

Team Project

Le Thi Thanh Tam _ Pham Thi Anh Thu _ Hoang Thuy Duong

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1. Team Member Contribution

There are 3 members in our group doing this project: Le Thi Thanh Tam, Pham Thi Anh Thu and Hoang Thuy Duong. After considering, we decided the team member contribution as: 45% for Le Thi Thanh Tam, 30 % for Pham Thi Anh Thu and 25 % for Hoang Thuy Duong. Although we have done the project together, Le Thi Thanh Tam is the leader and guides 2 other team members much. Therefore, there is not denied that Le Thi Thanh Tam has contributed to this group project much more 2 others.

2. Executive Summary

This paper is the result of data analysis project about the Oral Diabete drug category data. There are 4 main parts in this paper, including background information, data description, model description and finding & implementation. In particular, in this project, we try to find out the most significant model with appropriate variables in order to find out some effects of medicines to the consumers. This paper will focus on only 4 medicines, including Actos, Lantus, Avandia and Glucophage/Metformin with the time is in the last 40 weeks (exclude the very last week).

3. Background Information: Oral Diabete Drug Category

products	company_name	intro_year	chemical_ingredients	date_expiration
Actos	Takeda Pharmaceutical Company	1999	Pioglitazone Hydrochloride	Jan, 2011
Amaryl	Sanofi	1995	Glimepiride	Oct, 2020
Apidra	Aventis Pharmeceutical Inc	2004	Insulin Glusine Recombinant	N/A
Avandamet	SB Pharmco	2002	Metformin Hydrochloride, Rosiglitazone Maleate	N/A
Avandaryl	Glaxo Smith Kline	2006	Glimepiride, Rosiglitazone Maleate	N/A
Avandia	Glaxo Smith Kline	1999	Rosiglitazone Maleate	Jan, 2012
Fortamet	Andrx labs LLC	2004	Metformin Hydrochloride	Mar, 2021
Glucophage XR	Bristol Myers Squibb Products & Medicines	1957	Metformin Hydrochloride	Sep, 2000
Glucophage/Metformin	Bristol Myers Squibb Products & Medicines	1995	Metformin Hydrochloride	Jun, 2003
Glucovance/Metformin	Bristol Myers Squibb Products & Medicines	2002	Glyburide, Metformin Hydrochloride	Sep, 2000
Lantus	Sanofi	2000	Insulin Glargine Recombinant	Mar, 2028

products	company_name	intro_year	chemical_ingredients	date_expiration
Other Insulins	Eli Lilly, Novo Nordisk, Sanofi	1922	N/A	N/A
Pran/Star/Prec/Chlorpheniramine	Pfizer and Upjohn Company LLC	1996	Miglitol	N/A
Sulfonylureas	Marcel Janbon	1950	N/A	N/A
Symlin	Amylin Pharmaceuticals	2005	Pramlintide Acetate	Mar, 2019

There are 15 different kinds of medicines in Oral Diabetes drug category. Particularly, these medicines belonged to different pharmaceutical companies. However, there are some kinds of medicines in a similar company. For example, Avandaryl and Avandia are all belonged to Glaxo Smith Kline Company as well as Glucophage XR, Glucophage/Metformin and Glucovance/Metaglip are belonged to Bristol Myers Squibb Products & Medicines Company.

4 Data Description

- The original data contain 182,680 patient visits where a prescription was written by 2,127 physicians. This data was conducted for over an 18 month period from January 1st, 2007 to June 30th, 2008.
- For this study, we select “regular” physicians, those characterized by the following two conditions. First, the doctor has made at least one prescription every month. Second, the doctor has changed the prescription or not (switched brand). Moreover, we confine our attention in our analysis to 4 drugs “Actos”, “Lantus”, “Glucophage/Metformin”, “Avandia”. And we only focus on the last 40 weeks and exclude the last week because it includes only two dates.

