Rubber Price Drop, Smallholder Livelihood Effects, and Adaptation Measures in Sumatra

Master Thesis

University of Göttingen

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20 weeks thesis as part of the Development Economics degree
at the University of Göttingen

Submitted on 31. January 2017

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From Berlin

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1. Introduction

Farmer is still the number one profession in the world. 2.6 billion people were estimated to be engaged in agriculture in 2014 (IAASTD 2014) either as independent farmers or as employed labourers. While the share of the world population working in agriculture has been falling over the course of the last two centuries, their absolute number has actually increased in the last decades. This can be attributed to overall population growth, which is highest in some of the poorest regions of the world, notably in rural regions where the vast majority of people depend on agriculture to make a living. About 70 percent of the world's poor are rural and thus mostly depend on agriculture.

Most farms are small or very small. Worldwide, farms of less than one hectare account for 72 percent of all farms and another 12 percent of farms are smaller than two hectares. Population growth leads to further fragmentation of land holdings, increasing the challenge of land scarcity. The size of arable land per capita was twice as high in 1961 as in 2013 (World Bank 2016) and in the future, arable land will become increasingly scarce due to soil degradation and desertification. Climate change adds to the problem through more frequent incidences of extreme weather events increasing agricultural risk.

Smallholder farmers have limited resources and capacities to mitigate shocks. Any reductions in agricultural production and any output price falls are likely to have a significant negative impact on income and consumption and thereby on food security and well-being (e.g. Harvey et al. 2014). The estimated one billion (ILO 2014) of people employed as agricultural workforce are also often precariously employed and their income insecurity facing shocks is similarly high as for smallholder farmers.

The worldwide opening of markets together with improvements in transport and communication systems as well as overall economic growth have integrated a large share of smallholder farmers into markets. A high number of people engaged in subsistence farming or for the local market now produces "cash crops" for the world market. For many farmers, the market integration brought opportunities to generate a higher economic value. At the same time, while smallholders have already faced high risks before, global market fluctuations now add to the existing risks. Farmers have mostly no means to foresee the price development for their product on the global market and are regularly hit unpreparedly by grave price shocks. Indeed, many poverty crises of the last century were caused by such price shocks, e.g. the coffee crisis in the 1990s.

Ways to cope with shocks are manifold: rural-to-urban migration is an important trend for income diversification, for example (Giesbert 2007). Microfinance is seen by many as another way to reduce the impact of income volatility, even though it has received many critical comments in the last years (e.g. Stewart et al. 2010). The purchase and sale of durable assets or livestock is another way in which farmers engage in income smoothing (e.g. Lybbert et al. 2004). A challenge to all these types of coping mechanisms is that shocks faced by smallholders are often not idiosyncratic. Extreme weather events usually affect all farmers in a region, so that the social insurance net often does not work. Also, it has been found that prices for assets such as livestock fall in the presence of an income crisis as too many farmers want to sell their assets at the same time (e.g. Bussolo et al. 2007).

The degree of farmers' resilience to shocks differs among farmers according to their characteristics. Wealthier farmers can sell assets or livestock and have a better chance to get credit. Depending on the location, farmers have different options to generate off-farm income through working as wage labour or by small entrepreneurial activities. Access to new land for expanding the cultivated area or for switching to the cultivation of other crops also differs among farmers. Even within the same region, farmers' land rights can differ depending on their status and ethnicity, among other factors (Krishna et al. 2014). Farmers not being able to mitigate the income shock most likely have to translate the income fall into an uncontrolled consumption fall.

This makes smallholder farmers' vulnerability to agricultural shocks as well as market shocks a core problem in the global struggle to overcome extreme poverty and food insecurity. The enormous importance of smallholder agriculture in the world for understanding the dynamics of poverty and food insecurity in general has contributed to creating a firm scientific interest in the topic. In the next section, existing literature on how smallholder farmers are affected by income shocks and how they cope with them will be reviewed.

Afterwards, the study location and thematic background will be introduced. It will be shown that the lowlands in the province of Jambi on the Indonesian island of Sumatra are an ideal study location to analyse the effects of a commodity price fall. Nearly all farmers cultivate either rubber, oil palm or both of these crops. While the price for rubber has fallen significantly in the last years, the price for palm oil has remained more stable, yet having decreased slightly. This gives an ideal framework for the comparison between the different groups of farmers.

The data used for the analysis will be described in the next section followed by a section introducing the way household incomes are calculated and the methodology and hypotheses used in the remainder. The subsequent four sections will present the results of empirical analyses of the developed hypotheses, followed by a discussion on the results and possible policy recommendations. A last section concludes.

2. Literature review

There exist a considerable number of studies that analyse in some way the effect of falling prices and other income shocks on smallholder farmers. Following Harrower and Hoddinott (2005), two strands of literature exist on the extent to which households in developing countries[1] can protect themselves against adverse events. The first focuses on the extent of insurance against shocks. Economic theory suggests that households with concave utility functions, that means, decreasing marginal returns to consumption, prefer stable over volatile consumption paths. If households

[1] In the following, the term “developing countries” will be used to refer to countries which are on the DAC list published by the OECD. This is despite acknowledging that the term is criticized by many including the author of these lines due to its rigid classification of countries in either developed or less developed and due to the single path of development the term implies. For an introduction to the debate around this term and its alternatives, see World Bank (2015). The term is used nevertheless accepting the fact that most scholars use this or other similar terms to distinguish between richer and poorer countries.

have access to perfect credit and insurance markets, idiosyncratic shocks on households' incomes should have no effect on consumption. Only covariate shocks decreasing aggregate income are expected to have an effect on household consumption (e.g. Mace 1991).

A second strand of literature focuses on the ex ante mechanisms households apply to reduce the likelihood of the occurrence of negative shocks and the ex post mitigation mechanisms to deal with shocks. A number of studies discussing different coping mechanisms will be reviewed in the following paragraphs.

2.1 Overview

To get an understanding for the existing evidence on income shocks' effects on smallholder farmers' livelihoods and coping strategies, the specific setting of each study has to be taken into consideration. Many studies focus on the effect of food price changes for farmers who are producers and consumers of a food crop. Harvey et al. (2014), for instance, conducted a survey among 600 smallholder farmers in rural Madagascar in order to analyse the effects of agricultural shocks on households' livelihoods and food security. Their findings of significant increases in food insecurity following extreme weather events provide an example for how smallholder farmers suffer from the tremendous risks they face. Still, this evidence tells us only very little about the vulnerability of rubber and oil palm farmers as the latter produce crops exclusively for selling them for further processing and hence do not depend directly on their harvest in order to obtain food. However, their food security indirectly also hinges on generating sufficient income from crop production making agricultural shocks due to extreme weather events and market shocks due to price decrease equivalent in this sense. Fighting hunger is not only about increasing food production and availability. As Amartya Sen (1997) puts it:

> "Hunger is primarily a problem of general poverty and of deprivation of food entitlement and adequate health and social care."

In the Madagascar study, households did not only react by eating less and purchasing more from the market, but were also found to react by engaging in wage labour or by borrowing money to buy food, both being viable options also in the face of a market shock. Since agricultural shocks, such as extreme weather events, very often affect all or almost all crops, food insecurity could increase also for those farmers not directly depending on food production.

Many studies deal with farmers cultivating coffee and especially in times of low prices, interest in coffee smallholders' livelihoods is high. Notably in the wake of the coffee crisis which roughly spanned from 1998 to 2004, when the coffee price fell drastically, not only researchers became concerned about the fate of smallholder farmers and in this time, certification schemes like Fairtrade gained popularity by promising to assure farmers stable minimum prices.

Coffee cultivation shares important economic characteristics with both rubber and oil palm cultivation: firstly, it is a "cash crop" which is mostly cultivated for exportation and whose price heavily depends on world markets. Secondly, it is a tree crop so that it takes some years for a plant to mature and become productive making it more difficult for farmers to change crops rapidly. And thirdly, farmers do not consume any of their harvest themselves: rubber is not a food crop. In addition, rubber and oil palm have virtually no use before processing with heavy machinery farmers do not possess. Coffee is consumed in little quantities by farmers, but certainly it does not play any role for farmers' nutrition.

2.2 Coping with price decrease: Evidence from coffee farmers

Among studies analysing the effects of income shocks on coffee farmers, Christiaensen et al. (2006) stand out as the authors simultaneously analyse the welfare effects of health shocks, weather shocks and price shocks. In a huge sample of Tanzanian farmers, farmers cultivating different crops can be distinguished. Prices for coffee and cashew dropped considerably between the two survey rounds whereas prices for other products remained more stable. Dummies indicating whether or not a household belongs to different quintiles of coffee and cashew farmers proxy effects of a price shock. Moreover, the number of coffee trees is taken as a variable to estimate how much a household was exposed to the coffee price shock.

Household expenditure is taken as the welfare measure excluding expenditure for health, education and social functions such as baptisms and funerals and is regressed on dummy variables indicating whether or not a household was exposed to one of different types of shocks including health and weather shocks as well as control variables. Expenditure for health is excluded because if a health shock occurs in a household, health expenditure rises two- to threefold. As it is impossible to distinguish between shock-related and preventive health expenditure, the data is excluded to avoid a downward bias in the estimated coefficient of the welfare effect of health shocks.

In one of the two study regions, drought and health shocks seem not to have affected average household consumption significantly, mostly because there hardly is a health system to spend money on. In the other region, households were found to have been able to compensate more than half of the loss due to health and rainfall shocks through use of one's own savings or reliance on aid from family and neighbours. Households were better able to cope with health shocks than with rainfall shocks. As the rapid decline in coffee prices came at the heels of a coffee price hike, the better off coffee farmers seem to have been able to invest the windfall spending successfully, e.g. by switching to banana production. As rubber prices also reached a historical high before falling to the current level, similar effects might be observable in our sample.

Interpreting the coefficients of the variables telling whether or not a household cultivates e.g. coffee or cashew may produce two potential biases: first, taking the effect of being a coffee farmer as identical to the effect of the price drop implicitly assumes that coffee farmers and non-coffee farmers are equivalent concerning all other characteristics. This can be controlled for, e.g. with a Fixed Effects model which rules out all time-invariant heterogeneity across a sample. Second, if the overall economic activity in the region declines due to the price shock, the direct effect is likely to be underestimated.

Bussolo et al. (2007) analyse the effect of a coffee market liberalisation in Uganda in the beginning of the 1990s. The liberalisation led to a stark increase in the price received by Ugandan coffee farmers but after some years, world coffee prices fell so that authors could compare cross-section survey data from high price as well as low price periods. They find that the coffee boom led to more farmers cultivating coffee. Later, income earned from crops other than coffee compensated for the losses incurred from falling coffee prices. While the coffee price increased, the income from non-agricultural activities also rose in coffee-cultivating regions for coffee farmers and other households alike, yet, income growth for poorer households stemmed mostly from increased crop income. When the coffee prices fell, income gains from the boom period seemed to persist. The value of owned cattle decreased for coffee farmers when the coffee price fell, but increased for other farmers. The value of cattle fell most pronouncedly for more specialized coffee farmers, but the poorest farmers did not sell cattle.

Ha and Shively (2008) asked Vietnamese coffee farmers how they reacted to falling prices. The most common response was to fertilise coffee trees less. Larger farmers reduced inputs significantly more. Poorer and ethnic minority households appear to have had fewer opportunities to enhance liquidity requiring some of them to adjust to price changes by changing land use. Overall, bigger farmers responded less to reduced coffee prices, possibly because their livelihoods relied less on coffee compared with smaller farmers, enabling them to reduce inputs or change crops. Assuming that applying fertiliser increases yields and revenues, it can be regarded as a “poverty trap” when the smallest farmers have to reduce inputs out of a short-term pressure to reduce costs but thereby lose income in the long run.

Adhvaryu et al. (2013) test whether small enterprises form a strategy to cope with agricultural shocks. They use a panel from World Bank data from Tanzania. Business as a coping strategy can be applied both at the extensive margin (opening or closing a business) as well as at the intensive margin (investment in an existing business). First, they find that a drop in coffee prices lowers coffee growers' revenues and expenditure. It has no effects on coffee supply, yet, it does have an effect on the probability of running an own business. There is evidence for countercyclical behaviour in the sense that farmers open businesses when the coffee price is low and shut them when the coffee price is high. Labour inputs and revenues increase in times of price booms for those entrepreneurs who run their business in good and bad times.

Kruger (2007) investigates the effect of coffee price changes on child labour. She found that the hours worked by young boys increased with the coffee price as a higher price means higher returns to child labour. While in the long run, prospering households tend not to use their children as workforce, effects of a temporary income shock seem to be different to the effects of a permanent income shock. Kruger's findings are in line with a range of other studies, i.e. the substitution effect dominates the income effect as regards to the question whether higher returns to agriculture have effects on child labour.

Tucker et al. (2010) find access to land to be an important determinant of the possibilities coffee farmers have in reacting to the coffee crisis. Farmers in Honduras had more access to fallow and forest land than those in Mexico and Guatemala, and could thus expand their plantations or cultivate different crops without having to give up their coffee trees. Farmers in Guatemala and Mexico were more likely to reduce inputs with nearly a third of farmers in both countries having reduced multiple inputs during the coffee crisis. As the households were just asked once retrospectively and as sample sizes are very small, the explanatory power of this study is rather limited, however.

Another strand of literature analyses the effects of participation in certification schemes on farmers' welfare. While for ecological certification schemes, farmers just receive a bonus on their output prices, Fairtrade also decreases farmers' exposedness to price fluctuations by guaranteeing a minimum price. It can therefore be illuminating to look at the literature on the effects of Fairtrade certification, even though it is hardly ever possible to isolate the effect of insurance against negative income shocks from the other benefits that certification has for farmers.

Becchetti and Constantino (2008) assess the effects of Fairtrade certification on affiliated farmers. Essentially, affiliated farmers report higher price satisfaction than non-certified farmers and improved food consumption. Yet, it is not controlled for whether these findings can be attributed to the fact of not being exposed to the negative coffee price shock. One problem related to the effectiveness of being a member of such a certification scheme is that farmers may not sell their entire harvest through Fairtrade channels. Valkila and Nygren (2009) find that Nicaraguan coffee cooperatives in their sample could only sell between 30 and 60 percent of their harvest through Fairtrade channels. Beuchelt and Zeller (2011) find significant advantages of being affiliated with Fairtrade in terms of poverty reduction, but also point out that farmers are forced to sell big shares of their harvest on the spot market without benefitting from the Fairtrade price premium. The evidence shows that Fairtrade certification can have positive effects on farmers' livelihoods and it is likely that part of these positive effects are due to the minimum price providing farmers an insurance against extreme price risks.

It is important to keep in mind that higher prices do not automatically coincide with higher welfare for all. Miller and Ordinola (2010) find evidence that higher output prices can also have negative consequences as there appears to be a pro-cyclical pattern between child mortality and coffee prices. This is because especially women in farm households work more hours when coffee prices are high and thus invest less time in child healthcare.

2.3 Coping with agricultural shocks

As discussed above, while market shocks differ from agricultural shocks especially for food crops, strategies to cope with the fallen income can be applied similarly in both cases. Selected evidence on the way farmers coped with non-market shocks is summarized in the following paragraphs.

Paxson (1992) investigate whether farm households applied saving and dissaving as a strategy in response to unexpected income shocks from extreme rainfall patterns.

Using socio-economic surveys from Thailand, he finds that while farmers save a positive share of permanent income, propensity to save out of temporary income is higher. Higher savings accumulated in times of higher income are used to buffer consumption from negative rainfall shocks.

Kochar (1999) analyses how Indian farmers' hours spent working on the labour market develop in response to household-specific shocks in crop income. Results indicate that Indian farmers can smooth their income considerably by working in the labour market. However, this finding may not be valid for other countries alike as India has a big agricultural labour market. Also, it is likely that this way of coping with a shock is not similarly effective for covariate shocks as demand for labour would decrease as well.

Debebe (2010) assesses whether crop shocks make farm households use more child labour, hypothesising that child labour forms a buffer in times of income shocks. Different agricultural shocks in fact have a significant increasing effect on child labour in the subsequent period. Membership in a labour sharing arrangement does not affect child labour in normal times; it does affect it in the presence of shocks, however.

