this zone, they benefit from

the highest household income. Because landless households receive a substantial share of income from non-agricultural labour, they do not benefit at equally from the increase in agricultural wages. Due to the generally lower supply response and lower increase in most factor prices, household income changes are generally lower in the seasonal model across all agricultural households.

1
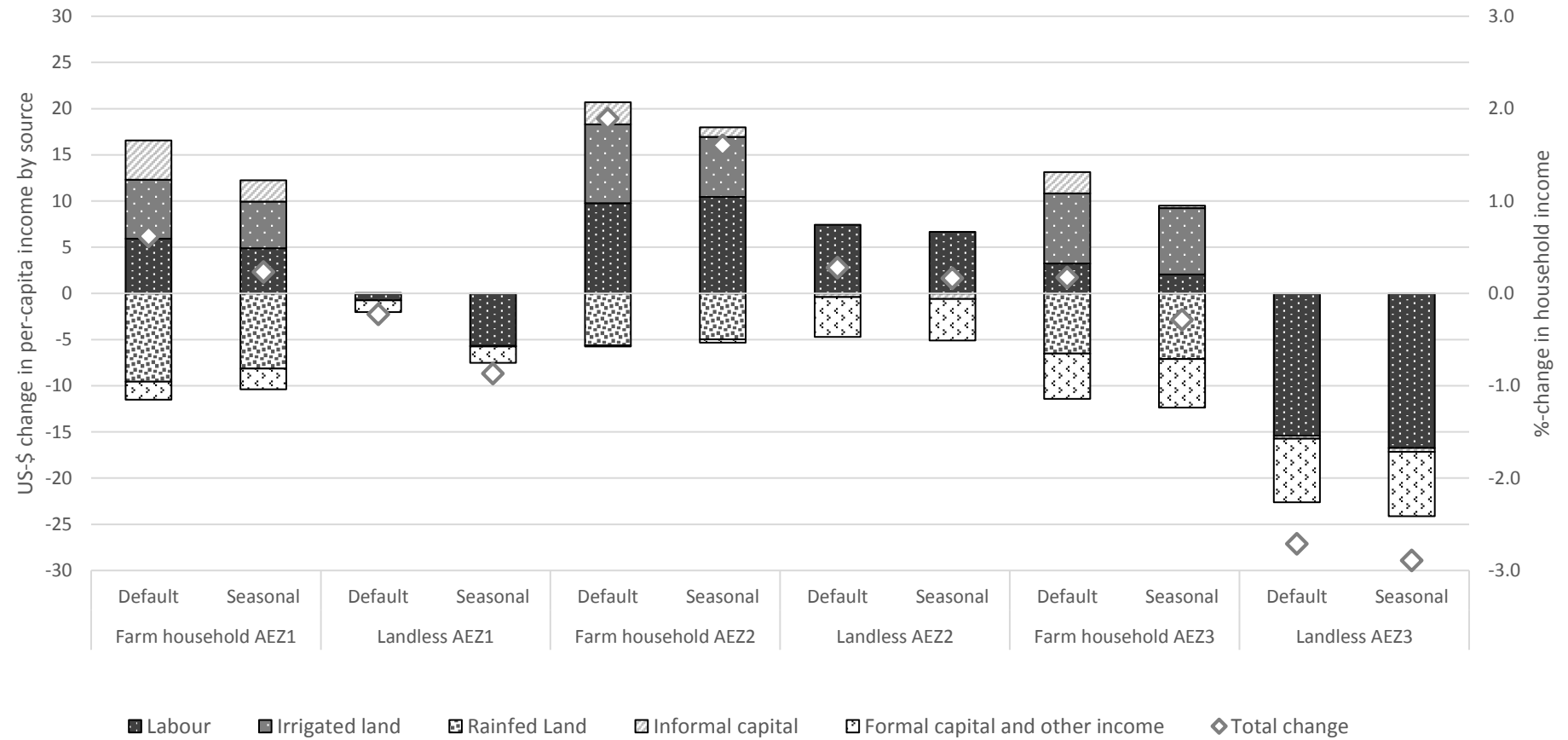
2

3   *Figure 7 - Changes of household income compared to base measured in terms of US-$ per capita and percentage of household income*