Table 2: **Descriptive Statistics for Oral Diabetes Data**

Variables	Observations	Mean	St.Dev
Patient visits	24,714	65.208	41.307
Severity (Mild)	5018	16.187	19.833
Severity (NotMild)	19,697	52.525	37.592
Age (Senior)	10,604	28.053	22.259
Age (NotSenior)	14,110	37.328	26.917
Actos	7,057	19.022	21.366
Lantus	5,520	15.082	15.202
Glucophage/Metformin	14,677	39.139	31.015
Avandia	1240	5.103	5.587
Detailing	5086	13.420	13.088

- Table 2 provides the basic descriptive statistics for the 379 physicians sampled. There are 24,714 patient visit observations, out of which 5,018 are mild patient visits (20.3%) while the rest are made by 19,697 (79.7%). 10,604 senior patients (42.9%) and the rest is 14,110 (57.1%). Each patient visit leads to write a prescription; 7,057(28.6%) and 7,057 (22.3%) and 1240 (5.0%) of prescriptions go to Actos,Lantos and Avandia respectively. Among that, Glucophage/Metformin accounts for the highest percentage with 14,677 (59.4%). During the last 40 weeks period, 5086 detailing activities were directed to physicians.
- An “average” physician in our sample is characterized by a combination of 65 patient visits (16 Mild Severity and 52 Not Mild) and 28 Senior and 37 not and 13 detailings. As evidenced by high standard deviations, there is a significant amount of heterogeneity across physicians.

Table 3: **Drug Shares**

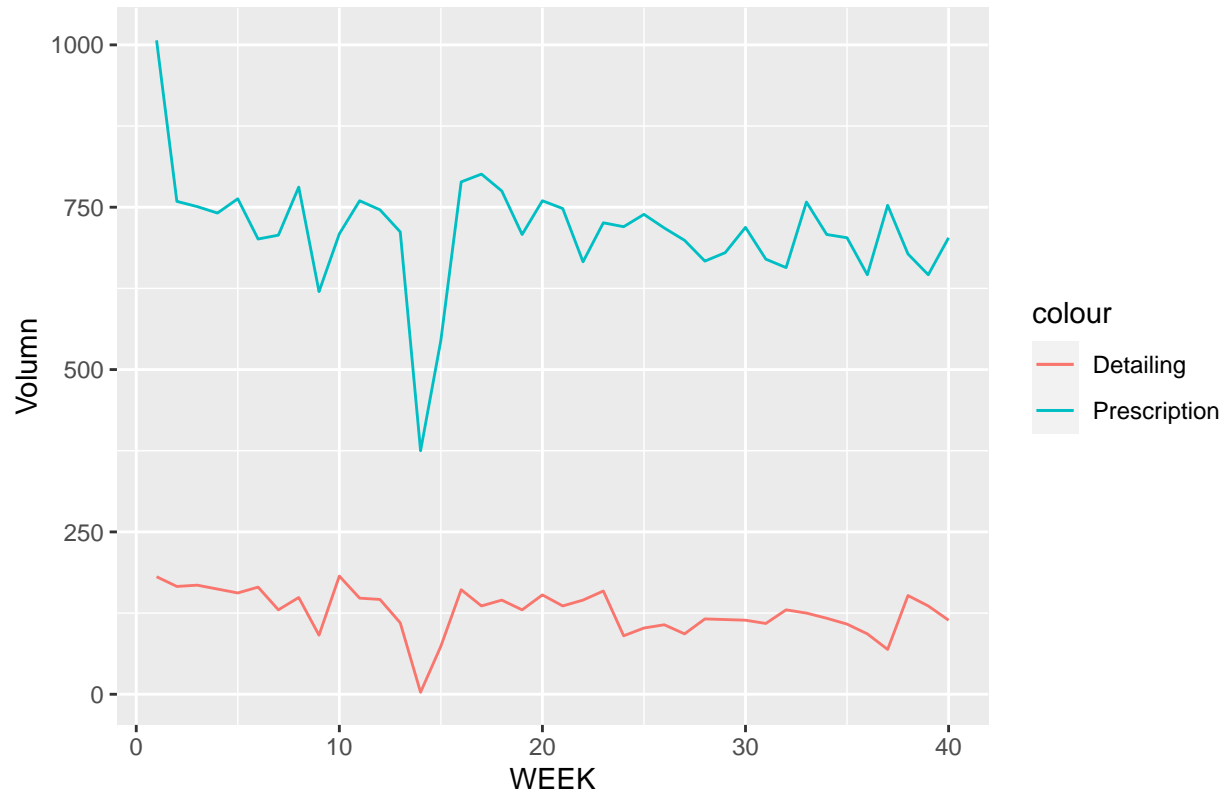
Drug	Prescription	Detailing	Previous.prescription	Drug.request	From	To
Actos	24.774	39.343	52.508	24.633	24.480	24.779
Avandia	4.352	28.588	3.344	7.234	4.363	4.245
Glucophage/Metformin	51.501	0.020	23.411	52.981	51.799	51.446
Lantus	19.373	32.049	20.736	15.152	19.358	19.530