Beegle et al. (2006) use panel data from rural Tanzania to examine the relationship between household income shocks and child labour. They find that crop shocks lead to a significant increase in the hours worked by children, and that households with assets can offset around 80 percent of this shock. Poorer households use the assets as a buffer stock while richer households do not have to do so as they have better access to credit. The data include reports of the value of crop loss due to insects, rodents, and other calamities.

Guarcello et al. (2010) add more to the story told by Beegle et al. (2006): they consider both the effects of shocks and of credit rationing on both, child labour and schooling. The latter two are not treated as mutually exclusive as there are many children who work as labour and attend school or do neither of both. As a shock variable they use a dummy indicating whether or not a household was hit by a number of pre-specified covariate or idiosyncratic shocks. Exposure to negative shocks is seen to increase child labour while access to coping mechanisms such as insurance reduces it. Children belonging to households where at least one member is covered by health insurance are about five percentage points less likely to work. Children of credit rationed households have a seven percent lower probability to attend school.

A number of studies were conducted to test for so-called poverty traps. A poverty trap is any self-reinforcing mechanism that hinders households to overcome poverty. It implies that (mostly asset-) poor households lack the possibility to invest in a way that would help them to get out of poverty. Giesbert and Schindler (2009) use representative panel data from Mozambique. They use an asset-based approach to poverty to identify poverty traps and analyse the ways households cope with a drought shock. Findings indicate that households at different points in the wealth distribution apply different shock coping strategies. Wealthier households react to shocks with the sale of assets while poorer households have few other options than reducing consumption.

Microfinance schemes are commonly promoted as a means to overcome poverty traps. Doocy (2005) finds no significant difference in capacities of Ethiopian farmers to cope with drought between those farmers being clients of a micro-credit scheme and others. Coping capacities only cover ex post coping strategies. However, there is evidence that clients were better able to use ex ante strategies, i.e. they showed a more diversified income. Also, the study showed that participation in micro-credit had an important impact on nutritional status and well-being of female clients and their families. Mobarak and Rosenzweig (2012) assess whether a formal rainfall insurance scheme crowds out informal risk-sharing. They find that this is only the case where informal risk-sharing covers aggregate risk which often is not the case.

So far, the literature review focused on studies dealing with how farmers reacted to shocks in order to maintain their income and prevent them from having to cut down consumption. It is worth it to shortly address studies dealing with consumption reactions to income shocks.

Harrower and Hoddinott (2005) regress consumption expenditure on a set of village dummies indicating the occurrence of an idiosyncratic shock, dummies for different household-level shock and household characteristics. It is found that idiosyncratic shocks have little effect on consumption, while covariate shocks do. This is evidence for the existence of some form of informal risk-sharing that prevents households from consumption poverty. The authors also estimate the effects of different idiosyncratic shocks on the probability to adopt certain coping mechanisms: a loss of crops due to insect infestation is found to increase the probability of out-migration and, among poor households, to induce remittance flows. Idiosyncratic shocks related to illness do not induce any action. Loss of livestock also increases the probability of out-migration as well as the likelihood of having positive livestock sales and of reporting food aid from friends and family. Asset non-poor households were more likely to enter into new activities as a response to income shocks. Asset-poor households were more likely to alter food consumption by consuming less preferred food and by reducing portions, particularly given shocks related to lost crops or illness. This does not indicate that poor households had no opportunity to diversify income, whatsoever. Indeed, poor households are found to generate income from a variety of sources in good and in bad times whereas non-poor households increase off-farm income after negative farm income shocks. They seem to be better able to allocate their labour towards the most beneficial activities and to be more flexible for times of economic downturn.

Dercon (2004) uses Solow’s growth model with household level panel data from rural Ethiopia. Specifically, he wants to test for persistent effects of shocks on the steady state household level welfare. He takes food consumption as the outcome variable, yet to control for the possibility that it is relative price effects that drive a diversion from food to non-food consumption, a subsample for which total expenditure data was available was analysed as well. He uses lags of food consumption and shock variables to estimate the growth in food consumption. Results show that groups which suffered substantially during the big famine of the 1980s showed markedly lower consumption growth rates in the 1990s.

Skoufias et al. (2012) use cross-section data from Indonesia asking how delayed rainfall or exceptionally low rainfall affects household expenditure. They also look at the mitigating effect of a selection of social programmes using propensity score matching to avoid endogeneity. A late monsoon onset has a negative but statistically insignificant effect on consumption. A low amount of rainfall is found to have a negative and significant effect. In both cases, effects on food expenditure are particularly drastic. This is not the case for rice farmers who are found to be more food-secure. Access to credit and public works projects can help households to cope with shocks.

Table 1 gives an overview of different coping strategies. Strategies are classified in ex-ante and ex-post strategies, in whether they can be used in response to an idiosyncratic or a covariate shock, on which factors their suitability depends and which publications provide evidence on the respective strategy. Living from remittances and transfers is not included in the list as it can help a household to cope with a shock, but a household can hardly influence whether he can receive substantial remittances or transfers or not except from motivating household members to migrate in order to receive a higher income. Institutions on which smallholder farmers only have minimal influence, such as large cooperatives with a considerable market power or minimum prices set by the government, are also not listed here. Also, reducing consumption is not included, as the way coping is interpreted here is avoiding a consumption drop and it goes beyond the scope of this thesis to address in detail the topic on how consumption decisions are altered in reaction to an income shock.

Table 1: Strategies for coping with income shocks

Strategy	Ex ante/ex post	Idiosyncratic/covariate	Depending on	Literature
Saving/dissaving	Ex ante	Both	Presence of saving facilities, absence of social pressures to spend windfall income, absence of high inflation	Christiaensen et al. (2006) Paxson (1992)
Buying/selling assets	Ex ante	Both, but better for idiosyncratic, because asset prices might fall in times of crisis	Protection against theft and expropriation / property rights	Bussolo et al. (2007) Beegle et al. (2006) Giesbert and Schindler (2009)
Informal insurance	Ex ante	Mostly idiosyncratic	High social capital and mutual trust	Christiaensen et al. (2006) Mobarak and Rosenzweig (2012)
Formal insurance	Ex ante	Mostly idiosyncratic, potentially both	Existence of insurance schemes, reliability of insurance schemes	Mobarak and Rosenzweig (2012)
Migration	Both	Both	Ease of financial transfers, labour opportunities (mostly in urban centres)	Harrower and Hoddinott (2005)
Employment	Both	Both, but better for idiosyncratic	Availability of employment opportunities, general economic situation	Kruger (2007) Kochar (1999) Skoufias et al. (2012)
Business	Ex ante	Idiosyncratic	Initial capital, skills, property rights, rule of law	Adhvaryu et al. (2013)
Crop diversification	Ex ante	Both	Know-how and availability of inputs and marketing schemes for various crops	Christiaensen et al. (2006) Bussolo et al. (2006) Ha and Shively (2008)
Expanding farm size	Both	Both	Access to land, property rights, capital to invest	Tucker et al. (2010)
Reducing inputs	Ex post	Both	Having applied inputs before	Ha and Shively (2008) Tucker et al. (2010)
Taking credit	Ex post	Both, but better for idiosyncratic	Availability of credit, assets as security	Beegle et al. (2006) Skoufias et al. (2012)

3. Study location and background

3.1 Study location

Jambi province is situated in the East of Sumatra, the biggest island in the Indonesian archipelago. In terms of gross regional product (GRP) per capita, Jambi ranked seventh among Indonesia's 34 provinces in 2015, with a GRP per capita of 46,004,120 Rupiah (3277 Euro in today's prices) which was roughly equal to Indonesia's GDP per capita of 42,432,080 Rupiah (BPS 2016b). In 2015, Jambi had a Human Development Index (HDI) of 0.689 and ranked sixteenth among all Indonesian provinces. The climate in Jambi's lowlands is tropical humid with two peak rainy seasons around March and December and a dryer period during July and August (Drescher et al. 2016). Jambi has a long tradition of agroforestry and the extraction of timber- and non-timber products from rainforests. The plantation economy became dominant around the beginning of the 20th Century. Chinese traders introduced the rubber tree (Hevea Brasiliensis) to the Sultanate of Jambi in the last years of the 19th century. After the Dutch brought Jambi under their control, the colonial administration forced Jambinese people to establish considerable rubber plantations (Locher-Scholten 2004, Kopp et al. 2014).

After the majority of forest land has been brought under the control of the central government, the first large logging concessions were issued in the 1970s. In the aftermath, large parcels of land were dedicated to large-scale rubber and, increasingly, oil palm (Elaeeis Guineensis) cultivation. Between 1967 and 2007, roughly 400,000 people were resettled to Jambi in the frame of the central government's Transmigration programme (Drescher et al. 2016). The Transmigration programme was a measure of the Indonesian government to motivate people from densely populated Java to migrate to less populated islands. The government established large oil-palm plantations where most of the area was managed by smallholder farmers. After an initial period, smallholders were given full property rights over the parcel they managed. Households were also often given a house and financial support in the beginning. For more details on the Transmigration programme, see McCarthy (2010).

Today, the province is the third largest producer of rubber and the fourth largest producer of crude palm oil in Indonesia (Schwarze et al. 2015). In contrast to oil palm cultivation, the primary production mode for rubber is smallholder agriculture because of its labour intensity. In 2011, 250,000 Jambinese households (roughly one million people) out of 619,000 depended on rubber cultivation (Kopp et al. 2014). Smallholder-managed land is making up the largest share of agriculturally used land in the province. About half of the workforce in Jambi is employed in agriculture (Clough et al. 2016). Generally, oil palm cultivation is comparably capital-intensive as the use of fertiliser and herbicides is higher than for rubber. Rubber is comparably labour-intensive as rubber trees are tapped every two to three days on average with some farmers even tapping every day, for instance in an attempt to get most out of old trees that will be replanted anyway. Therefore, labour-scarce households often adopted oil palm (Euler 2015).

Martini et al. (2010) suggest a mixed portfolio of oil palm and rubber for smallholders to minimise risk and to achieve an income growth that can hold step with incomes from unskilled urban labour. Despite the rapid growth of the palm oil sector, rubber remains the most important crop in ensuring the livelihoods for millions of smallholder families in Jambi (Kopp and Brümmer 2015). Still, many oil palm farmers are contract farmers who are part of a big plantation controlled by a company. Cahyadi and Waibel (2016) find that farmers in a contract scheme are less affected by a negative oil palm price shock while being similarly affected by an output shock.

The increase and intensification of rubber and oil palm cultivation in Jambi has had significant effects on forest cover. While intensively managed rubber and oil palm plantations help millions of smallholder households to generate their income, the conversion of forest to plantations brings significant environmental problems. Biodiversity in rubber and oil palm plantations is much lower than in forest areas. This is particularly worsening as Indonesia is considered a biodiversity hotspot with an outstanding species richness and endemism. Figure 1 shows how the land cover of Jambi province developed between 1990 and 2013. While in 1990, still about half of the province's area was covered by forest, this share fell drastically over the following years. Unsustainable farming practises have led to more degraded land area. Agriculture and tree crops expanded at the expense of forest coverage.

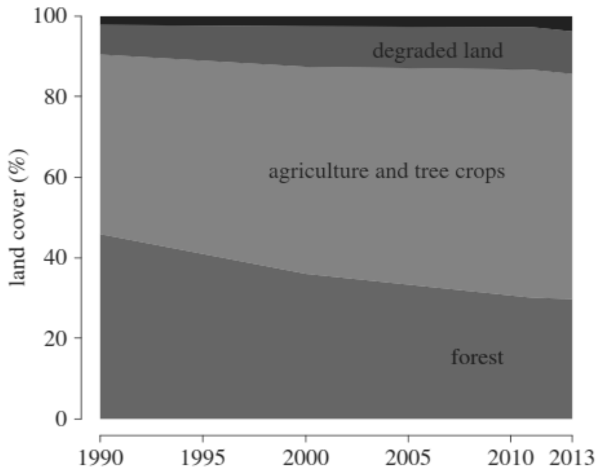

Figure 1: Development of land cover in Jambi, from Clough et al. (2016)

“Jungle rubber” refers to a system of intercropping rubber with other plants and refraining from the use of herbicides to clear the natural flora. With regard to biodiversity and other environmental functions such as carbon stock, jungle rubber performs worse than natural forest, but better than monocultures. It can be seen as a compromise between socioeconomic and environmental functions of and has been the dominant form of land use in Jambi, but has mostly been replaced by rubber monocultures. The graph, taken from Clough et al. (2016), provides a comparison of different forms of land use with regard to their ecological and economical functions.

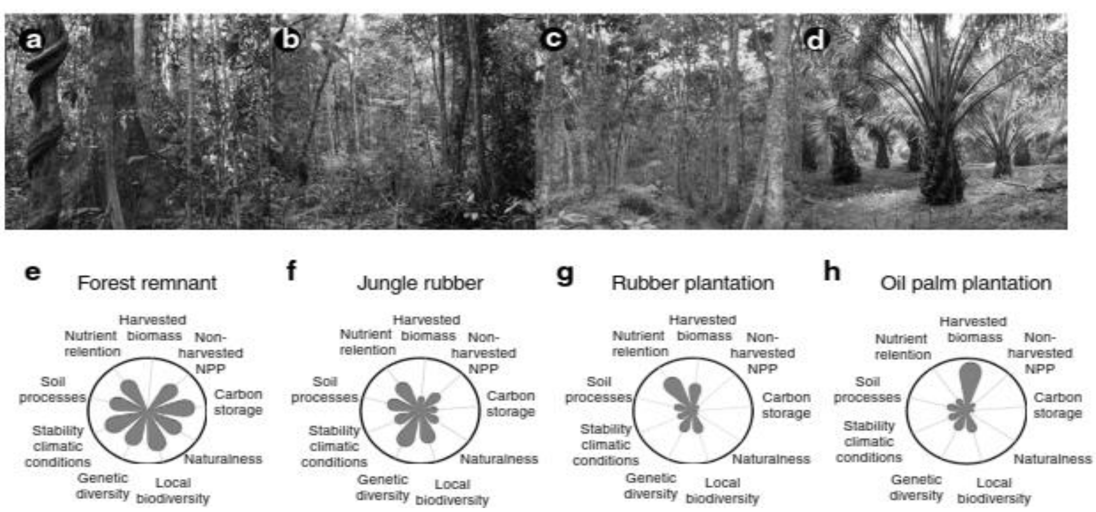

Figure 2: Ecological and economic functions of different land use systems, from Clough et al. (2016)

Land conversion in Indonesia, both from forest to agricultural land as well as well as the replacement of old and unproductive plantations is very often done through burning (see e.g. Stolle et al. 2003). Large-scale fires, mostly started on purpose, but often getting out of control, constitute an immense environmental problem in Indonesia not only through the damage done and lost environmental functions of burned forest, but also endangering human health in the region and contributing to global climate change through greenhouse gas emissions. During our field research in 2015, Indonesia faced (and caused) one of the worst "haze"[2] crises in the last years, advantaged by the long dry period due to the El Niño phenomenon. In October 2015, Indonesia's daily CO2 emissions exceeded the United States' (World Bank 2016). The author of these lines can tell from personal experience that the entire study site was deprived from sunlight for about two months in the dry period of 2015 and media reports point at the "haze" having darkened the skies of big parts of Indonesia, Malaysia and Singapore. In Jambi, as in many other provinces, the air and sky were filled with yellowish-grey dust for weeks letting some locals refer to the condition as a third season: while the climate is shaped naturally by dry and rainy season (musim kering and musim hujan), in many years, there is an additional "hazy season" (musim asap). New research estimates that the fires of 2015 alone have caused around 100,000 premature deaths (BBC 2016).

3.2 The rubber market

In the last years, increasing demand for rubber has led to an increase in the area dedicated to rubber cultivation worldwide. The recent economic downturn and lower growth rates in China, which accounts for 40 percent of global demand for natural rubber, have lowered demand nevertheless. As rubber trees need about six to seven years to become productive and some more years to reach their maximum output, the supply response to demand developments is lagged by some years and many rubber

[2] Actually, it is rather smoke than just haze which is emitted by the forest fires. Yet, the term "haze" or its Indonesian equivalent "asap" is the common way to refer to these emissions.

plantations became productive recently, in times of low economic growth. At the same time, the price for petroleum has fallen. Natural rubber can be substituted by synthetic rubber in some applications and the latter is made out of petroleum. The lion’s share of the world’s natural rubber production is used for tyres where the composition can be varied in a way that natural rubber is replaced partly by synthetic rubber. The price for natural rubber thus also falls due to the low oil price (Naranjo and Langenberger 2016).

