The Swiss wood market: estimating elasticities with time series simultaneous equations

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Abstract

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1 Introduction

Wood is an important resource for the construction industry. While steal, concrete and cement have substituted timber to a large extent in the last century, the environmental advantage of wood in construction still makes a case in favor of this material. Indeed wood sequesters carbon and, if used in building, prevents CO_2 to spill in the atmosphere (Lippke et al., 2010). Also, the production of timber requires less energy and hence produces less CO_2 than other materials such as cement or concrete (Gustavsson et al., 2006). A more intensive use of wood in construction can therefore be useful as an additional tool to mitigate climate change (FOEN, 2007) and meet the pledges of Paris Conference of Parties.

The wood market has four interesting economic specificities. First, from the raw material, a large panel of products can be produced. Differences in the wood quality, assortment or essence increase the heterogeneity, which comes with heterogeneous prices (Kostadinov et al., 2014). Also, there is some complementarity and substitutability in the production of some products. Indeed, from a particular harvested tree,both energy wood and timber can be produced and wood waste can also be turned into valuable energy.

Second, wood markets are usually composed of a multitude of small decentralized actors such as forest owners, logging companies for the harvest, sawmills for the transformation and end-users, which can be institutional actors, private firms or households.

The third specificity are the important externalities associated with the wood supply. Indeed, the exploitation of wood impacts the different forests functions such as recreation, protection against landslides, water and air purification and habitat for biodiversity. Given these external effects and the important deficit of forestry since the 90’s, forest companies are usually heavily subsidized or public owned in Switzerland. Therefore, the wood supply may not be profit driven but rather target a given revenue (Farsi and Krähenbühl, 2015).

And fourth, wood is a storable good (Hendel and Nevo, 2004). Entrepreneurs may either choose not to harvest at time t and let the tree standing until $t+1$ or cut it at time t and store the wood until $t+1$, before the sales. Consumers may also choose to buy at time t and store it until the next period. This may impact the short vs. long term elasticities: since adaptation becomes easier with time, entrepreneurs and consumers reactions to a change in price (or in any other factor) should be higher in the long term than in the short term, and hence short term price-elasticities should be lower than long term price-elasticities. However, the opposite is also possible if, in the

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short term, entrepreneurs boost their production in reaction to a temporary price rise, at the cost of the long run productivity. On the demand side, if consumers anticipate their purchase in reaction to a temporary price fall (Roberts and Schlenkera, 2013), short run demand elasticities may be larger than long run. All these specificities need to be kept in mind when analyzing the wood market.

Swiss forests grow and the volume of standing wood increases since the 19th century. Given the relative environmental friendliness of wood, the sustainable aspect of an increase in wood production (Borzykowski and Kacprzak, 2016) and the potential of wood mobilization, the Swiss government decided to promote the use of this material in the Forest policy 2020 (FOEN, 2013) and the wood resource policy (FOEN, 2008). Yet some concerns emerge regarding the responsiveness of wood market actors to incentives (Farsi and Krähenbühl, 2015).

We use a rich yearly time series dataset to estimate demand and supply price-, income- and cross-elasticities on the market for construction round wood in Switzerland. Our time series analysis covers the period 1947-2013 and considers both short term and long term relationships, thanks to the Error Correction Model (ECM) (Engle and Granger, 1987). We correct for the price endogeneity using a supply-demand equations system estimated with the 3 Stages Least Squares (3SLS) approach.

2 Methods

The use of Ordinary Least Squares (OLS) in a time series context is not recommended if series are not stationary. Indeed the non-stationary nature of series leads to the problem of spurious regressions and thus to unreliable statistical inference (Granger and Newbold, 1974). We therefore first test for stationarity using the Dickey-Fuller test (Dickey and Fuller, 1979), the Philips-Perron test (Phillips and Perron, 1988) and the KPSS test (Kwiatkowski et al., 1992), that are standard procedure with longitudinal data.

Non-stationary time series require the Error Correction Model developed by Engle and Granger (1987) for multivariate analysis. This approach is composed of three steps: First, estimate the long-run relationship with OLS on variables' levels as in equation 1:

$$Y_t = \alpha_{LR} + X'_{LRt}\beta_{LR} + z_t \tag{1}$$

With Y_t the explained variable, α_{LR} a constant, X_t a matrix of covariates, β_{LR} a vector of regression coefficients, which can be interpreted as the long run impact of X and z_t the error term. The second step is to get the residuals and test them for stationarity[1]. If the errors are stationary, then the series are co-integrated I(1) meaning that a short run relationship can consistently be estimated with the ECM on first differences[2] with the following model:

$$\Delta Y_t = \alpha_{SR} + \Delta X'_{SRt}\beta_{SR} + \gamma \hat{z}_{t-1} + \varepsilon_t \tag{2}$$

With ΔY_t the first difference of the explained variable, α_{SR} a constant, ΔX_t a matrix of explanatory variables' first differences, β_{SR} a vector of coefficients, interpreted as the short run impact of X on Y, and $\hat{z}_{t-1}$ the lag of the error terms from model 1. The associated coefficient of the latter variable, γ, is the lagged error-correction term and can be interpreted as the "adjustment speed" to the long run equilibrium.

In addition to the stationarity issue, as we analyze the whole market, we have to deal with endogeneity. Indeed, at the equilibrium, prices and quantities are simultaneously determined by the market according to demand and supply. Therefore, a system of simultaneous equations accommodating both sides of the market is necessary to instrumentalize the endogenous variables. This model can then be estimated using a Two Stage Least Squares (2SLS) or 3SLS approach. 3SLS is usually more efficient and thus preferred (AlDakhil, 1998).