- Table 3 presents, for each of the 4 drugs, its market share with respect to each of the variables discussed above. The top prescription share drugs are Glucophage/Metformin and Actos. Glucophage/Metformin, the largest prescription share drug (51.5%), is also the most requested by patients (53%), but is not the most detailed (only 0.02%). Due partly to Glucophage/Metformin's large prescription share, prescription switches from Glucophage/Metformin happen most frequently. Actos is the second drug for prescription (24.8%) but the most detailing drug. Avandia accounts for only 4.4% in prescription but 28.6% in detailing.

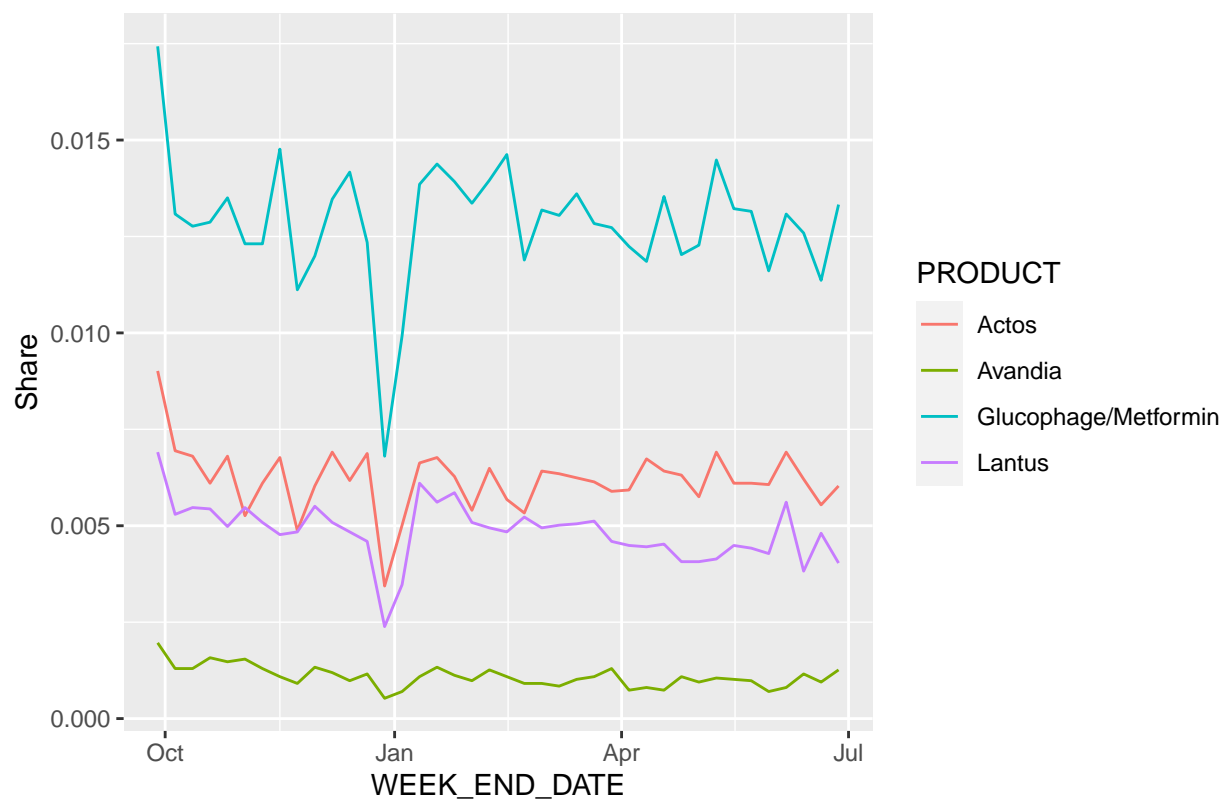
Figure 1 Prescription and Detailing Patterns