Measuring changes in welfare as the share of the equivalent variation (EV) over discretionary spending in the base (*DS0),* we can analyse welfare implications by differentiating between two components that measure the change in (1) purchasing power and (2) discretionary spending as shown in equation (11).

$$
\frac{EV_h}{DS0_h} = \underbrace{\prod_{ca}\left(\frac{PCA0_{ca,h}}{PCA_{ca,h}}\right)^{\beta_{ca,h}}}_{\text{(1) Change in purchasing power}} * \underbrace{(1+\alpha_h)}_{\text{(2) Change in discretionary spending}} - 1 \tag{11}
$$

where *h* denotes the set over all representative household groups, set *ca* identifies the aggregate commodity groups, *PCA0* and *PCA* is the aggregate purchaser price of the commodity group *ca* in the base and ex-post simulation, β is the marginal budget share and α_h is the change in discretionary spending. Results (Table 7) show that most households suffer from a decline in discretionary spending.

Table 7 - Welfare changes and its components

Representative household groups	% share of food expenditure	%-change in welfare (EV/DS0)		Change in purchasing power (Base = 1.000)		Change in discretionary spending (Base = 1.000)	
		Default Model	Seasonal Model	Default Model	Seasonal Model	Default Model	Seasonal Model
Skilled Households	33.3	-5.4	-5.4	1.024	1.025	0.924	0.923
Unskilled Households	45.2	-8.3	-8.4	1.014	1.015	0.904	0.902
Other Income Households	35.0	-6.4	-6.4	1.018	1.019	0.920	0.919
Farm AEZ1	50.5	-3.0	-3.6	0.993	0.997	0.977	0.967
Landless AEZ1	48.2	-3.8	-4.8	0.997	1.002	0.964	0.950
Farm AEZ2	50.4	0.5	0.1	0.993	0.996	1.012	1.005
Landless AEZ2	42.9	-1.1	-1.5	1.000	1.001	0.988	0.983
Farm AEZ3	43.7	-1.3	-2.2	1.006	1.009	0.981	0.969
Landless AEZ3	49.9	-8.6	-8.9	1.008	1.010	0.907	0.902

For non-agricultural households this is mostly due to falling household income. In contrast, agricultural households have largely experienced an increase in household income as reported in Figure 7. Yet, the increase in food prices results in higher expenditure needed for subsistence

consumption, which offsets the increase in household income resulting in a reduction of discretionary spending. Farm households in AEZ2 are again an exception, where the increase in household income still allows for discretionary spending to increase by 1.2% and 0.5% if seasonality is accounted for. Interestingly, most households benefit from an increase in purchasing power, which is the case when the purchasing power component is larger one. This can be explained by falling prices of non-food items which comprise a larger share of discretionary spending and whose marginal budget shares are consequently the highest. Farm households in AEZ1 and AEZ2 face a loss in power purchasing, which are those households spending most of their income on food and on cereals in particular.