In the chart below, rubber prices per kg are given for the period between January 2012 and November 2015. The data come from GAPKINDO (Rubber Association of Indonesia). The given price is the average buying price of the five rubber factories in Jambi City which is reported daily to GAPKINDO except for Sundays and public holidays. The factories set the price taking 85 percent of the Bloomberg/Singapur commodity and Tokyo commodity prices as the maximum price. The maximum price only applies for high quality rubber; the usual percentage is 70 percent. The minimum price is set at 50 percent. Note that the farmers often get a lower price, since only a very small share of farmers sell directly to a factory. A complex chain of traders acts as an intermediary between the province’s nine processing factories, which eventually export the processed rubber, and the 250,000 rubber farmers in Jambi. According to Kopp et al. (2014), an estimated 16,000 village-level and district-level traders and warehouses operate in Jambi. When moving along the value chain from the village trader, the product passes 3.1 other traders on average before reaching the factory (Kopp and Brümmer 2015). Both, factories and traders have market power. Kopp et al. (2014) find that factories are price takers with respect to the international market price, but price setters with respect to their suppliers. The prices received by traders and farmers in Jambi from the factories are transmitted from the international prices asymmetrically: in times of price hikes, the price changes are transmitted to the local market much slower than in times of price declines. In the graph, we can see that the price paid by Jambi City factories has fallen by more than 50 percent.

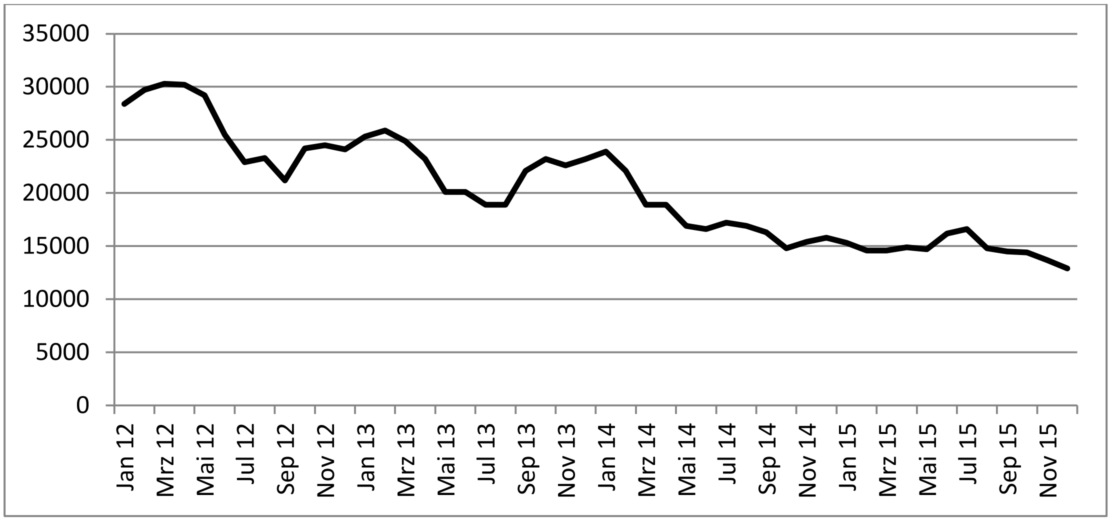

Figure 3: Rubber price per kg in Jambi in Rupiah per kilo, 2012-2015

Figure 4 shows the world market prices for rubber and oil palm in comparison for the last ten years. The rubber price is the price per ton for the standard No. 3 smoked sheet at the Singapore Commodity Exchange. The palm oil price is the price per ton of crude palm oil (Malaysia Palm Oil Futures). The initial price of September 2006 is taken as the basis and set to 100 and the subsequent monthly prices are reported relative to the basis price. The vertical lines indicate the start and end of data collection in our two survey waves in both of which information has been asked for retrospectively for one year. The data will be further described in the next section.

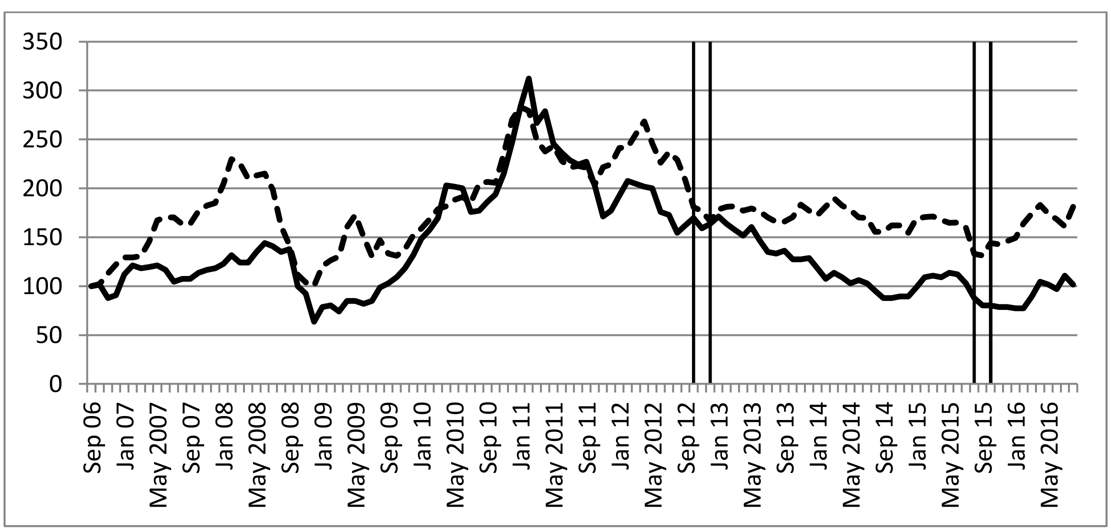

Figure 4: World market prices for rubber (blue) and palm oil (red), September 2006=100 (Indexmundi 2016)

4. Data

The data analysed in this thesis come from a comprehensive household survey which is part of the international collaborative research centre (CRC) “Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems” (EFForTS)” of the University of Göttingen, the University of Jambi, Bogor Agricultural University (IPB), Tadulako University and the Indonesian Institute of Science. The CRC aims at analysing how different land use systems provide different ecological and socio-economic functions to the society and the ecosystem. In addition, it provides guidelines on how to protect and enhance ecological functions of tropical forests, forest remnants and agricultural transformation systems while improving human welfare at the same time. Faust et al. (2013) provide more information about the CRC, its research objectives and research design.

The selection of sample households followed a multi-stage random approach. Five of Jambi’s eleven regencies were selected purposively covering all predominantly rural lowland and non-coastal regencies. For a wider village survey, four districts in each regency and five villages in each district were selected randomly. Two villages had to be excluded due to logistical reasons. For the household survey analysed here, 40 villages were selected randomly from the 98 villages covered in the village survey. Five villages were selected purposively because farmers in these villages were included in experiments from other subgroups of the CRC. Within the 45 villages, most farmers were selected randomly; some others were selected purposively to meet requirements for other surveys, but these farmers are excluded from the analysis here. The number of selected farmers depends on the total population of the villages. Data collection took place through face-to-face interviews, for the first wave between October and December 2012, for the second wave between August and October 2015. For a more detailed description of the survey design, see Faust et al. (2013).

The total sample of randomly selected households in 2012 consists of 683 households. Since 41 households could not be interviewed again, the panel analysed in this thesis consists of 642 households, of which 537 cultivate rubber and 249 cultivate oil palm. Of the 41 households who dropped out of the sample, 10 refused to answer, some claiming that the interview was too long in 2012, 19 migrated out of the village and 12 dropped out for other reasons (like temporarily being away). Table 2 below compares characteristics of households for which panel data is available with those who dropped out of the panel. An asterisk indicates that both sample means differ at the ten percent significance level, two asterisks indicate a difference at the five percent significance level. For few variables, the null hypothesis that dropouts do not differ significantly from panel households had to be rejected at the ten percent significance level. Dropouts own more land with mostly oil palm plantations, the share of ethnic Javanese is smaller and the share of households running a business is higher among dropouts. While these differences should be taken into account when drawing conclusions, it is nevertheless unlikely that they will bias the results severely as attrition is very low after all.

Farmers in the baseline study have 3.71 ha of land on average, with 65 farmers owning less than one ha and 198 farmers owning less than two ha. 37 farmers own more than ten ha. 48 percent of households are indigenous, 44 percent are of Javanese origin and the rest is of other ethnicities or mixed descent. About 30 percent of the surveyed households came to Jambi over the Transmigration programme, nearly all of them Javanese.

Table 2: Characteristics of panel households and dropouts

Variable	Panel households	Dropouts
Mean total land (ha)	3.633217	4.976829*
Mean area with rubber (ha)	2.677033	3.32439
Mean area with oil palm (ha)	.9561838	1.652439*
Share of farmers cultivating only rubber	.6261682	.5365854
Number of household members	3.186916	3
Years of schooling of household head	7.482866	7.243902
Share of ethnic Melayu farmers	.4844237	.4878049
Share of ethnic Javanese farmers	.4485981	.2926829*
Share of farmers owning a business	.194704	.3170732*
Mean farm income per person equivalent	24114.89	26726.09
Mean total income per person equivalent	35015.38	41197.08

* $p < 0.1$, ** $p < 0.05$

Roughly every fifth household owns a business. Most businesses in the sample are small shops; others include food stalls, motorbike repairs or being a rubber trader. In 46 percent of households at least one household member is employed, mostly as agricultural labourer. The predominant way of remuneration for labour in oil palm cultivation are wage payments, while in rubber cultivation, sharecropping arrangements are predominant.

The average yearly per capita income of our survey households in 2012 and in today's prices is 24.5 million Rupiah (1688 Euro), two thirds of which are generated through own, independent agriculture. While Jambi is not among the poorest regions of Indonesia, our focus on smallholder farmers explains that the average income in our sample is much lower than Indonesian GDP per capita in 2012 (3316 Euro) (World Bank data). 16 percent of households in our survey have a per capita income of less than 1.25 US-Dollar (1.12 Euro) which was the World Bank's international threshold for extreme poverty until 2015, 27 percent of households lie below the new threshold of 1.90 US-Dollar (1.69 Euro)[3].

5. Methodology

5.1 Income calculations

Most studies that analyse household welfare in what is commonly referred to as the developing world use consumption rather than income as a measure for welfare. Deaton (1997) gives a good overview for why this is the case. While an exact measurement of both, income and consumption, is difficult, measurement error is a bigger problem in the assessment of income data. Generally, income appears to be underestimated. Small-scale farmers and entrepreneurs are likely not to have any idea on what income means and what costs to subtract. Also, income and assets are sometimes deliberately understated e.g. to avoid jealousy or to hide illegal activities.

[3] All exchange rates used are from 23 September 2016

Also, while food consumption expenditure is usually asked for the last week, income is mostly asked for the last year which, in the presence of high inflation, would lead to a relative understatement of income. Survey-based estimates of income are often severely lower than survey-based estimates of consumption, even though households are found to save on the aggregate level. A last reason why consumption is regularly preferred over income in household surveys is the relative ease of calculation. Taking consumed quantities of different products (which are typically much more limited in variety in poorer countries) multiplied by their prices gives an accurate estimate of households' consumption. To get a good estimate for income, many different possible sources of income have to be distinguished and cautiously be asked for. As Deaton (1997) puts it:

> "To get better estimates, the survey must collect detailed data on all transactions, purchases of inputs, sales of outputs, and asset transactions, and do so for the whole range of economic activities for wage earners as well as the self-employed."

In the data used here, farmers were indeed asked in detail about every possible source of income. Farmers were asked for the exact quantities of harvested products, exact quantities of bought inputs, and prices for both. Furthermore, farmers were asked about livestock, fishing, forest activities (such as collecting wood), employment, own business, credit, savings and transfers. Credit, savings and transfers as well as income from the sale of assets and large livestock (that is, excluding poultry) are excluded in income calculation as the purpose of this work is to analyse how farmers manage to maintain their livelihoods on their own and without direct support from others. Also, as the reporting periods for asset sales and purchases as well as for credit differs from other income sources, it is hard to calculate a composite measure. The refusal rate was very low and respondents generally talked very openly about their sources of income, in some cases even including income from illegal gold mining or logging. Income data has been calculated with caution and a series of plausibility and consistency checks have been performed giving hope that income data is extraordinarily accurate.

Farm Income is calculated as

$$Farm\ Income = Farm\ Revenue - Input\ Costs - Labour\ Costs,$$

where

$$Farm\ Revenue = p\_rubber * q\_rubber + p\_oilpalm * q\_oilpalm + p\_otherproducts * q\_otherproducts,$$

with p an q denoting the prices and marketed quantities of the respective commodities. Note that while for overall comparisons average prices are used, in the income calculations the self-reported prices of farmers were used which differ depending on farmers' locations, produced quality and other characteristics. Input costs and labour costs are calculated accordingly with the reported quantities of inputs purchased and hours of labour worked multiplied by the reported prices for the different inputs and the reported wages paid. For rubber farmers, most of labour costs occur in the frame of sharecropping contracts. In this case, the share of harvest given to the sharecropping worker is multiplied by the total revenue as calculated above for all plots on which the sharecropper worked to obtain labour costs. Non-farm income is the sum of different sources of income other than growing and marketing agricultural crops on one's own account.

$$Non - Farm\ Income = Forest\ Income + Fishing\ Income + Employment\ Income + Business\ Income + Poultry\ Income$$

Lastly, total income is calculated as the simple sum of farm income and non-farm income:

$$Total\ Income = Farm\ Income + Non - Farm\ Income$$

All income data and all reported components of income data are reported in 2015 prices using inflation rates reported by the World Bank. All income data have been divided by numbers according to the OECD modified equivalence scale in order to take into account effects of different household sizes. In the OECD modified equivalence scale, the first adult in a household is attributed a weight of 1, each additional adult is given the weight 0.5 and each additional child the weight 0.3. The income of a household consisting of two adults and two children would thus be divided by 2.1, for instance. The use of an equivalence scale has several advantages over calculating simple per capita household income. It takes into account economies of scale as well as the fact that children generate less income on average and have lower consumption needs than adults. (OECD 2013)

5.2 Hypotheses and methodology

The following four hypotheses will be addressed in this thesis:

H1: The degree to which farm and off-farm income are affected by the price shock depends on farm households' and village characteristics. Farmers cultivating only rubber are affected most.

H2: Smallholders adjust input and labour usage and production levels of rubber to reduce the impacts of the output price shock on farm income.

H3: Off-farm income opportunities and asset ownership help mitigate the effect of price shock on total household income.

H4: These mitigation mechanisms help to buffer the transmission of fallen farm income on consumption.

With regard to the first hypothesis, descriptive statistics and charts will show how different groups of farmers have developed differently between the two waves of the survey. Rubber farmers are expected to have been hit worse by the price development and therefore are expected to have lost income. Farmers' income development will be separated and compared between different income quintiles and across time.

In order to explore the second hypothesis, the difference between the farmers' expected farm income in 2015 and their actual farm income is analysed. The expected farm income of households in 2015 will be simulated by only adapting the prices to the 2015 level and assuming everything else (e.g. input usage) to stay constant as in 2012. The expected farm income is thus the income farmers would have received if they had not changed their economic behaviour in any way e.g. by harvesting less, applying less fertiliser or by increasing family labour to reduce wage labour. The expected income is comparable with the short-term effect of fallen prices before farmers have the possibility to respond (see e.g. Minot and Daniels (2002) who simulated poverty effects of a cotton price drop). It is hypothesised that rubber farmers have adjusted their economic behaviour (input usage, labour demand, produced quantity) in a way that the fall in farm income was less pronounced than it would have been just from the price effect.