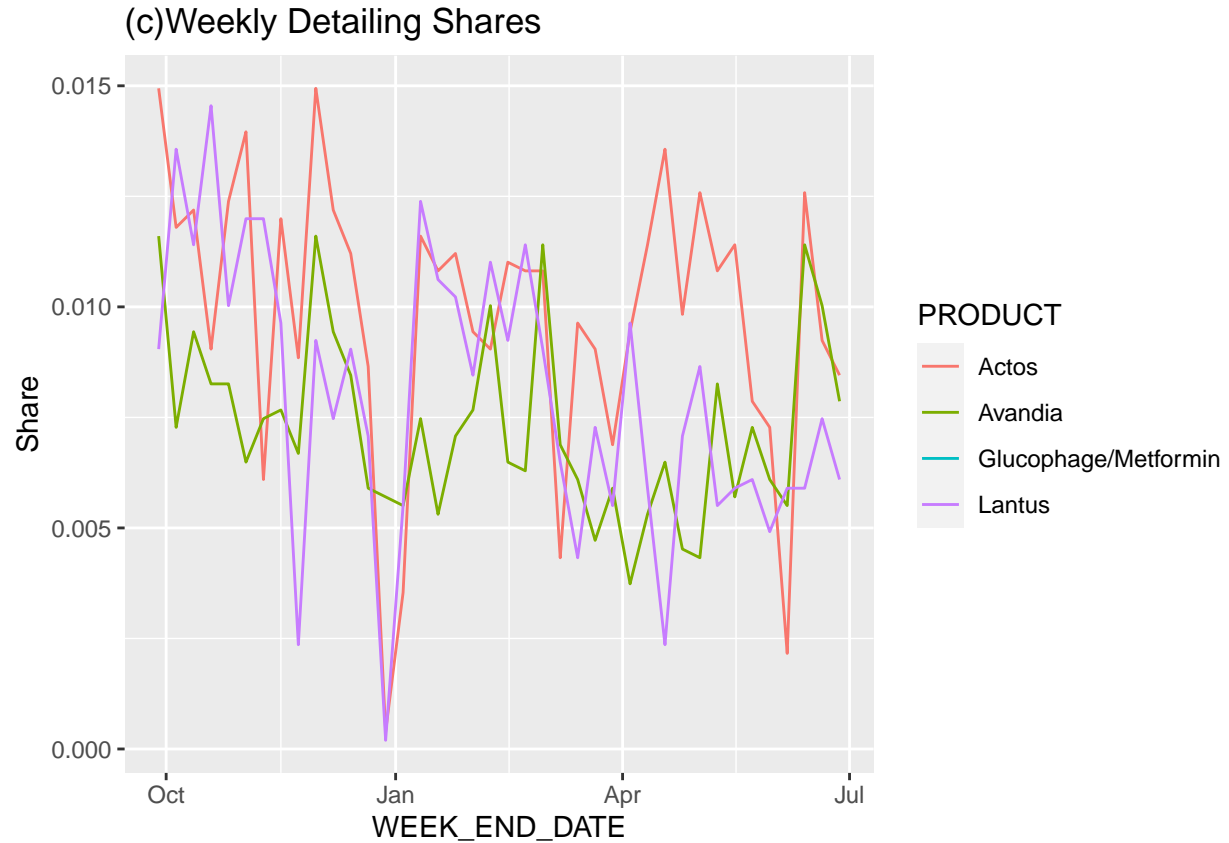
- Figure 1 shows (a) weekly category volumes of prescription and detailing, (b) weekly prescription shares, and (c) weekly detailing shares. Visual inspection of the plots in the panel (a) suggests that the prescription and detailing volumes are quite stable over time. They both had slight fluctuations around their weekly means (approximately 750 prescriptions and 125 detailings) throughout the sample span. Two outliers occur during the Christmas and New Year holiday season (weeks 14 and 15)
- The prescription shares in the panel (b) indicates they all product see the decreasing in the New Year day. The detailing shares in the panel (c) show that their evolution patterns are not very systematic.