To sum up, to account for series' non-stationarity and price endogeneity, we run an ECM on the simultaneous demand-supply equations system presented in equation 3. This approach is accepted since Hsiao (1997a; 1997b).

$$\begin{cases} Q_t^D = & \alpha^D + \beta_1^D P_t + \beta_2^D Psubs_t + \beta_3^D Wage_t + \beta_4^D Investment_t + \beta_5^D T_t + \epsilon_t^D \\ Q_t^S = & \alpha^S + \beta_1^S P_t + \beta_2^S Wage\ in\ forestry_t + \beta_3^S txi_t + \beta_4^S Penergy_t + \beta_5^S Vivian90_t + \beta_6^S Lothar00_t + \beta_7^S T_t + \epsilon_i^S \end{cases} \tag{3}$$

With Q_t the quantity produced, P_t the price of construction wood, $Psubs_t$ the price of steal, $Investment_t$ the investment in the construction sector, $Wage\ in\ forestry_t$ the average wage in the forest industry, an indicator of the cost of labor, txi_t the interest rate on savings, an indicator of the cost of capital, $Penergy_t$ the price of energy wood, $Vivian90_t$ a dummy accounting for the hurricane Vivian in 1990, $Lothar00_t$ a dummy accounting for the hurricane Lothar in 2000, α^i the constants ($i = S; D$), T_t^i time trends and ϵ_t^i the error terms.

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[1] A simple Dickey-Fuller or Philips-Perron test can be used but critical values are not the usual ones. Critical values for the test of co-integration are available in Engle and Yoo (1987)

[2] This result calls upon the superconsistency theorem. See Engle and Granger (1987).

3 Preliminary results

All series are found to be non-stationary on level but stationary on first difference.

On the long run, we observe that the price-elasticity of demand is, as expected, negative. The magnitude of this effect, whether the demand for construction wood is rather price-elastic or price-inelastic depends on the model. The addition of regime breaks (Gregory and Hansen, 1996) does not result in any statistically significant change in slope. We find that the lag of price has a positive impact on the demand: If the price was higher at $t-1$, consumers will tend to postpone their purchase and buy more in t. Income-elasticity is found to be positive and less than 1. Construction wood is hence a normal, first necessity good. As expected, the cross-elasticity between construction wood and steal is positive. Steal is thus a substitute to wood in the construction sector. Indeed if the price of steal increases, the latter becomes less attractive, which causes an increased demand of construction wood. Investment in construction also has a positive impact on the demand, which is an expected result. Finally, we observe a negative trend. That may mean that construction became more efficient in using wood for construction purposes or simply that the technology changed.

On the supply side, we observe a positive price-elasticity. Coefficients associated with the price are inferior to 1, supply is thus price-inelastic in the long run. The lag of price has a negative impact on the supply: if the price was higher at $t-1$, suppliers may have anticipated the price fall and produce more at $t-1$, at the expense of production at time t. Also the price of energy wood negatively affects the supply of construction wood. This result means that suppliers may have some room to substitute the production of construction wood with energy wood if it becomes more profitable. Indeed the production of construction wood comes with a higher marginal cost than energy wood and the profit may be higher with the production of energy wood rather than timber. We also observe an important effect of the two hurricanes Vivian and Lothar that increased the wood supply.

After estimating the long run co-integration relationships, we extract the residual and test them for stationarity. They are found to be stationary, which confirms the co-integration relationship of the series.

We now comment the results of the short run relationship. On the demand side, price-elasticities are again negative. In general, as expected, short run demand elasticities are smaller than long run elasticities. The demand for construction wood is hence robustly price-inelastic in the short run. The cross-elasticity between wood and steal is again positive. The nature of the relationship between steal and wood is therefore unchanged and steals remains a substitute to wood in the short run as well as in the long run. The magnitude of this elasticity is similar in the short run as in the long run. Wage has a negative impact on the demand for wood, but statistically insignificant. Finally the demand is positively and significantly affected by investments in construction. For the latter variable, a 1% higher amount invested in construction causes an increase of about 0.6% in the demand for construction wood.

The supply significantly reacts to prices. Our models suggest that the price-elasticity of the supply for construction wood is higher than 1, hence higher in the short run than in the long run. This is an unexpected but meaningful result. Indeed (Roberts and Schlenkera, 2013) suggest that price-elasticity of the supply for storable goods may be higher in the short run if suppliers decide to increase their production in reaction to a temporary price rise at the cost of the long run productivity. In the case of wood harvest, forestry entrepreneurs may decide to cut more wood when prices are higher in period t and be leftover with hillier or more uneven zones, thus more costly to harvest. Production factors such as the price of labor and the price of capital do not have any significant effect in the short run, which is not very surprising since those variables did not have significant effects in the long run either. The elasticity of the supply for construction wood with respect to price of energy wood is negative and higher than 1 in absolute terms, which tend to show that both types of wood are again substitutes on the production side. Again, our results suggest that, with respect to this variable, the elasticity is higher in the short run that in the long run. The production of energy wood may be used as adjustment. Regarding natural hazards, while Lothar has an important short term impact, the insignificant coefficients of the variable $Vivian90$, tend to suggest that this hurricane had an important long run impact but a limited impact (if any) on the short run. Following Lothar, the Swiss government decided to subsidize the extraction of fallen trees, which boosted the short-run production. This policy was not implemented in 1990, which can explain the different impacts of these natural disasters.

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