To address the third hypothesis, the change in farm income, non-farm income and total household income will be regressed on a set of explanatory variables. The latter will include characteristics of farm households taken from the baseline study in 2012 such as income, age, gender and education of the household head, an asset index, migration history, ethnicity, dummies indicating whether the farm household was engaged in wage employment, sharecropping employment or own business activities in 2012, among others. Standard OLS regression with heteroscedasticity-robust standard errors will be used as well as a Fixed Effects model. The advantages of the different models will be shortly discussed in this section. A Logit model will be estimated to investigate which farmers applied which strategies in response to the price decrease.

Lastly, to test the fourth hypothesis, similar regressions will be made using consumption or consumption growth as the dependent variable while changes in farm income and off-farm income will be used as explanatory variables. Following economic theory, risk-averse households prefer to smooth consumption. Given access to perfect credit and insurance markets, risk-averse households would choose to keep consumed quantities stable over different years. If credit and insurance markets are imperfect, household consumptions may be suspect to shocks (e.g. Christiaensen et al. 2006). In this part of the analysis, conclusions from investigating the first and third hypotheses can be developed further, answering how different patterns in income growth are reflected by different patterns of consumption growth. The hypothesis is that those farmers who have better opportunities to generate off-farm income, e.g. by living close to an oil palm plantation, are better able to mitigate the impact of the price shock not only on their total income (H3), but also on consumption and can thus stay on a more stable consumption path.

6. Heterogeneity of income development

Taking the price development summarized in section 3.2 into account, it is logical to assume that rubber farmers' income developed worse than oil palm farmers'. In this section, it will be investigated whether this assumption is met in the data.

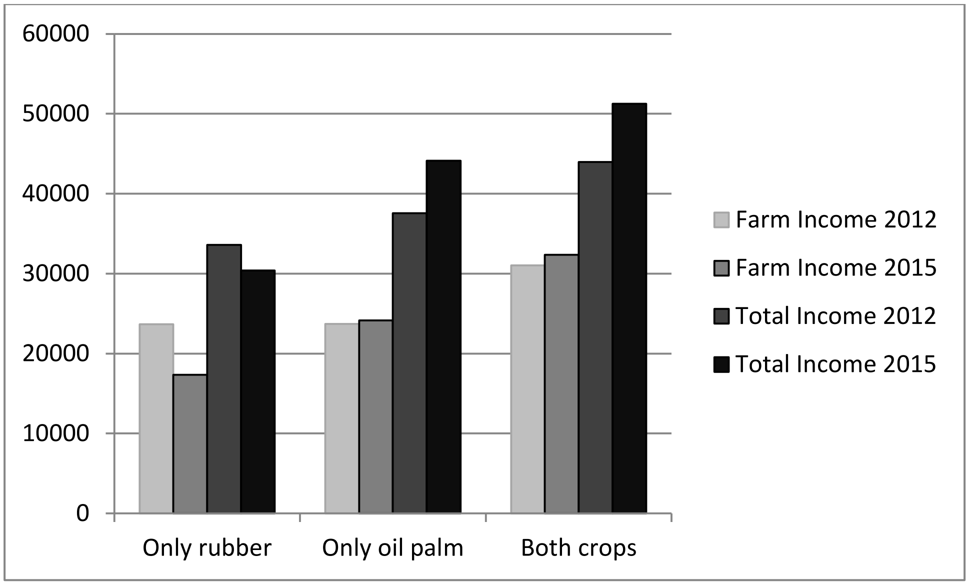

Figure 5: Development of income by crop, in '000 Rupiah

Figure 5 shows the expected difference in development of farm income. Rubber farmers' income from agriculture fell substantially whereas oil palm farmers' income from agriculture increased slightly. Also, farmers cultivating both crops experienced a slight increase in farm income and were generally richer than the other two groups in both years. Regarding total income, the trends differ even more in scope. Rubber farmers' off-farm income rose, but slightly less than for oil palm farmers and not enough to offset the drop in farm income.

When the price for rubber falls, not only the household income of rubber farmers drops, but also the total income of regions dependent on rubber cultivation. To have a look at how household and village development coincides, the sample was split into oil palm villages and other villages. All villages where more than 50 percent of the area covered in our sample was dedicated to oil palm were defined as oil palm villages, ignoring all crops other than rubber and oil palm. This leaves us with 8 oil palm villages and 37 rubber villages. Between these villages, we observe similar differences as comparing rubber with oil palm farmers with the income increase for oil palm villages being even slightly higher than for oil palm farmers. This can be interpreted as an indicator for the macroeconomic effect on the village or regional level that also hits households that do not directly depend on rubber cultivation. If farmers earn less money, they also spend less in the local market, hence decreasing local aggregate demand.

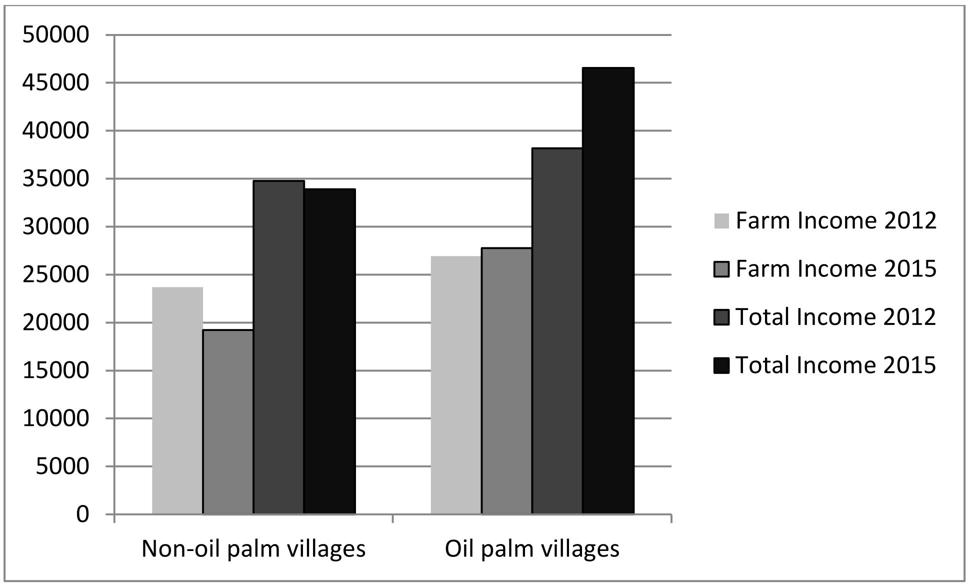

Figure 6: Development of income by dominant crop in village, in '000 Rupiah

In order to investigate in more detail which rubber farmers were hit hardest by the price drop, it could make sense to look at the income distribution. In table 3, only farmers who only cultivate rubber are included, separated into quintiles by quintiles of total income (TI), farm income (FI) and non-farm income (NFI) in 2012. The numbers indicate the change in mean total, non-farm and farm income for farmers who belonged to the respective quintile in 2012. The results are rather surprising at first sight as there seems to be a strong trend of convergence in income. Lower quintiles of the income distribution performed much better in 2015 while higher quintiles lost a substantial part of their income. The trend is somewhat less clear when dividing the sample by quintiles of non-farm income, but holds for quintiles of farm income. Non-farm income rises mostly for those who had little non-farm income in 2012 and is not clearly related to farm income. The trend can thus not be explained by smaller, poorer farmers being forced into non-farm activities by falling agricultural prices. The convergence in non-farm income could be explained for some farmers by low incomes in 2012 due to investments that later paid off.

Table 3: Development of rubber farmers' income by quintiles of income, in ‘000 Rupiah

	Lowest	Second lowest	Medium	Second highest	Highest
TI by TI quintiles	14506	8877	2397	-7860	-37333
TI by FI quintiles	11006	8489	2640	-1893	-40632
TI by NFI quintiles	-1975	6558	732	-315	-18036
NFI by TI quintiles	6031	5252	4255	-937	554
NFI by FI quintiles	2691	1697	3042	4651	3690
NFI by NFI quintiles	9150	7606	4932	-292	-7633
TI by TI, excluding farmers with <90% productive trees 2012	15130	8985	1682	-8847	-39920

At least for the lower quintiles, the overall convergence trend could possibly be explained by the circumstance that farm income is lowest for farmers whose trees are too young to be productive; hence the positive trend can be explained by trees maturing. In order to eliminate this effect, in the last row, all farmers whose ratio of productive to total trees was lower than 90 percent in 2012 were dropped from the analysis. As the trend is unchanged, immaturity of new trees can hardly explain the convergence in incomes.

Scatter plots of income from different sources and in different years are shown in figure 7; there are few clearly visible patterns of linearity between 2012 and 2015 data. Before concluding a real convergence in incomes, further analysis has to be performed. As dividing farmers into quintiles is a somewhat arbitrary task, noise in the data can lead to households being grouped in the wrong group and hence spoil the explanatory power of the results. To develop a better understanding of these patterns, it will be helpful to control for different variables that could explain what seems to be an income convergence trend. Therefore, multivariate regression analysis will be applied in a later part of this thesis.

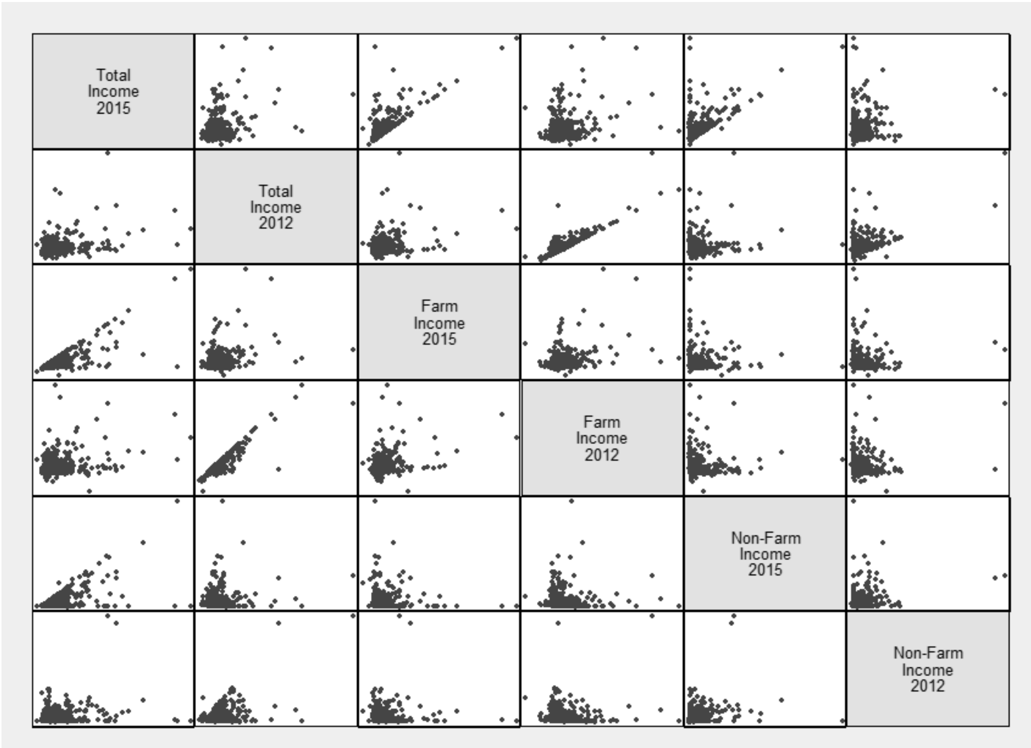

Figure 7: Scatter plots of different income sources in different years

It is important to note that even after the price drop, rubber generated more income per hectare on average. Table 4 shows average (non-equivalised) household income generated from one hectare of rubber or oil palm in 2012 and 2015. The data stem from all interviewed farm households, not excluding drop-outs and new farmers. While the relative profitability of rubber dropped, in 2015, one hectare of rubber still generated more income than one hectare of oil palm. The advantage of oil palm is actually not a higher profitability per hectare, but its relatively lower labour-intensity. As Euler et al. (2015) find, labour-scarce households opt for cultivating oil palm while land-scarce households often opt for cultivating rubber.

Table 4: Profitability per hectare (in '000 Rupiah in 2015 prices)

	2012	2015
Rubber	13862	8772
Oil palm	9700	7200
Rubber (only positive profits)	18815	10515
Oil palm (only positive profits)	14627	10151

7. Reactions in farm income

In the last section, we could see that the drop in rubber prices caused the income of rubber farmers to drop substantially. This finding leaves out the different efforts farmers have taken to cope with the price shock. Indeed, they are already incorporated in the numbers reported. What would have happened had the farmers not reacted to the price shock at all? This question shall be addressed in the following paragraphs.

First, let us take a look at the difference in mean farm income and mean "expected" farm income, that is, the income farmers would have gained if they had not altered their input and output and only prices had changed. For the entire sample, the expected income per household member equivalent is hardly half of the actual income in 2015. On average, a household gained 20.8 million Rupiah (1417 Euro) per adult equivalent in 2015, while if it had not altered input use and harvested quantity, the household would have gained only 11.1 million Rupiah (756 Euro) on average from independent agriculture. Note again that the expected income was only simulated for farm income excluding non-agricultural income and income from livestock and fishery. For farmers cultivating only rubber in 2012, the difference between expected and actual income from farm income is 7.5 million Rupiah (511 Euro).

To get a better understanding of how farmers changed their costs and revenues structures, it will help to break down expected and actual farm income into its components: labour costs, input costs and farm revenue. Table 5 shows the results: we can see that on average, input costs for all groups of farmers were not just lower than expected, but even lower than in 2012. The only exception is oil palm farmers who had higher labour costs in 2015 than in 2012. It was expected that rubber farmers would have lower labour costs and oil palm farmers would have higher labour costs in 2015, but while the direction of the change was predicted, its magnitude was underestimated. Labour costs developed differently due to the type of contract that usually underlies these costs. Virtually all labour costs for rubber farmers are based on sharecropping arrangements. The labourer gets a fixed share of the harvest, or rather of the revenue, as the owner's and the labourer's shares are usually marketed together. When the rubber price falls, the "wage" paid to sharecropping labourers falls accordingly. In oil palm cultivation, sharecropping is uncommon and most labourers receive a fixed wage. Accordingly, oil palm farmers have to pay higher wages holding step with general wage increases.

Table 5: Expected and actual farm income and its components for different crops, in '000 Rupiah

	Only rubber farmers			Only oil palm farmers			Farmers cultivating both		
	Actual 2012	Expected	Actual 2015	Actual 2012	Expected	Actual 2015	Actual 2012	Expected	Actual 2015
Input costs	1675	2080	1002	8126	9113	6785	5917	7053	5707
Labour costs	16196	13376	6662	4504	6043	8364	31515	27219	14670
Input costs (non-zero)	2680	3328	2035	8873	9951	7447	6485	7730	6838
Labour costs (non-zero)	72285	59701	25752	8915	11961	14476	58346	50391	29110
Revenue	62196	33203	32792	54321	43753	48636	99699	61331	65544
Farm income	44934	18263	25127	43321	29978	33487	62453	27217	45168
Farm equivalent income	23665	9800	17326	23716	16360	24165	31025	13436	32348

Rubber farmers in particular reduced input costs substantially. Table 6 provides information about what inputs farmers purchased. It shows the percentage of randomly selected rubber and oil palm plots on which certain inputs were applied. It can be seen that fertilization is far less common on rubber plots than on oil palm plots. Also the use of herbicides, manure and soil amendments is far lower among rubber farmers. The biggest change can be found for fertilisation which is discontinued on half of formerly fertilized plots.

Table 6: Percentage of plots where different inputs are applied

Year	Crop	Seedlings	Manure	Soil amendments	Fertilizer	Herbicides/pesticides
2012	Rubber	6%	1%	1%	27%	49%
	Oil palm	8%	6%	15%	72%	76%
2015	Rubber	7%	8%	4%	14%	35%
	Oil palm	2%	11%	15%	63%	61%

As a result of reduced input costs and labour costs, the drop in farm income was much smaller for rubber farmers than it would have been had nothing but the prices changed. In addition, oil palm farmers fared better than expected, mostly due to higher revenues. Farmers cultivating both crops exceeded the expected income by far, mostly due to lower labour costs. Broadly, it was expectable that input costs would be lower than calculated as farmers will react to price changes by demanding cheaper inputs, e.g. replacing a type of fertiliser that became more expensive by a cheaper one. It is a bit puzzling that labour costs have changed this much, less for farmers cultivating rubber, more for those only cultivating oil palm. Including only non-zero costs does not change anything in the whole picture. Farmers did not alter harvested quantities a lot. For rubber farmers, 2015 revenue was just slightly lower than expected, oil palm farmers had higher revenues indicating that they did harvest more.