(a) Weekly Category Prescription and Detailing Volumes



(b) Weekly Prescription Shares





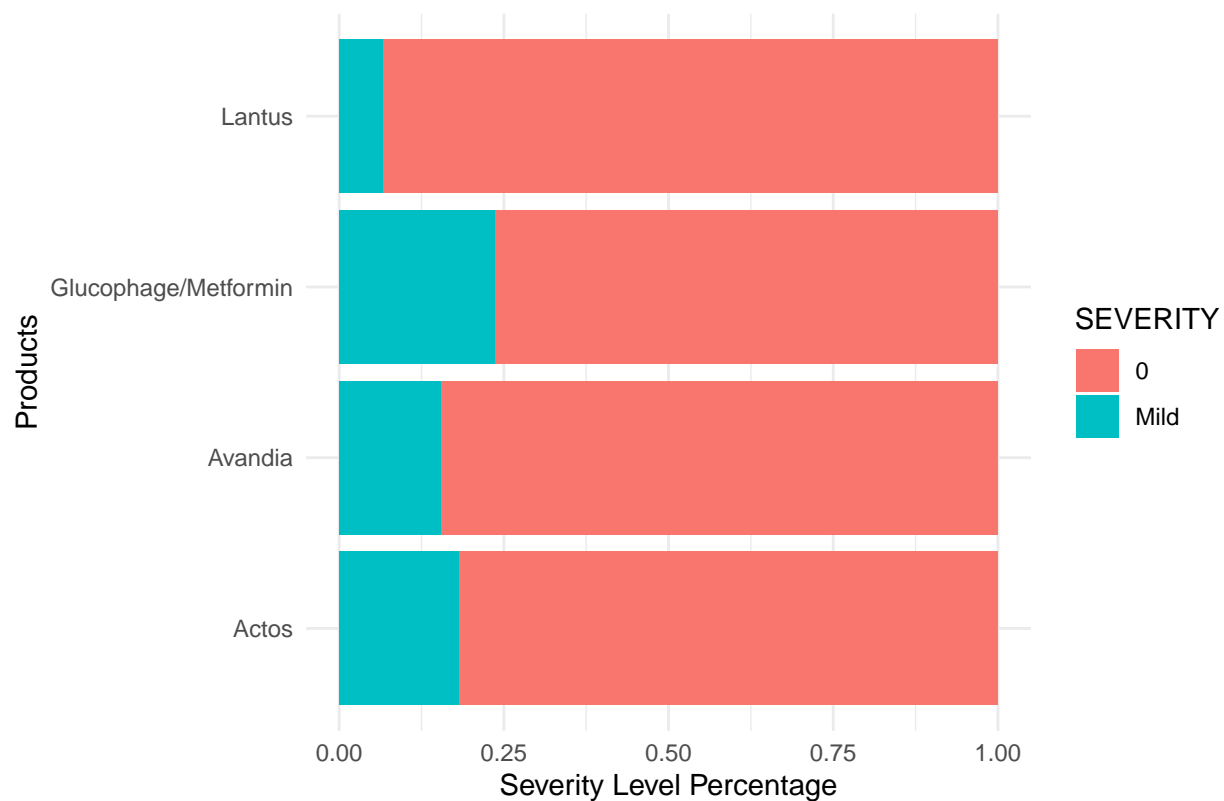
5. Model Description

Choice of independent variables

Our final model is : **choice** ~ **goodwill**|**severity**+**age**+**insurance**