Differences in the results of welfare changes can only be detected for agricultural households and farmers in AEZ2 are the only ones experiencing an increase in welfare according to both models, as they benefit from substantially higher factor income as explained previously. Differences in welfare changes are also much more pronounced for all remaining agricultural households, for whom the seasonal model reports much higher welfare losses. Converting the welfare changes in US-$ per capita as in Figure 8, the model differences become more illustrative. While in the default model farm households in AEZ3 suffer a welfare loss worth 4.0 USD per capita, this loss is 6.9 USD per capita according to the seasonal model. While it is problematic to aggregate welfare changes, it is nevertheless insightful that the absolute welfare loss per capita for agricultural households is valued 43.4% higher than under the default model. However, it also needs to be acknowledged that differences in welfare are marginal for non-agricultural households and that the implications of incorporating seasonality are largely relevant when analysing rural livelihoods.
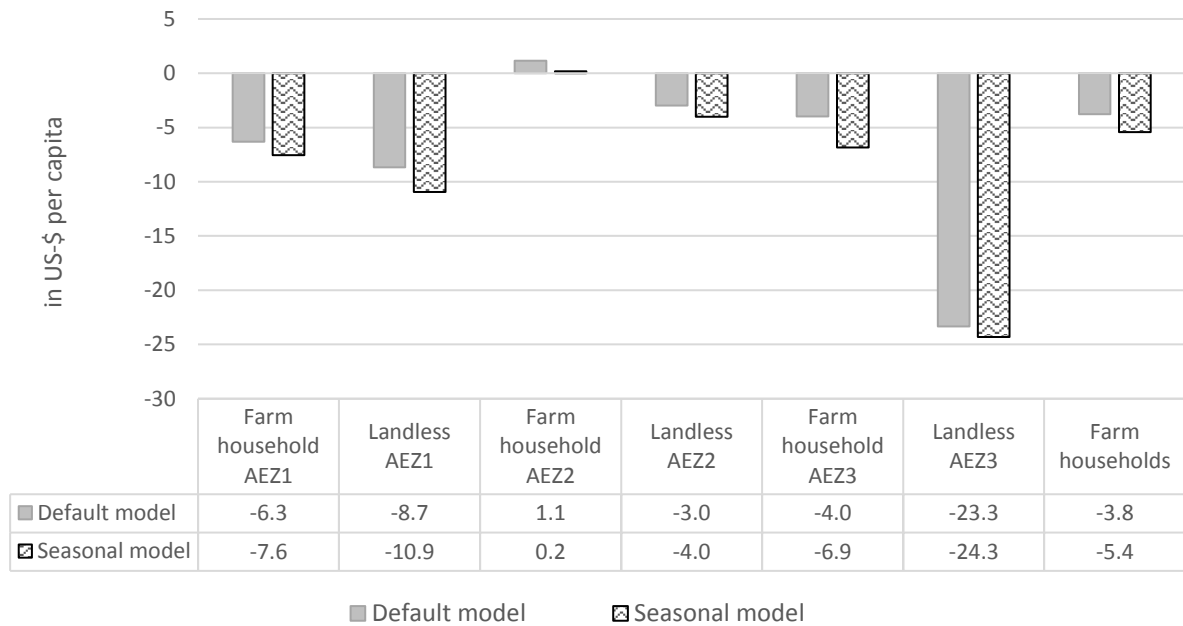
	Farm household AEZ1	Landless AEZ1	Farm household AEZ2	Landless AEZ2	Farm household AEZ3	Landless AEZ3	Farm households
■ Default model	-6.3	-8.7	1.1	-3.0	-4.0	-23.3	-3.8
⊠ Seasonal model	-7.6	-10.9	0.2	-4.0	-6.9	-24.3	-5.4

Figure 8 - Welfare changes from increased cereal import prices measured as equivalent variation (EV) in US-$ per capita

6. Discussion

Both models show that an asymmetric shock of higher cereal prices results in predominantly adverse impacts for non-farm households in Bhutan, which are all net-food consumers, while the livelihoods of farm households face less negative impacts or are even benefit from it. These results are in line with general findings of the literature on food-price impacts (Arndt *et al.*, 2008). Seasonality even seems to play a minor role as regards the macro-level model-outcomes, as counter-cyclical activities (i.e. textiles and forest products) with high export shares reduce output much less when seasonality is accounted for.

Seasonality especially matters when simulating the supply response of the agricultural sector, which is substantially overestimated when seasonal constraints are disregarded. Furthermore, the disaggregation of agricultural sector is important when analysing the role of seasonality, which follows different patterns in regions differentiated by agroclimate, farming systems or socio-economic characteristics. The low-altitude zone in Bhutan (AEZ1), is characterized by low cereal yields, labour intensive cultivation systems and a high share of subsistence

agriculture. As shown in Figure 1, this zone also has the most pronounced labour peak, which following the cereal price shock results in sever labour bottlenecks and a much lower supply flexibility compared to the other zones where seasonal patterns are less extreme. Hence, the magnitude at which seasonality matters for model outcomes seems highly dependent on region-specific seasonal labour calendars and the amount of "flexible" labour that can be allocated across periods (e.g. time used in forestry activities). This finding is important when conducting simulation modelling of rural labour markets that incorporate seasonality in other countries, as the agricultural sector particularly in tropical and developing countries is highly heterogeneous.