Table 7: Input costs per ha, in '000 Rupiah

	Only rubber farmers		Only oil palm farmers		Farmers cultivating both	
	2012	2015	2012	2015	2012	2015
Input costs per ha (in 2015 prices)	443 (523)	239	2352 (2777)	1997	1034 (1221)	934
Only non-zero (in 2015 prices)	709 (837)	481	2568 (3032)	2169	1134 (1339)	1119
Labour costs per ha (in 2015 prices)	2548 (3009)	834	938 (1107)	2084	3346 (3951)	1436
Only non-zero (in 2015 prices)	11372 (13428	3184	1856 (2192)	3527	6195 (7314)	2850

To correct for effects of changes in land endowment, input and labour costs per hectare are shown in table 7. Below each number from 2012, the same number is given in 2015 prices by using the general inflation rates that have been used in income calculation as well. Note that this inflation rate is much less exact than the calculations that have been made to calculate the expected income of farmers in 2015.

Table 8: Input and labour cost of farmers cultivating only rubber by quintiles of farm income, '000 Rupiah

	Lowest quintile		Second lowest		Middle		Second highest		Highest quintile	
	2012	2015	2012	2015	2012	2015	2012	2015	2012	2015
Input costs	982	404	788	575	833	453	1130	734	5152	3170
Labour costs	24424	1155	18652	3669	5301	2713	1519	2473	37038	26453

The patterns are the same as before: all groups of farmers reduced their inputs, rubber farmers and those cultivating both crops substantially reduced their labour costs while oil palm farmers faced increasing labour costs. Comparing just farmers only cultivating rubber divided by quintile according to farm income in 2012, it is notable that labour costs have fallen most drastically in the two lowest quintiles.

The fact that labour costs are much lower than expected for rubber farmers and much higher than expected for oil palm farmers leads to the assumption that rubber farmers decreased and oil palm farmers increased the amount of labour demanded. Plot-level data does not support this explanation, though. For all rubber plots for which data was available for 2012 and 2015, average working hours per year actually increased from 819 to 1017, while for oil palm the increase was from 172 to 246. However, these data have to be interpreted with caution as farmers are generally not aware of the exact time spent on different activities. This is even more the case for rubber farmers who gave land to sharecropping labourers as the latter typically manage the land on their own without any interference from the landowner's side.

Changes in sharecropping arrangements can hardly explain the drastic changes in labour costs for rubber farmers. The average share of harvest given to sharecropping labourers as a wage increased from 45 to 54 percent among farmers in our panel.

Possibly, some differences in input and labour use can be explained by trees maturing. Neither very old nor very young trees are usually fertilized. Normaly, farmers start harvesting oil palms about four years after planting and use them for about twenty years. Rubber trees are tapped for the first time after about seven years and are commonly used for about twenty-five years (Schwarze et al. 2015). In fact, as the vast majority of plantations were not yet too old to be productive and few plots were replanted, the mean age of trees on farmers' plantations rose from 15 to 17 for rubber trees and from 9 to 12 for oil palms between the two survey rounds. The share of trees that were still immature fell by about 10 percentage points for both rubber and oil palm. The share of trees which were too old to be economically productive rose by 2 percentage points for rubber and by about 10 percentage points for oil palms. Hence, the share of productive trees rose for rubber and roughly stayed the same for oil palm so that altered input costs cannot be explained by life cycle effects of trees.

Table 9: Percentage of farmers who answered having taken distinct measures as a reaction to the rubber price fall

	Farmers cultivating only rubber in 2012	All farmers who cultivated rubber between rounds
Decreased household savings	80.8%	82.4%
Sold land	3%	3%
Applied for more credit	8.3%	8.9%
Changed plantations to oil palm	0.8%	1.5%
Opened up new plantations	3%	2.8%
Started or increased wage labour	3.8%	3.4%
Opened a new business	6.3%	5.7%
Stopped tapping the rubber trees	6.3%	6.4%
Reduced farm inputs	61.1%	62.3%
Applied any other measure	2.5%	2.2%

When asked directly whether and how rubber farmers reacted to the price fall (and explicitly to the price fall and not to anything else), two answers were dominant: farmers decreased savings and reduced farm inputs. Our data on input and labour costs give further evidence that this was a common way of reacting to the shock. In the next section, it will be assessed which farmers responded to the price development in which way.

8. Mitigation mechanisms

In section 6, we could see that while farm income fell for rubber farmers and stagnated for the other groups, total income rose for some groups. For rubber farmers, non-farm income was important in dampening the effect of fallen output prices on total income. In section 7, we have seen that farm income fell much less than predicted due to decreased expenditure for inputs. In this section, we will also turn to dynamics in off-farm income.

8.1 Selection of variables

As the purpose is to develop an understanding on how different groups of farmers developed differently over the three years, the change in income from different sources is the relevant variable to explain in regression models. Unlike much of the literature on income growth, our full sample does not allow working with either percentage or logarithmically transformed changes, as some values are negative. Farm households have to live off something, so a total income of zero is not plausible at first sight. Here, income from credits, transfers and remittances and the sale of assets is excluded so that cases of total income below zero are possible. For the different sources of income, it is not implausible to find values below zero as they can be explained by high investment costs. Yet, after dropping households with negative income, the models will be estimated with percentage changes as the dependent variable as well. First, the analysis will be limited to Ordinary Least Squares (OLS) regression with heteroscedasticity-robust standard errors using Stata's standard command for robust standard error estimation. As it is likely that residuals of households residing in the same village are not independent of each other, another option for correcting standard errors for heteroscedasticity would be using the "cluster" option with villages as clusters. Where the significance of variables differs importantly using clusterisation, it will be reported with the results. Fixed effects and random effects estimation will also be applied in order to handle possible endogeneity problems. The change of income derived from different sources is modelled with data from the 2012 survey round.

Table 10: Variable names and descriptions

Variable name	Description
age_hhh	Age of household head
age_hhh_2	age_hhh squared
female_hhh	Is the household head female?
shareofmen	Share of men aged 15-49 among household members
indigenous	Is the household of indigenous (Melayu) ethnicity?
area_oilpalm	Area under oil palm cultivation in ha
area_oilpalm_2	area_oilpalm squared
area_rubber	Area under rubber cultivation in ha
area_rubber_2	area_rubber squared
onlyrubber	Does the household only cultivate rubber?
farmincome_eqs	Equalised income from farm activities in 2015 prices in Million Rp
farmincome_eqs_2	farmincome_eqs squared
nonfarmincome_eqs	Equalised income from non-farm activities in 2015 prices in Million Rp
nonfarmincome_eqs_2	nonfarmincome_eqs squared
business	Does at least one household member run an own business?
employment	Is at least one household member employed?
takencredit_formal	Did the household take formal credit that is still not fully repaid?
takencredit_informal	Did the household take informal credit that is still not fully repaid?
householdassets	How many fridges and washing machines does the household own?
vehicles	How many motorised vehicles does the household own?
transvillage	Does the household live in a transmigrant village?
oilpalmvillage	Does the household live in an oil-palm dominated village?
year2015	Dummy for the year 2015

The explanatory variables include age and gender of the household head, ethnicity, the share of men in working age of the total number of household members, the area used for rubber and oil palm cultivation, respectively, a dummy whether the household only cultivates rubber, farm and non-farm income in 2012, dummies indicating whether a household member owned a business or was employed as wage labour or sharecropping labour, dummies indicating whether the household took formal or informal credit and data on assets (number of fridges, washing machines and motorized vehicles) as an indicator for household wealth. Lastly, two variables are included that capture characteristics of the village a household lives in: a dummy indicating whether the household lives in a transmigrant village and a dummy whether the household lives in an oil palm village as defined in section 6.

8.2 Results

Table 11 shows the results of a regression of the change of income from different sources on the set of explanatory variables mentioned above. Income is given as total income (TI), farm income (FI), non-farm income (NFI), employment income (EMPI) and business income (BUSI), the first being the sum of the second and third and the third being the sum of the fourth and the fifth as explained in section 5.

It seems that households led by an older person did not have bigger trouble in adapting to the price shock in general. While the coefficient for age in a model not including squared terms is negative and significant, we can see in table 11 that the relationship is actually hyperbolic. Only if the household head is older than 85, age is associated with a significantly lower income gain (or higher income loss). Whether a household is female-led is not significantly related to a higher or lower income growth, nor is ethnicity or the share of men in working age. Households with a higher income in 2012 have developed worse, repeating the finding of a convergence effect that could already be seen in the descriptive statistics. A larger cultivated area seems to be associated with improvements in farm income, on the other hand. This effect is quadratic for rubber and linear for oil palm. Asset wealth as measured by the number of motorized vehicles the household owns is associated with an increase in non-farm income from both employment and business. However, the reason for this could lie in the measurement, as households that own more vehicles can send their members further away to work or purchase inputs for their own business. One vehicle is associated with a raise of non-farm income by 10 million Rupiah (681 Euro).

Table 11: Effects on changes in income from different sources

	(1) Change in TI	(2) Change in FI	(3) Change in NFI	(4) Change in EMPI	(5) Change in BUSI
age_hhh	1686.9*	902.5	784.4	637.9*	388.0
	(2.46)	(1.86)	(1.54)	(2.33)	(1.10)
female_hhh	1679.2	261.5	1417.8	1375.5	-2371.7
	(0.28)	(0.05)	(0.40)	(0.47)	(-1.49)
shareofmen	-1997.4	-4319.4	2322.0	-1974.3	2735.8
	(-0.20)	(-0.55)	(0.33)	(-0.47)	(0.67)
indigenous	-3492.4	-5333.5	1841.2	1054.4	-1386.1
	(-0.86)	(-1.54)	(0.76)	(0.77)	(-0.75)
area_oilpalm	3835.7	3404.7*	430.9	565.1	-482.1
	(1.94)	(2.07)	(0.39)	(1.22)	(-0.69)
area_rubber	1338.6	1792.8	-454.2	-443.3	217.7
	(1.00)	(1.38)	(-0.69)	(-1.24)	(0.57)
onlyrubber	-1481.4	105.0	-1586.4	895.5	-2313.4
	(-0.33)	(0.03)	(-0.54)	(0.67)	(-1.15)
farmincome_eqs	-628.4***	-681.0***	52.53	39.43	-19.81
	(-4.95)	(-6.13)	(0.71)	(1.14)	(-0.49)
nonfarmincome_eqs	-673.4**	23.35	-696.7***	-197.3	-444.2***
	(-2.97)	(0.18)	(-3.92)	(-1.90)	(-3.72)
business	6583.0	3388.4	3194.5	5063.7**	-3488.4
	(1.35)	(0.93)	(0.95)	(3.05)	(-1.61)
employment	-851.3	-2191.6	1340.3	-4974.8***	5592.9**
	(-0.22)	(-0.76)	(0.53)	(-4.30)	(2.91)
takencredit_formal	8372.8	492.8	7880.0*	254.5	3219.4
	(1.76)	(0.15)	(2.22)	(0.16)	(1.66)
takencredit_informal	764.9	-483.1	1248.0	2314.8*	-888.8
	(0.28)	(-0.28)	(0.58)	(2.32)	(-0.61)
householdassets	1917.0	1026.6	890.4	-1035.8	2059.5
	(0.83)	(0.69)	(0.46)	(-1.48)	(1.49)
vehicles	9537.5	-1452.8	10990.3***	2984.9*	8884.4***
	(1.92)	(-0.36)	(3.44)	(2.03)	(3.67)
transvillage	-4114.9	-1905.0	-2209.9	-1063.9	-4152.3*
	(-0.87)	(-0.54)	(-0.63)	(-0.67)	(-2.04)
oilpalmvillage	8674.7	7609.3	1065.4	4812.2**	-298.9
	(1.36)	(1.90)	(0.20)	(2.67)	(-0.14)
farmincome_eqs_2	-1.167***	-0.954**	-0.212	-0.0626	-0.0325
	(-3.43)	(-3.15)	(-1.06)	(-0.69)	(-0.28)
nonfarmincome_eqs_2	-0.117	-0.0490	-0.0681	0.601	-0.807*
	(-0.13)	(-0.07)	(-0.12)	(1.77)	(-2.16)
area_oilpalm_2	15.22	52.47	-37.25	-20.23	-7.219
	(0.32)	(1.36)	(-1.31)	(-1.63)	(-0.45)
area_rubber_2	114.7***	114.2***	0.483	1.948	-8.779
	(5.01)	(5.87)	(0.03)	(0.29)	(-1.00)
age_hhh_2	-19.74**	-10.83*	-8.906	-6.646*	-4.410
	(-2.89)	(-2.18)	(-1.81)	(-2.44)	(-1.30)
_cons	-19602.5	-9449.4	-10153.1	-9929.5	-4309.9
	(-1.22)	(-0.92)	(-0.76)	(-1.52)	(-0.50)
N	642	642	642	642	642
adj. R^2	0.446	0.540	0.198	0.126	0.364

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Households who owned a business in 2012 increased their income from employment; households who had employed members in 2012 decreased their earnings from wage labour and increased earnings from business activities. Taking formal credit was associated with an increase in off-farm income and taking informal credit was associated with an increase in income from employment. Lastly, living in an oil palm village increased employment income on average. Truly, employment is mostly available in oil palm regions where a lot of casual workers are hired for harvesting fruit bunches. The interpretation of the coefficient for employment is somewhat difficult as very different types of employment arrangements are summarized under the binary variable, notably sharecropping workers and wage workers. Since the first are in the clear minority, they are probably not be the driving force behind the results, though. Households in transmigrant villages decreased income from business.

Particularly interesting could be the interpretation of the coefficient for the dummy indicating whether a farmer only cultivates rubber or a mixture of crops. Supposedly, this group of farmers is particularly exposed to the shock as their farm income is not diversified across two or more crops. The fact that the coefficient is not significant means that other variables can explain differences in how much farmers were hit by the price shock. Table 12 shows the differences between farmers cultivating only rubber and the average for all farmers in the sample for a set of variables. One asterisk denotes that the difference in means is statistically significant at the ten percent level; two asterisks indicate significance at the five percent level.

Table 12: Differences between farmers cultivating only rubber and whole sample in the baseline study

	Other farmers	Farmers only cultivating rubber
Total area	4.5	3.2**
Number of persons per household	3.1	3.2
Share of men in working age	49.1%	48.6%
Share of indigenous households	42.9%	51.9%**
Household head's years of schooling	7.6	7.4
Share of households with own business	24.7%	17.5%*
Mean farm income per person equivalent	25266	23666
Mean non-farm income per person equivalent	13075	9917*
Percentage of migrant households	60.6%	49.3%**
Percentage of transmigrant households	48.4%	17.2%**
Percentage living in transmigrant villages	37.8%	25%**
Percentage living in oil palm villages	44%	2.4%**

The impact of the price decrease appears to be rather related to the area under cultivation. When including only the total area under cultivation and its squared term and not distinguishing between rubber and oil palm area, the coefficient for farmers cultivating only rubber remains insignificant. Apart from the area under cultivation, village effects seem to play an important role. Households residing in villages dominated by oil palm cultivation develop better.

If the model is repeated using 2015 income instead of the change in income as the dependent variable, the coefficients which change most notably are the ones for 2012 income. This is expectable as when the income change is regressed on the 2012 level of income, it is corrected for the level of income on both sides. If the level of income 2015 is regressed on the same variables, it would indeed be strange if the coefficient of 2012 income would be negative as it would imply a revolutionary re-distribution. Of course, on average, households that were richer in 2012 are also among the richer ones in 2015. Including squared terms shows that for very high households, the trend effect of farm income 2012 would be negative, but even for the richest farmers in our sample, the mathematical effect of farm income is positive.