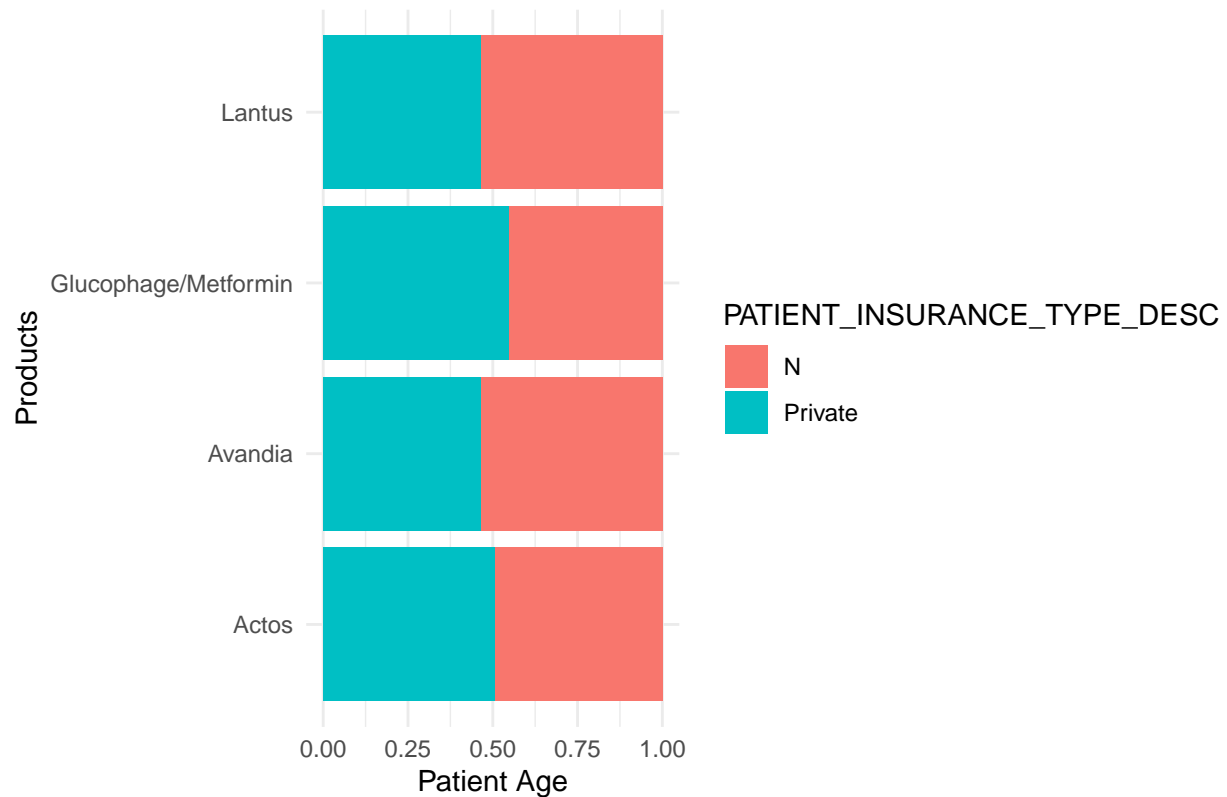
We decided to choose goodwill - alternative specific variable and 3 patient specific variables (severity, age, insurance type) for our final model.

- For the variable **PATIENT_AGE** representing the age of the patient, we converted it to one binary variable, with value “**Senior**” for age greater than or equal to 65, and value “**0**” age less than 65. The reason why we divided the variable that way is because in the drug market, 65 is the conventional magic number : Greater than or equal to 65 is considered as Senior, less than 65 is young people.
- For the variable **SEVERITY** representing the patient’s condition, we also transformed it into one binary variable, with value “**Mild**” for mild, and value “**0**” for moderate and severe. The reason is shown in the following stacked bar chart.



We can see that **Moderate** has the most observations. We also compute the prescription shares. The prescription shares of **Moderate** are closer to **Severe**, therefore we decided combine those 2 values.

- For the variable **PATIENT_INSURANCE_TYPE_DESC** representing the type of insurance plans that the patients own, we converted it to one binary variable : “**Private**” for HMP/PPO/POS and “**N**” for all the other cases. The reason is shown in the following bar chart.



We noticed that **HMO/PPO/POS**, which is the private insurance, occupies the most shares throughout all the 4 drugs. Therefore, we decided to assign one dummy value for **HMO/PPO/POS** and one dummy value for the other cases.