Another important finding is also that when seasonality is not accounted for, modellers could defer wrong conclusions as regards the actual constraint that limits the supply response. In the default model, the increase in land prices limits the paddy supply and a substantial increase in labour intensity for paddy cultivation is reported in all zones. In contrast, the high increases in seasonal wages lead to a stagnant or lower labour intensity in AEZ1 and AEZ2. Hence, both models would result into very different policy implications, as the former would highlight the need for investment in irrigation infrastructure while the latter would rather call for policies improving the labour productivity during peak labour periods.

The chosen approach and model structure is intended to be as generic as possible, yet still inhibits limitations that need to be addressed. The choice of lengths of periods is somewhat arbitrary and largely determined by data availability. For example, if an important agricultural operation such as paddy transplanting takes place at the end and beginning of two subsequent months, the monthly disaggregation is likely to overestimate the competition with other activities for labour in those months. Also our model does not include seasonal migration across zones or from non-farm to farm sectors. Accounts of seasonal migration within Bhutan are rare, probably due to the scattered and remote locations of villages. However, seasonal migration in other countries plays an important role during periods of labour shortage.

Unfortunately, no data was available to estimate how much labour is provided by the elderly and children. In case of the elderly, anecdotal evidence suggests that particularly they are predominantly involved in less intensive work such as crop guarding. Without knowing their current contribution to agriculture, it is not possible to reasonably gauge how much more labour these groups could provide. As we estimated the labour employed in agriculture using a bottom-up approach based on labour requirement per cultivated area, any labour supplied is reflected in the model such that we assume that the additional labour supply from these age groups is rather limited. Another factor that might be underestimated in our model is the role of labour supplied by children and the elderly. A dimension, which was not accounted for in our model structure, is the labour division by gender within agriculture. As seasonal wages increase at the highest rate during the transplanting periods, this would mostly benefit female labour who predominantly perform this operation. This is to be investigated by future research as the available data did not allow to disaggregate seasonal labour by gender.

Our model allows for some flexibility in seasonal labour demand setting the elasticity of substitution across periods at a minimum of 0.1. This means, that to a certain degree labour needed for transplanting can be substituted by labour supplied in other periods, e.g. harvesting or weeding. Certainly, farmers can compensate for less labour provided in one period by contributing more labour in others, yet there is an inherent risk to allow for unrealistic substitution. Therefore, more sophisticated setups could be developed that would allow for activities to systematically shift the timing of operations. Future research in this field could also address the role of sequential decision making in a dynamic recursive framework, which however would have much higher data requirements such as data on seasonal consumption.

7. Conclusion

Our results show that the depiction of seasonal labour results in important differences when modelling the supply response of the agricultural sector towards increasing cereal prices.

Seasonal bottlenecks in which labour supply is constrained by the physically available labour force within a certain time period are pivotal and need to be accounted for when simulating large shocks to the agricultural sector, which result in increasing agricultural production. By the same token, activities that have a counter-cyclical pattern of labour demand experience lower competitive pressure for their factor inputs and thus reduce output by a much lower extent. These findings are relevant for largest share of developing countries where most of the labour force is employed in the agricultural sector. The incorporation of seasonal labour also has implications for policymakers and modellers that use economy-wide models like CGE models to inform the former on past or future policy interventions. Economies are complex systems not only as regards their interaction with other systems but also within the economy. Simplistic representations of apparently complex rural labour markets maybe owed to data paucity. This study has, however, shown that seasonality matters for model outcomes and that extending a model to incorporate seasonal labour is worthwhile.

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