Few other variables have to be interpreted differently using levels as left-hand side variables: female-headed households have less business income. As it is only corrected for whether a household runs a business or not and not for the income from business activities in the first survey wave, it is possible and probable that businesses run by female-headed households are less profitable in general, but to further investigate this possible explanation goes beyond the scope of this thesis. The coefficients of the 2012 employment and business dummies on employment and business income in 2015 are still significant now, yet of the opposite sign.

Table 13: Effects of lagged variables on the level of income from different sources in 2015

	(1) TI	(2) FI	(3) NFI	(4) EMPI	(5) BUSI
L3.age_hhh	1686.9*	902.5	784.4	674.0**	323.2
	(2.46)	(1.86)	(1.54)	(2.66)	(0.93)
L3.female_hhh	1679.2	261.5	1417.8	2218.1	-3023.7*
	(0.28)	(0.05)	(0.40)	(0.73)	(-1.99)
L3.shareofmen	-1997.4	-4319.4	2322.0	-787.7	1902.1
	(-0.20)	(-0.55)	(0.33)	(-0.19)	(0.49)
L3.indigenous	-3492.4	-5333.5	1841.2	1222.1	-851.0
	(-0.86)	(-1.54)	(0.76)	(0.93)	(-0.47)
L3.area_oilpalm	3835.7	3404.7*	430.9	297.2	-305.5
	(1.94)	(2.07)	(0.39)	(0.62)	(-0.40)
L3.area_rubber	1338.6	1792.8	-454.2	-393.9	129.4
	(1.00)	(1.38)	(-0.69)	(-1.08)	(0.34)
L3.onlyrubber	-1481.4	105.0	-1586.4	19.11	-1411.2
	(-0.33)	(0.03)	(-0.54)	(0.02)	(-0.71)
L3.farmincome_eqs	371.6**	0.319**	0.0525	35.09	-10.97
	(2.93)	(2.87)	(0.71)	(1.02)	(-0.26)
L3.nonfarmincome_eqs	326.6	0.0234	0.303	274.4**	-3.871
	(1.44)	(0.18)	(1.70)	(2.79)	(-0.04)
L3.business	6583.0	3388.4	3194.5	-3339.3*	6040.6**
	(1.35)	(0.93)	(0.95)	(-1.99)	(2.80)
L3.employment	-851.3	-2191.6	1340.3	2481.0*	-950.2
	(-0.22)	(-0.76)	(0.53)	(2.13)	(-0.56)
L3.takencredit_formal	8372.8	492.8	7880.0*	822.6	2973.0
	(1.76)	(0.15)	(2.22)	(0.57)	(1.55)
L3.takencredit_informal	764.9	-483.1	1248.0	1407.7	1.259
	(0.28)	(-0.28)	(0.58)	(1.42)	(0.00)
L3.householdassets	1917.0	1026.6	890.4	-771.8	1790.3
	(0.83)	(0.69)	(0.46)	(-1.11)	(1.33)
L3.vehicles	9537.5	-1452.8	10990.3***	1977.8	9222.1***
	(1.92)	(-0.36)	(3.44)	(1.43)	(4.04)
L3.transvillage	-4114.9	-1905.0	-2209.9	-1204.5	-3433.4
	(-0.87)	(-0.54)	(-0.63)	(-0.75)	(-1.71)
L3.oilpalmvillage	8674.7	7609.3	1065.4	4418.4**	181.5
	(1.36)	(1.90)	(0.20)	(2.69)	(0.08)
L3.farmincome_eqs_2	-1.167***	-0.000954**	-0.000212	-0.0321	-0.0611
	(-3.43)	(-3.15)	(-1.06)	(-0.31)	(-0.49)
L3.nonfarmincome_eqs_2	-0.117	-0.0000490	-0.0000681	-0.951**	1.011**
	(-0.13)	(-0.07)	(-0.12)	(-2.90)	(3.28)
L3.area_oilpalm_2	15.22	52.47	-37.25	-16.15	-7.529
	(0.32)	(1.36)	(-1.31)	(-1.28)	(-0.43)
L3.area_rubber_2	114.7***	114.2***	0.483	4.596	-10.00
	(5.01)	(5.87)	(0.03)	(0.68)	(-1.19)
L3.age_hhh_2	-19.74**	-10.83*	-8.906	-7.077**	-3.603
	(-2.89)	(-2.18)	(-1.81)	(-2.82)	(-1.09)
_cons	-19602.5	-9449.4	-10153.1	-10941.2	-3696.6
	(-1.22)	(-0.92)	(-0.76)	(-1.78)	(-0.44)
N	642	642	642	642	642
adj. R^2	0.368	0.436	0.117	0.103	0.212

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

If the same models are repeated reducing the sample to farmers who cultivated only rubber in 2012, the same patterns of convergence in income can be found. Again, the squared farm size has a positive effect on farm income. More vehicles are associated with a higher business income. Living in an oil palm village is now not associated with a higher employment income anymore. If clustered standard errors are used instead of regular robust standard errors, village effects show up significant in the regressions. Using clusterisation, living in a transmigrant village is associated with lower business income and living in an oil palm village is associated with a higher farm, employment and total income.

Table 14: Effects on the change in income from different sources, only rubber farmers

	(1) Change in TI	(2) Change in FI	(3) Change in NFI	(4) Change in EMPI	(5) Change in BUSI
age_hhh	1000.0	642.1	357.9	363.0	119.1
	(1.45)	(1.24)	(0.63)	(1.24)	(0.25)
female_hhh	-3224.2	-5255.7	2031.5	2457.5	-2499.0
	(-0.67)	(-1.95)	(0.48)	(0.71)	(-1.28)
shareofmen	1231.2	-1984.8	3216.0	-1375.8	2407.8
	(0.11)	(-0.21)	(0.43)	(-0.31)	(0.52)
indigenous	-3829.9	-6419.5	2589.5	1551.0	151.3
	(-0.86)	(-1.58)	(0.99)	(1.03)	(0.08)
area_rubber	2246.4	1480.2	766.2	119.6	588.5
	(1.49)	(0.94)	(1.15)	(0.25)	(1.44)
farmincome_eqs	-621.2***	-593.6***	-27.54	-13.34	4.093
	(-4.30)	(-4.25)	(-0.48)	(-0.49)	(0.09)
nonfarmincome_eqs	-577.3**	50.53	-627.8***	-291.7**	-429.8***
	(-2.71)	(0.46)	(-3.49)	(-2.87)	(-3.50)
business	-63.31	-1164.9	1101.6	6129.2**	-5512.9**
	(-0.01)	(-0.48)	(0.28)	(2.66)	(-2.66)
employment	-144.0	-894.2	750.2	-4054.7**	4852.9*
	(-0.05)	(-0.41)	(0.32)	(-3.20)	(2.57)
takencredit_formal	4545.5	-2665.1	7210.6*	1733.0	2879.7
	(1.03)	(-0.80)	(2.49)	(1.15)	(1.33)
takencredit_informal	4251.6	857.7	3393.9	1827.4	780.8
	(1.39)	(0.47)	(1.32)	(1.52)	(0.41)
householdassets	3688.6	922.2	2766.4	5.067	1707.8
	(1.48)	(0.67)	(1.27)	(0.01)	(0.83)
vehicles	15171.6	1712.9	13458.8*	207.5	11897.4**
	(1.84)	(0.30)	(2.48)	(0.08)	(2.79)
transvillage	-6842.6	-3774.1	-3068.5	-235.4	-3259.7
	(-1.52)	(-0.91)	(-0.95)	(-0.11)	(-1.59)
oilpalmvillage	15025.9	12578.2	2447.7	404.5	1411.4
	(1.63)	(1.35)	(0.77)	(0.24)	(0.38)
farmincome_eqs_2	-1.213***	-1.134***	-0.0792	0.0140	-0.106
	(-3.48)	(-3.35)	(-0.53)	(0.18)	(-0.89)
nonfarmincome_eqs_2	-0.997	-0.747	-0.250	0.986**	-0.900*
	(-1.46)	(-1.83)	(-0.46)	(3.17)	(-2.36)
area_rubber_2	92.28***	117.3***	-25.02	-4.735	-19.40*
	(3.76)	(5.20)	(-1.87)	(-0.55)	(-2.00)
age_hhh_2	-11.49	-7.194	-4.294	-4.112	-1.593
	(-1.67)	(-1.34)	(-0.78)	(-1.43)	(-0.36)
_cons	-13050.3	-5964.0	-7086.3	-4011.8	-2614.3
	(-0.85)	(-0.55)	(-0.54)	(-0.56)	(-0.24)
N	402	402	402	402	402
adj. R^2	0.612	0.643	0.246	0.110	0.348

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 15: Effects of lagged variables on the level of income from different sources in 2015, only rubber farmers

	(1) TI	(2) FI	(3) NFI	(4) EMPI	(5) BUSI
L3.age_hhh	1000.0	642.1	357.9	448.9	-11.57
	(1.45)	(1.24)	(0.63)	(1.55)	(-0.03)
L3.female_hhh	-3224.2	-5255.7	2031.5	2866.3	-2706.2
	(-0.67)	(-1.95)	(0.48)	(0.82)	(-1.40)
L3.shareofmen	1231.2	-1984.8	3216.0	-1543.9	3372.6
	(0.11)	(-0.21)	(0.43)	(-0.33)	(0.82)
L3.indigenous	-3829.9	-6419.5	2589.5	1092.2	849.7
	(-0.86)	(-1.58)	(0.99)	(0.70)	(0.43)
L3.area_rubber	2246.4	1480.2	766.2	220.6	451.2
	(1.49)	(0.94)	(1.15)	(0.44)	(1.07)
L3.farmincome_eqs	378.8**	0.406**	-0.0275	-19.17	10.73
	(2.62)	(2.91)	(-0.48)	(-0.68)	(0.25)
L3.nonfarmincome_eqs	422.7*	0.0505	0.372*	290.9**	-54.16
	(1.98)	(0.46)	(2.07)	(2.64)	(-0.58)
L3.business	-63.31	-1164.9	1101.6	-3444.5	4652.9*
	(-0.01)	(-0.48)	(0.28)	(-1.38)	(2.53)
L3.employment	-144.0	-894.2	750.2	1805.7	-759.4
	(-0.05)	(-0.41)	(0.32)	(1.37)	(-0.47)
L3.takencredit_formal	4545.5	-2665.1	7210.6*	1943.8	2548.9
	(1.03)	(-0.80)	(2.49)	(1.23)	(1.24)
L3.takencredit_informal	4251.6	857.7	3393.9	1063.2	1467.5
	(1.39)	(0.47)	(1.32)	(0.87)	(0.74)
L3.householdassets	3688.6	922.2	2766.4	-61.59	1832.5
	(1.48)	(0.67)	(1.27)	(-0.08)	(0.90)
L3.vehicles	15171.6	1712.9	13458.8*	-37.54	12408.8**
	(1.84)	(0.30)	(2.48)	(-0.01)	(3.09)
L3.transvillage	-6842.6	-3774.1	-3068.5	-160.6	-3448.4
	(-1.52)	(-0.91)	(-0.95)	(-0.07)	(-1.74)
L3.oilpalmvillage	15025.9	12578.2	2447.7	-767.7	2523.0
	(1.63)	(1.35)	(0.77)	(-0.44)	(0.78)
L3.farmincome_eqs_2	-1.213***	-0.00113***	-0.0000792	0.0486	-0.136
	(-3.48)	(-3.35)	(-0.53)	(0.50)	(-1.04)
L3.nonfarmincome_eqs_2	-0.997	-0.000747	-0.000250	-0.878**	1.091***
	(-1.46)	(-1.83)	(-0.46)	(-2.61)	(3.60)
L3.area_rubber_2	92.28***	117.3***	-25.02	-4.542	-19.25
	(3.76)	(5.20)	(-1.87)	(-0.50)	(-1.96)
L3.age_hhh_2	-11.49	-7.194	-4.294	-5.256	0.0630
	(-1.67)	(-1.34)	(-0.78)	(-1.83)	(0.01)
_cons	-13050.3	-5964.0	-7086.3	-5432.4	-878.6
	(-0.85)	(-0.55)	(-0.54)	(-0.77)	(-0.08)
N	402	402	402	402	402
adj. R^2	0.443	0.497	0.187	0.071	0.191

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Next, to develop a better understanding of how to interpret the coefficients for different variables, a model will be calculated where the dependent variable is the percentage change in income. Calculating a percentage change is only reasonable and possible for households whose initial income is larger than zero. Out of the sample, 19 households had an income of less than zero in 2012. 100 households had a negative farm income (caused by e.g. immature trees or replanting activities) and 8 households had a negative non-farm income. It is thinkable that fewer farmers actually lose money with their farming activities, but appear to do so due to overestimating input and labour costs. The sample size in the new set of regression models differs between the models depending on the chosen dependent variable.

Table 16: Effects of lagged variables on the percentage change of income from different sources

	(1) TI	(2) FI	(3) NFI	(4) EMPI	(5) BUSI
L3.age_hhh	-0.109	0.228	0.243	-0.329	0.223
	(-0.49)	(1.92)	(0.62)	(-0.89)	(1.29)
L3.female_hhh	3.116	-0.563	1.942	1.306	-1.281
	(1.14)	(-0.76)	(0.64)	(1.50)	(-1.14)
L3.shareofmen	3.458*	-0.239	7.521	3.736	0.779
	(2.29)	(-0.17)	(1.90)	(1.31)	(0.37)
L3.indigenous	0.215	-1.418	-0.569	-1.646	0.449
	(0.33)	(-1.28)	(-0.26)	(-1.36)	(0.37)
L3.area_oilpalm	0.275	0.430	0.350	-0.402	-0.151
	(1.88)	(1.52)	(0.54)	(-0.74)	(-0.43)
L3.area_rubber	0.582*	1.054	0.0443	-0.132	0.335
	(2.23)	(1.90)	(0.15)	(-0.65)	(0.95)
L3.onlyrubber	-0.402	-0.145	2.025	0.0127	-0.897
	(-0.57)	(-0.14)	(1.47)	(0.02)	(-0.71)
L3.farmincome_eqs	-0.0962***	-0.108**	-0.0614	-0.00263	0.00527
	(-3.81)	(-2.63)	(-1.55)	(-0.27)	(0.26)
L3.nonfarmincome_eqs	-0.0849**	0.0148	-0.201***	-0.255*	-0.0779*
	(-2.99)	(0.74)	(-4.74)	(-1.99)	(-2.34)
L3.business	0.268	0.415	-8.061**	0.653	
	(0.32)	(0.65)	(-2.93)	(1.54)	
L3.employment	-0.552	0.0449	-13.27***		1.107
	(-0.99)	(0.10)	(-3.48)		(0.99)
L3.takencredit_formal	1.344	-0.662	1.874	0.245	2.145
	(1.46)	(-1.46)	(1.23)	(0.60)	(1.90)
L3.takencredit_informal	0.489	-0.131	6.682*	-0.268	-1.078
	(0.57)	(-0.21)	(1.99)	(-0.41)	(-1.13)
L3.householdassets	0.769	0.507	1.080	0.394	0.874*
	(1.67)	(1.20)	(0.95)	(0.84)	(2.08)
L3.vehicles	0.201	-0.203	1.466	-0.120	0.640
	(0.31)	(-0.31)	(1.46)	(-0.32)	(1.26)
L3.transvillage	0.0440	-0.627	-3.386	-1.758	-0.450
	(0.10)	(-1.01)	(-1.80)	(-1.95)	(-0.36)
L3.oilpalmvillage	1.132	1.531	1.709	0.905*	2.224
	(1.39)	(1.11)	(0.94)	(1.98)	(1.39)
L3.farmincome_eqs_2	0.000219**	0.000181**	0.000155	0.00000255	-0.0000429
	(3.14)	(2.89)	(1.36)	(0.09)	(-0.65)
L3.nonfarmincome_eqs_2	0.000215*	-0.000112	0.000564***	0.00376	0.000191*
	(2.30)	(-1.10)	(4.20)	(1.79)	(2.10)
L3.area_oilpalm_2	-0.00403	-0.00743	-0.0109	0.0450	0.00124
	(-1.25)	(-1.14)	(-0.68)	(0.69)	(0.15)
L3.area_rubber_2	-0.00805	-0.00696	-0.00434	0.0191	-0.00686
	(-1.95)	(-0.63)	(-0.77)	(0.77)	(-1.06)
L3.age_hhh_2	0.000814	-0.00226	-0.00309	0.00288	-0.00274
	(0.39)	(-1.86)	(-0.82)	(0.83)	(-1.51)
_cons	2.565	-4.568*	7.164	10.53	-4.787
	(0.46)	(-2.56)	(0.87)	(1.08)	(-1.28)
N	623	529	432	298	125
adj. R^2	0.099	0.153	0.147	0.059	0.074

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The share of men in working age in 2015 has a strong positive effect on the development of non-farm income this time. For nearly all farmers, the area of rubber plantation is associated with a decrease in total income. Using clustered standard errors, the area of oil palm also has a significant effect. After the inclusion of squared terms, the effect of 2012 income depends on the amount of income; for the clear majority of households, the estimated effect would be positive. Farmers residing in transmigrant villages decreased their earnings from employment. This might be related to a decrease in labour demand as it was found in an earlier part of this thesis. As oil palm villages are controlled for, the effect of the transmigrant village dummy is driven by rubber-dominated transmigrant villages. In oil palm villages, the farm income developed more positively. Households which have members employed or running a business lose income between the two survey rounds whereas taking informal credit is associated with an increase in non-farm income. The dummy for farmers only cultivating rubber has no significant coefficient again. Unfortunately, the explanatory power as measured by the adjusted R-squared of all models is quite low.