6. Findings and Business Implications

Main findings from the model estimation results

The baseline scenario is set up as the following: * Brand = AC * Severity = 0 (Not Mild) * Age = N (Not Senior, under 65) * Insurance = N (Not Private)

Relative to the baseline AC, if we change the drug from AC to AV, it has a positive impact on prescription (1.6599669). The physicians are more likely to prescribe AV; similarly with GL and LT. Relative to AC, all those 3 brands have higher prescription propensity. Regarding **Severity**, AV has a lower probability of prescription (-0.9177910) than AC if the patient's severity condition is **mild** while GL and LT have a higher probability of prescription (0.2045482) than AC. With regard to **Age**, all the 3 brands AV, GL and LT have a lower chance of prescription to patients aged 65 and over, relative to AC. As regards **Insurance Type**, AV has less chance of prescription (-0.0977750) to the patients with **private insurance**, while GL and LT has higher chance, relative to AC.

The next factor we would like to mention is the brand specific intercept terms. Given AC as the baseline, if the drug is AV, the intercept term increases by 1.6599669. Which means, when all other variables equal to zero, the **intrinsic preference** for AV is nearly 1.66 relative to AC. Likewise, if the drug is GL, the intrinsic preference for GL is around 1.60 relative to AC. If the drug is LT, the intrinsic preference for LT is nearly 2.39 relative to AC.

In that case, LT has the highest intrinsic preference (2.3893368); followed by AV (1.6599669), GL (1.6030793) and AC, respectively. Which implies that, without any of the other variables (goodwill, severity, age, insurance), the predicted market shares of LT must be number one. However, according to the real data's observed market shares among all the 15 brands, GL ranked first (26.4%), followed by AC (12.9%), LT (10.24%) and AV (4.07%), respectively. We can see that the **observed market shares** and the order of the **intrinsic preferences** are different.

That difference might be explained by the other variables. The first one to consider is **Severity**. For mild patients, LT is more frequently prescribed relative to AC (0.5562606). The second one is **Age**. We noticed the negative coefficient of LT relative to AC (-0.1159849), which means the physicians have less tendency to prescribe LT to 65-and-older patients, to AC. The third variable is **Insurance Type**. We noticed that LT is prescribed more to the patients with **private insurance** (0.2826933). Taking into account those 3 variables, the physicians are less likely to prescribe LT to patients with severe condition, to senior patients, and to patients with non-private insurance.

The alternative specific variable - **Goodwill**, has a positive impact on the prescription (0.0554673). What we can expect is, the drugs with more detailings will lead to higher goodwill for the physicians. With higher goodwill, the physicians are likely to prescribe more.

Business implications

The model estimation results show that **Actos** have a tendency to be prescribed more to senior patients, relative to the 3 other drugs. This finding is within expectations. Older patients typically lack the ability to flush the drugs out of their kidneys before they accumulate at toxic levels. According to our market research, the chemical ingredient of **Actos** is pioglitazone hydrochloride, which is metabolized in the liver, not the kidneys and it is therefore typically the safest way to control type 2 diabetes in older patients. Meanwhile, Metformin, which is the chemical ingredient of **Glucophage**, is nearly always cited as the wrong treatment for older patients.

The model estimation results also indicate the impact of owning private insurance on the prescription choice of physicians. According to GoodRx website, the most common version of **Lantus** is covered by 82% of insurance plans at a co-pay of \$37.50-\$67.50; and the generic metformin (**Glucophage**) and generic pioglitazone (**Actos**) is covered by most insurance plans. That might be the reason why according to our model coefficients, **Glucophage/Metformin**, **Lantus** and **Actos** are more likely to be prescribed to patients with private insurance, relative to **Avandia**.

In terms of severity condition, **Glucophage/Metformin** turns out to have higher probability of prescription to mild patients, relative to Actos. In fact, according to our market research, **Metformin** is generally the first medication prescribed for type 2 diabetes; it works primarily by lowering glucose production in the liver and improving your body's sensitivity to insulin. That might explain why **Glucophage/Metformin** has a high chance of prescription to patients with mild condition.