To further exploit the panel structure of our data, other panel data models can be used. A Hausman test rejects the null hypothesis that the difference in coefficients retrieved from a random effects model and from a fixed effects model is not systematic which implies that the error term is correlated with unobserved time-invariant heterogeneity. Hence, the random effects (RE) estimator is not consistent and the model has to be estimated using fixed effects (FE). In an FE model all time-invariant variables drop out of the equation. This includes all village variables. We will see in table 17 whether the FE model can shed more light on the story. Dependent variables are now total income, farm income and non-farm income; a year dummy is included which takes the value one if the year is 2015. Its coefficient is negative and significantly different from zero for farm income and total income. When letting the year dummy interact with the dummy for households only cultivating rubber, the dummy's coefficient itself is not significant anymore and the interaction term is significantly related to a lower farm income. This would mean that only farmers relying on rubber cultivation were worse off in 2015.

Table 17: Fixed effects model

	(1) TI	(2) TI	(3) FI	(4) FI	(5) NFI	(6) NFI
year2015	-6395.0*	-4820.0	-5.357**	-1.653	-1.038	-3.167
	(-2.55)	(-1.17)	(-2.84)	(-0.46)	(-0.60)	(-1.42)
age_hhh	-235.7	-342.2	0.123	0.0415	-0.359	-0.384
	(-0.22)	(-0.32)	(0.14)	(0.05)	(-0.49)	(-0.50)
female_hhh	1559.4	2291.3	5.045	6.144	-3.485	-3.853
	(0.24)	(0.35)	(0.91)	(1.09)	(-0.89)	(-1.01)
shareofmen	14999.6*	14756.9*	7.928	7.616	7.072*	7.141*
	(2.22)	(2.20)	(1.28)	(1.24)	(2.49)	(2.50)
area_oilpalm	4600.6*	4210.1	5.167**	4.701*	-0.566	-0.491
	(2.00)	(1.70)	(2.69)	(2.28)	(-0.56)	(-0.48)
area_rubber	7304.0**	7018.4**	5.986*	5.755*	1.319	1.264
	(2.73)	(2.63)	(2.25)	(2.15)	(1.94)	(1.87)
onlyrubber	35843.2	35864.4	-0.377	0.245	36.22	35.62
	(1.41)	(1.40)	(-0.04)	(0.03)	(1.38)	(1.36)
business	16948.0***	11255.4	-2.996	-7.072	19.94***	18.33***
	(4.32)	(1.73)	(-1.05)	(-1.57)	(6.29)	(3.91)
employment	3675.4	2476.5	-5.114*	-5.516	8.789***	7.993***
	(1.20)	(0.68)	(-2.19)	(-1.94)	(4.80)	(3.44)
takencredit_formal	-511.2	-804.4	-1.036	-1.152	0.524	0.347
	(-0.15)	(-0.23)	(-0.35)	(-0.39)	(0.25)	(0.16)
takencredit_informal	-1936.7	-2027.2	-1.718	-1.866	-0.218	-0.161
	(-0.84)	(-0.88)	(-0.98)	(-1.06)	(-0.16)	(-0.12)
householdassets	4825.6	3726.6	1.848	0.816	2.977	2.911
	(1.70)	(1.27)	(0.75)	(0.31)	(1.76)	(1.72)
vehicles	483.1	-58.52	-1.427	-2.028	1.910	1.970
	(0.15)	(-0.02)	(-0.74)	(-1.03)	(0.85)	(0.88)
age_hhh_2	0.752	1.612	-0.00449	-0.00386	0.00524	0.00548
	(0.09)	(0.18)	(-0.59)	(-0.50)	(0.90)	(0.91)
int_onlyrubber		-5956.1		-7.015*		1.059
		(-1.59)		(-2.25)		(0.49)
int_business		9933.2		7.174		2.760
		(1.21)		(1.28)		(0.52)
int_employment		1624.8		-0.0794		1.704
		(0.32)		(-0.02)		(0.56)
_cons	-18669.2	-11667.8	5.611	10.78	-24.28	-22.45
	(-0.44)	(-0.27)	(0.23)	(0.44)	(-0.65)	(-0.57)
N	1322	1322	1322	1322	1322	1322
adj. R^2	0.121	0.126	0.119	0.127	0.177	0.176

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Households with a higher share of men in working age are able to gain a higher off-farm income. Most coefficients are as expected: households with a higher area under cultivation have a higher income, so do households who run a business. Households which have members employed (logically) have a higher non-farm income, but a lower farm income. It is likely that causality is reversed here and households with little farm income rather seek for alternative income sources. Also, there exists a trade-off between investing scarce labour time in own agricultural activities and wage employment.

To summarise the results of the different models, it seems, thus, that households with more land were better able to cope with the shock in terms of farm income. It made no difference, on the other hand, whether a household only cultivates rubber or another crop in addition. As the group of households only cultivating rubber differs along different characteristics from those farmers cultivating other crops (less migrants including transmigrants, lower total area under cultivation), these characteristics might be a better explanation for observed differences in development. Living in a village dominated by oil palm cultivation was associated with a significantly better development of income in some models, though. Particularly employment income developed more positively for households living in oil palm villages. However, this can also mean that employment income is getting lower in rubber-dominated villages as it is also indicated by the decrease in rubber farmers' labour costs. Households with more motorized vehicles and those which receive credit also seem to be better able to cope with the shock through increased off-farm income. A higher share of men in working age helps to generate off-farm income, while income from employment and business activities does not appear to have a significant influence on total income development as they can be related to lower farm income. The fact that farmers cultivating oil palm have more land on average is related to the relatively lower labour-intensity of oil palm. As we saw in section 6, after the price drop, the income per hectare was about the same for oil palm and rubber farmers, but the income per hour of work was clearly smaller for rubber farmers.

8.3 Self-reported reactions to the price shock

In the 2015 survey, rubber farmers were asked directly whether they applied any of nine given measures or other measures not listed explicitly in the questionnaire in order to cope with the rubber price shock. An overview of the different strategies is given in section 7. Multivariate regressions shall now help to get a better understanding of who was able to apply which coping strategy. In table 18, logit regressions were performed using dummies for the two common ways to cope as dependent variables, namely whether farmers reduced farm inputs and whether farmers reduced savings.

Table 18: Reactions to the price decrease

	(1) Decreased savings	(2) Reduced inputs
L3.age_hhh	1.044	1.047
	(0.68)	(0.86)
L3.female_hhh	0.338*	0.777
	(-2.47)	(-0.60)
L3.shareofmen	1.172	1.661
	(0.20)	(0.79)
L3.indigenous	0.803	1.011
	(-0.70)	(0.05)
L3.area_oilpalm	0.598	0.744
	(-0.74)	(-0.83)
L3.area_rubber	1.242*	1.109
	(2.46)	(1.86)
L3.onlyrubber	0.395	0.767
	(-1.16)	(-0.53)
L3.farmincome_eqs	1.000	1.000
	(-0.49)	(0.10)
L3.nonfarmincome_eqs	1.000	1.000
	(-0.66)	(0.43)
L3.business	0.586	0.942
	(-1.45)	(-0.19)
L3.employment	1.187	1.082
	(0.58)	(0.34)
L3.takencredit_formal	1.492	0.951
	(1.18)	(-0.20)
L3.takencredit_informal	1.843	0.729
	(1.81)	(-1.34)
L3.householdassets	1.386*	1.162
	(2.01)	(1.23)
L3.vehicles	0.938	1.250
	(-0.21)	(0.81)
L3.transvillage	0.773	2.637***
	(-0.71)	(3.34)
L3.oilpalmvillage	0.785	0.819
	(-0.45)	(-0.47)
L3.farmincome_eqs_2	1.000	1.000
	(0.61)	(0.58)
L3.nonfarmincome_eqs_2	1.000	1.000
	(0.47)	(0.14)
L3.area_oilpalm_2	1.115	1.045
	(0.83)	(0.97)
L3.area_rubber_2	0.995	0.996*
	(-1.11)	(-2.09)
L3.age_hhh_2	0.999	0.999
	(-0.90)	(-1.08)
N	528	528

Exponentiated coefficients; *z* statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Four of five households mentioned having reduced household savings as a response to the fall in rubber prices. While the extraordinarily high percentage of respondents answering with "yes" to this question might be partly due to the fact that it is the first question asked, it is nevertheless plausible that in fact, many households reduced savings in the face of the shock. Table 18 gives more information about which were the households who reduced savings. Apparently, female-lead households were less prone to reducing savings. The more hectares of rubber cultivations households had, the more households reduced savings. Households who took informal credit and who owned more household assets were more likely to do so as well. In interpreting these results, one has to keep in mind that of course only those households who had savings in 2012 could reduce them. Unfortunately, data on savings is not available for 2012, but probably assets and business are correlated with 2012 savings as only richer farmers are able to accumulate savings. For opening a business, a certain amount of savings is necessary and assets can be interpreted as “frozen” savings.

Nearly two thirds of farmers reported having reduced inputs between the two survey waves as a reaction to the price shock. Descriptive statistics have also shown that this was the case on average. Possibly, all groups of farmers reduced inputs similarly, at least nearly none of the coefficients in the second column model is significant. Yet, the more land a household has under rubber cultivation, the higher is the chance that it reduced inputs, while this is less so, the larger the area in oil palm. The only other significant coefficient is the one for the dummy indicating whether a household lives in a transmigrant village. When including village dummies instead of the two variables of village characteristics used before, two more coefficients show up as significant at the ten percent level. Households with a higher share of men in working age are more likely to reduce inputs. On the contrary, households who took informal credit were less likely to do so. This can mean, however, that these were the households that applied inputs in the first place, as rubber is not very capital-intensive in general and many households applied very little inputs. The number of household members in working age might be directly related to some patterns of input use as the application of inputs always requires working hours, but at the same time some inputs (e.g. herbicides) can be a substitute for manual labour (in this case manual weeding).

9. Effects on consumption

In the last chapters, it was analysed how income developed for different groups of farmers in the face of the price decrease. Now, the analysis will turn to expenditure. Assuming decreasing marginal utility from consumption, households want to smooth consumption over different periods. Hence, temporary income shocks should have no influence on consumption expenditure. Testing whether consumption fell for rubber farmers thus also means testing whether farmers were able to mitigate effects of the price fall or not.

Consumption expenditure in the following tables and graphs is split into yearly food and non-food expenditure. 2012 expenditure data is reported in 2015 prices in order to be able to compare values for different years. For simplicity and acknowledging the fact that children's contribution to household consumption is generally larger than their contribution to household income, expenditure is not calculated per adult equivalent as it was done for income above, but total household expenditure was simply divided by household size. Expenditure data above is thus expenditure per capita.

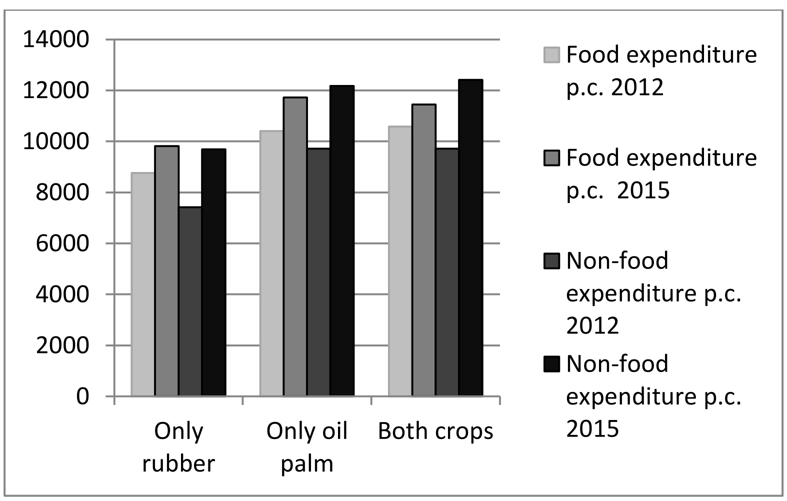

Figure 8: Expenditure by cultivated crops, in '000 Rupiah

When mean per capita expenditure is compared for different groups of farmers, it can be found that farmers cultivating oil palm indeed have a higher consumption growth. Yet, all groups including those households only cultivating rubber have a higher food and non-food expenditure in 2015 than three years before.

At the village level, the differences in consumption growth are even more pronounced. Yearly food expenditure grew by about 22 percent for oil palm villages, but only for about 11 percent for other villages. Non-food expenditure grew by about 43 percent for oil palm villages and by about 28 percent for other villages.

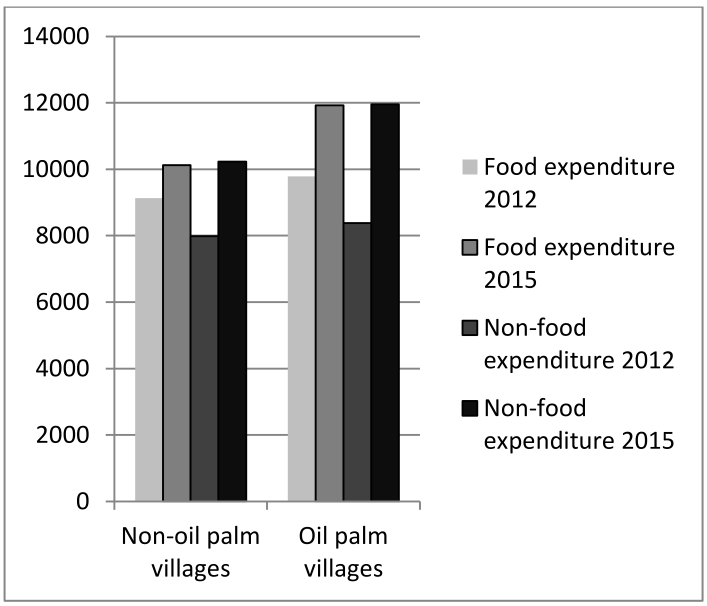

Figure 9: Expenditure by type of village, in '000 Rupiah

In order to analyse how different groups of households developed regarding consumption and how consumption growth depended on income growth, the regressions that were reported using income as the dependent variable will be repeated with consumption as the dependent variable and including income as an explanatory variable.

Table 19: Effects on percentage consumption growth

	(1)	(2)	(3)	(4)
	pct_food	pct_food	pct_nonfood	pct_nonfood
age_hhh	0.112***	0.103***	0.163**	0.152**
	(5.41)	(4.94)	(3.03)	(2.77)
female_hhh	0.205	0.198	-0.381	-0.390
	(0.79)	(0.82)	(-0.74)	(-0.75)
shareofmen	0.531	0.557	0.535	0.560
	(1.44)	(1.54)	(0.65)	(0.68)
indigenous	0.0669	0.0905	-0.219	-0.196
	(0.59)	(0.78)	(-0.85)	(-0.76)
area_oilpalm	0.0423	0.0186	0.0502	0.0260
	(1.25)	(0.53)	(0.49)	(0.25)
area_rubber	0.0272	0.0181	-0.0404	-0.0492
	(0.59)	(0.42)	(-0.59)	(-0.71)
onlyrubber	-0.0162	-0.0153	0.383	0.385
	(-0.11)	(-0.10)	(1.28)	(1.30)
farmincome_eqs	-0.00000546*	-0.00000128	-0.00000418	-2.73e-09
	(-2.50)	(-0.38)	(-0.75)	(-0.00)
nonfarmincome_eqs	-0.00000677	-0.00000374	0.00000274	0.00000633
	(-1.09)	(-0.59)	(0.14)	(0.31)
business	0.112	0.0775	0.530	0.494
	(0.61)	(0.46)	(0.95)	(0.88)
employment	0.0604	0.0718	-0.357	-0.347
	(0.43)	(0.51)	(-0.98)	(-0.95)
takencredit_formal	-0.109	-0.150	-0.339	-0.386
	(-0.96)	(-1.34)	(-1.12)	(-1.28)
takencredit_informal	0.0712	0.0663	-0.644***	-0.649***
	(0.67)	(0.63)	(-3.38)	(-3.42)
householdassets	-0.0511	-0.0605	0.136	0.126
	(-1.00)	(-1.19)	(0.89)	(0.82)
vehicles	0.0683	0.0230	0.263	0.209
	(0.55)	(0.18)	(0.70)	(0.56)
transvillage	0.247	0.268	-0.0141	0.00937
	(1.69)	(1.80)	(-0.04)	(0.03)
oilpalmvillage	0.0228	-0.0338	0.00756	-0.0501
	(0.15)	(-0.22)	(0.02)	(-0.17)
farmincome_eqs_2	7.84e-12	1.49e-11*	-1.21e-13	7.17e-12
	(1.33)	(2.51)	(-0.01)	(0.40)
nonfarmincome_eqs_2	2.80e-11	2.89e-11	-2.34e-11	-2.26e-11
	(1.52)	(1.58)	(-0.36)	(-0.34)
area_oilpalm_2	-0.00129	-0.00147	-0.00241	-0.00257
	(-1.56)	(-1.75)	(-1.02)	(-1.06)
area_rubber_2	-0.000299	-0.00104	-0.000121	-0.000874
	(-0.37)	(-1.05)	(-0.10)	(-0.68)
age_hhh_2	-0.000962***	-0.000848***	-0.00137*	-0.00125*
	(-4.57)	(-4.05)	(-2.57)	(-2.27)
change_FIEQS		0.00000646		0.00000653
		(1.84)		(1.49)
change_NFIEQS		0.00000467		0.00000545
		(1.90)		(1.35)
_cons	-2.914***	-2.798***	-3.458**	-3.336*
	(-6.68)	(-6.41)	(-2.61)	(-2.50)
N	639	639	639	639
adj. R^2	0.065	0.094	0.026	0.029

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 20: Random effects model of consumption

	(1)	(2)	(3)	(4)
	foodexp_pc	foodexp_pc	nonfoodexp_pc	nonfoodexp_pc
year2015	519.2	267.8	1203.5	2530.3
	(1.62)	(0.27)	(1.63)	(1.31)
farmincome_eqs	0.0646***	0.0681***	0.132	0.134
	(5.46)	(5.71)	(1.75)	(1.81)
nonfarmincome_eqs	0.0849***	0.0876***	0.137**	0.138**
	(4.72)	(4.89)	(3.04)	(3.03)
age_hhh	-331.8***	-315.4***	125.7	146.2
	(-3.81)	(-3.70)	(1.02)	(1.21)
female_hhh	-1699.8**	-1732.8**	-907.0	-783.7
	(-3.24)	(-3.28)	(-0.98)	(-0.84)
shareofmen	7275.3***	7056.1***	7307.8**	7133.8**
	(7.68)	(7.76)	(2.76)	(2.81)
indigenous	-33.40	-45.46	-508.1	-600.3
	(-0.09)	(-0.12)	(-0.60)	(-0.72)
area_oilpalm	33.79	16.35	264.5	249.3
	(0.28)	(0.14)	(0.75)	(0.70)
area_rubber	-210.0*	-229.7*	-1192.7	-1206.8*
	(-2.17)	(-2.36)	(-1.95)	(-2.00)
onlyrubber	-425.5	-538.0	480.4	277.9
	(-0.94)	(-0.99)	(0.52)	(0.25)
business	-213.5	184.6	-140.1	303.7
	(-0.51)	(0.31)	(-0.11)	(0.16)
employment	-802.4*	-401.8	-2017.9*	-749.8
	(-2.05)	(-0.89)	(-2.32)	(-0.94)
takencredit_formal	186.0	242.0	179.2	241.3
	(0.44)	(0.58)	(0.21)	(0.29)
takencredit_informal	-313.1	-383.1	143.7	179.7
	(-0.84)	(-1.01)	(0.23)	(0.29)
householdassets	409.9*	388.2	1216.9**	1199.3**
	(2.11)	(1.95)	(2.83)	(2.78)
vehicles	541.5	591.5	3148.2**	3185.5**
	(1.50)	(1.64)	(2.97)	(2.98)
transvillage	737.4	-538.4	198.6	164.6
	(1.42)	(-1.04)	(0.19)	(0.16)
oilpalmvillage	-127.5	-19.00	-864.0	-888.5
	(-0.21)	(-0.03)	(-0.72)	(-0.65)
farmincome_eqs_2	-0.000000165***	-0.000000174***	-0.000000552	-0.000000559
	(-4.97)	(-4.97)	(-1.45)	(-1.47)
nonfarmincome_eqs_2	-0.000000233***	-0.000000244***	-0.000000411*	-0.000000413*
	(-4.15)	(-4.35)	(-2.54)	(-2.52)
area_oilpalm_2	-2.339	-2.224	-2.593	-2.337
	(-0.61)	(-0.57)	(-0.32)	(-0.28)
area_rubber_2	14.05***	14.35***	108.2***	108.5***
	(3.60)	(3.66)	(3.40)	(3.44)
age_hhh_2	2.991***	2.831***	-2.076	-2.303
	(3.58)	(3.45)	(-1.71)	(-1.94)
int_onlyrubber		226.1		365.3
		(0.25)		(0.20)
int_business		-741.2		-842.5
		(-0.92)		(-0.39)
int_employment		-811.9		-2637.8*
		(-1.26)		(-1.96)
int_transvillage		2527.8**		-164.1
		(3.18)		(-0.08)
int_oilpalmvillage		-216.6		238.6
		(-0.19)		(0.14)
_cons	12543.1***	12418.3***	198.4	-651.6
	(5.78)	(5.66)	(0.07)	(-0.22)
N	1322	1322	1322	1322

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The explanatory power of the models is very low. Neither cultivated area nor any village nor most household characteristics are significantly related to a higher or lower consumption growth. Age is positively related to consumption growth, but its effect decreases with the age of the household head. Having taken informal credit is associated with a significantly lower non-food consumption growth. While non-farm income is not significantly associated with consumption growth, farm income is to some extent and its influence is positive for most farmers. Changes in income are significantly related to changes in food consumption at the ten percent significance level (at the five percent level using clustered standard errors), but not to non-food consumption. Also, if the sample is reduced to farmers only cultivating rubber, results do not differ much. Using clustered standard errors, living in a transmigrant village is associated with a higher growth in expenditure for food consumption, however.

To further exploit the panel nature of our data, an RE model is estimated whose results can be found in table 20. This time, a Hausman test has found the RE estimator to be consistent. Note that the dependent variables are now levels of expenditure for food and non-food items and not growth rates anymore. In this model, it can be shown that there is a strong connection between income and expenditure. Also, households with more assets spend more. Households with a little area of rubber cultivation consume less whereas those with a bigger area consume more.

Again, a dummy for the year 2015 is included which is significantly positive at the ten percent level only if its interaction terms are left out of the model. These show that in 2015, households with employment had a lower consumption and households who lived in transmigrant villages had a higher consumption. Interestingly, unlike when income was modelled, none of the village variables alone are significant now. The age of the household head is related to higher food consumption, but less so for very old households. Again, the turning point from which the statistical effect of an additional year on expenditure would be negative is very high at over 100 years. Female-headed households spend less on food and households with a higher share of men in working age consume more of both, food and non-food items. The circumstance that female-headed households spend less on food is fairly surprising as evidence from other literature regularly points out that women spend more on nutrition, on average. The underlying reason might be that female-headed households are generally marginalised to a certain degree which limits their consumption options.

Overall, it could be found that indeed richer households, both in terms of income and assets, consume more and that especially smaller rubber farmers are consumption-poor. Households in transmigrant villages had better options to increase their food consumption between the two survey rounds.

10. Discussion

In this section, the results from the sections above shall be collected and analysed and policy implications shall be identified. While rubber farmers lost a substantial part of their income due to the price fall, a more detailed analysis has shown that the impact is highly heterogeneous and that different groups of farmers had different coping possibilities. Off-farm income played a large role for rubber farmers especially in offsetting decreased farm income. Regression models have shown that households with more assets, households with access to credit and households with more men in working age were better able to increase off-farm income.

Differences in income and consumption growth were even more pronounced when differentiating between village categories by dominant crop. This points at the local macroeconomic effects of the price development. When the aggregate income and labour demand fall, farmers also have fewer opportunities to receive income from employment or business opportunities. Hence, in villages dominated by oil palm cultivation, also rubber farmers were better able to offset their loss through higher non-farm income. Farmers who already had a business or employment in 2012 did not perform better than those who only relied on their independent agriculture before. It seems that indeed other characteristics, notably the location, were more important in determining which farmers could increase their off-farm income.

The described patterns of income development highlight the importance for regional development policy to diversify sources of income at the village level. The expansion of oil palm has had tremendous benefits for Jambi's rural economy in this regard. The dimension of the crisis would clearly be much more severe if the economy relied on rubber cultivation only. While income generated from rubber cultivation per unit of labour is significantly lower than income generated from oil palm cultivation after the price fall, income per hectare is now roughly equal for both crops. Yet, it was mostly oil-palm-dominated and often transmigrant-dominated villages which benefitted from the oil palm boom. To increase the resilience of local farmers and agricultural labourers toward price shocks, future expansion plans have to aim at limiting the clusterisation of different cultivation systems. Another conclusion policy makers might draw from the results is to increase microcredit schemes as it has been shown that credit-rationed farmers had more difficulties in coping with the farm income shock by increasing off-farm income. This finding could be based on reverse causality, however, as credit-rationed households might have been the more precarious households in the first place and hence were not classified as credit-worthy. Expansion of credit schemes to formerly credit-rationed households does not come without risks and should be done carefully.

The most common ways rubber farmers responded to the price decrease were by reducing savings and decreasing inputs. Especially poorer farmers had to reduce inputs and are doomed to remain at a relatively low productivity level. Furthermore, labour costs were reduced to an extent that goes well beyond the decrease expected due to sharecropping arrangements. Meanwhile, oil palm farmers faced higher labour costs. Nevertheless, richer farmers lost more income than poorer farmers. There seems to be a strong convergence trend regarding income. At the same time, a larger area was associated with income gains, possibly through the sale of land, crop changes or improved access to credit.

The results indicate the possible existence of an "input poverty trap" that forces farmers to reduce inputs like fertilisers not out of considerations about the ideal input quantities, but out of sheer financial need. Subsidisation of and credit for fertilisers and other inputs could hence possibly help farmers to overcome the vicious cycle of poor yields and low input use. Such measures have to be handled with great care, whatsoever. While plot-level data of inputs and yields in 2012 show that farmers did generally not overuse fertilisers, this analysis neglects the long-run effects of fertilisation on soil and water quality. Any policy aiming at altering input use and other agricultural practises should be based on rigorous evidence from modern agricultural research and best practises.

Even though consumption growth was correlated with income growth on the household level, average consumption expenditure increased for all groups of households, but more for oil palm farmers and in oil palm villages. This can be an indicator for successful coping through dissaving, but caution has to be taken in order not to take any immature conclusions. Possibly, consumption data was asked for more rigorously in the second survey. Another limitation to interpretations is that prices were transformed to 2015 levels using national inflation rates. As smallholder farmers consume only few products and a big part of their income is spent on staple foods, a higher inflation rate for this type of products would overestimate consumption growth by construction.

11. Conclusions and outlook

The effects of a fall in rubber prices by about 50 percent on smallholder rubber farmers were analysed using a sample of 642 Sumatran smallholder farmers cultivating rubber, oil palm or both crops. Results indicate that rubber farmers indeed lost a substantial part of their farm income due to the output price shock. However, income decreases were much lower than expected, both for farm income and for total income. Farm income fell less than expected, because rubber farmers reduced input and labour costs. While in the short run, using less inputs can be a successful coping strategy, the long-run effects of e.g. less fertilization on yields could potentially offset the short-term gains. Average total income of rubber farmers decreased only little, as losses in farm income could be compensated for by gains in off-farm income from employment or business activities.

Whether farmers managed to cope with the price decrease did not only depend on household characteristics but also on village characteristics. Farmers in oil-palm dominated villages had better opportunities to increase non-farm income mostly from employment. Rubber famers in oil palm villages could find work as agricultural labour in oil palm plantations, while farmers in rubber-dominated villages suffered from the decrease of local aggregate demand. Apart from locational effects, farmers with more assets and with access to credit along with farmers with a higher share of men in working age in their households were better able to increase income from non-farm activities.

Despite the crisis, all groups of farmers managed to increase consumption of both food and non-food products, on average. For rubber farmers, reducing savings was an important strategy for coping with the price shock and mitigating effects of fallen farm revenue on consumption. Income growth and consumption growth are correlated and thus, consumption increased more in oil palm-dominated villages.

The results from a representative sample of smallholder farmers from the lowlands of Jambi, Indonesia, potentially help to better understand the possibilities smallholder farmers have in coping with a severe output price shock. The study region is particularly convenient to analyse the effects of an output price shock as virtually all farmers depend on the cultivation of either one or both of two crops. The results are relevant for many regions around the world where rural economies depend on the cultivation of one or few, often perennial, crops.

Findings from Jambi could motivate policy makers in the fields of regional planning and land use management to keep in mind that a high dependence on one crop is the riskier for individual households, the more the village and the region they live in depends on the cultivation of this crop. Income diversification can help to reduce risks at all levels of administrative units. The expansion of oil palm has provided considerable benefits to the people of Jambi and has helped them to live through the rubber crisis without a wide-scale massive impoverishment. Further research is needed to better understand the effects of an output price crisis on local labour markets and non-agricultural households. Still, the benefits from oil palm cultivation should not conceal the unprecedented environmental damage that comes along with unsustainable practises of agricultural expansion in Indonesia.

Another observation highly relevant for improving agricultural practises in order to allow smallholder farmers to maintain and improve their livelihoods while minimizing environmental damages is that smallholder rubber farmers' input use heavily depends on their current economic situation. Nearly two thirds of farmers reported having reduced inputs in the face of the price decrease. The number of farmers who fertilise their rubber plots has halved. Identifying the optimal amount of fertilisation and the use of other inputs goes far beyond the scope of this work and is subject to research in the agricultural sciences. It can be concluded, whatsoever, that farmers use less inputs due to economic constraints instead of agricultural considerations. When particularly the poorer farmers have to decrease inputs, a poverty trap of little inputs and little yields might be the consequence.

Meanwhile, the worst appears to have passed for rubber farmers as world prices for natural rubber have recovered slightly. Between December 2015 and November 2016, the price increased by 50 percent (indexmundi 2016) while still lying far below 2012 levels. However, in our globalised world, everything is connected to everything and no one can foresee the price development for different crops over a longer time period. Improving the resilience of smallholder farmers not only to agricultural risks but also to market risks has to remain among the top priorities of local policy makers and decision makers in development cooperation as well as of agricultural researchers.

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I hereby declare that I wrote this present thesis paper independently, without assistance from external parties, and without use of other resources than those indicated. All information that are taken from other publications or sources in text or in meaning are duly acknowledged in the text. The two hard copies of the thesis are corresponding to the electronic version.

Göttingen, 27 January 2017